

Supplementary Appendix

Table of Contents

Item	Page Number
Figure S1: Annual number of TCARs performed, demonstrating the increasing utilization of this new procedure over time. TCAR indicates transcarotid artery revascularization.	4
Figure S2: Regional uptake of TCAR overall, in 2017, 2020, and 2022, demonstrating the early uptake in the East, then overtaken by the Southern U.S. TCAR indicates transcarotid artery revascularization.	5
Figure S3: Number of TCARs implanted and the number of centers performing them over time among high-risk patients. TCAR indicates transcarotid artery revascularization.	6
Figure S4: Number of TCARs implanted and the number of centers performing them over time among standard-risk patients. TCAR indicates transcarotid artery revascularization.	7
Figure S5: Relative percent market share of TCAR, CEA, and TF-CAS at centers reporting all procedures among high-risk patients. CEA indicates carotid endarterectomy; TCAR, transcarotid artery revascularization; and TF-CAS, transfemoral carotid artery stenting.	8
Figure S6: Relative percent market share of TCAR, CEA, and TF-CAS at centers reporting all procedures among standard-risk patients. CEA indicates carotid endarterectomy; TCAR, transcarotid artery revascularization; and TF-CAS, transfemoral carotid artery stenting.	9
Figure S7: Scatter plot demonstrating the percent of procedures that an individual proceduralist performed in 2015 that were TF-CAS, against the percent of procedures performed by that same person in 2020 that were TF-CAS, TCAR, or CEA among all proceduralists with data in both timepoints (Panel A) and after limiting to proceduralists with at least 5 cases in 2015 (Panel B). CEA indicates carotid endarterectomy; TCAR, transcarotid artery revascularization; and TF-CAS, transfemoral carotid artery stenting.	10
Figure S8: Density of propensity scores of high-risk patients receiving TCAR, CEA, and TF-CAS, demonstrating that patients receiving TCAR are similar to either CEA or TF-CAS patients, while patients receiving CEA and TF-CAS are relatively distinct from each other. CEA indicates carotid endarterectomy; TCAR, transcarotid artery revascularization; and TF-CAS, transfemoral carotid artery stenting.	11
Figure S9: Density of propensity scores of standard-risk patients	12

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Figure S10: Distribution of SVS VQI Physician Specialties, available at: vqi.org/wp-content/uploads/2022-Detailed-Annual-Report-FINAL.pdf 13
SVS VQI indicates Society of Vascular Surgery Vascular Quality Initiative

Table S1: Characteristics of patients who underwent TF-CAS by year and overall. 14/15
TF-CAS indicates transfemoral carotid artery stenting

Table S2: Characteristics of patients who underwent CEA by year and overall. 15/16
CEA indicates carotid endarterectomy.

Table S3: TCAR uptake over time by region of the United States. 17

Table S4: Percent of carotid revascularization procedures that were 18
TCAR in 2021/2022 stratified by TF-CAS use in 2015, determining whether centers who use TF-CAS more frequently were also more or less likely to utilize TCAR over time

Table S5: Risk of in-hospital stroke or death after TCAR when stratified by 19
proceduralist- or center-level annual TCAR volume.

Figure S1: Annual number of TCARs performed, demonstrating the increasing utilization of this new procedure over time.

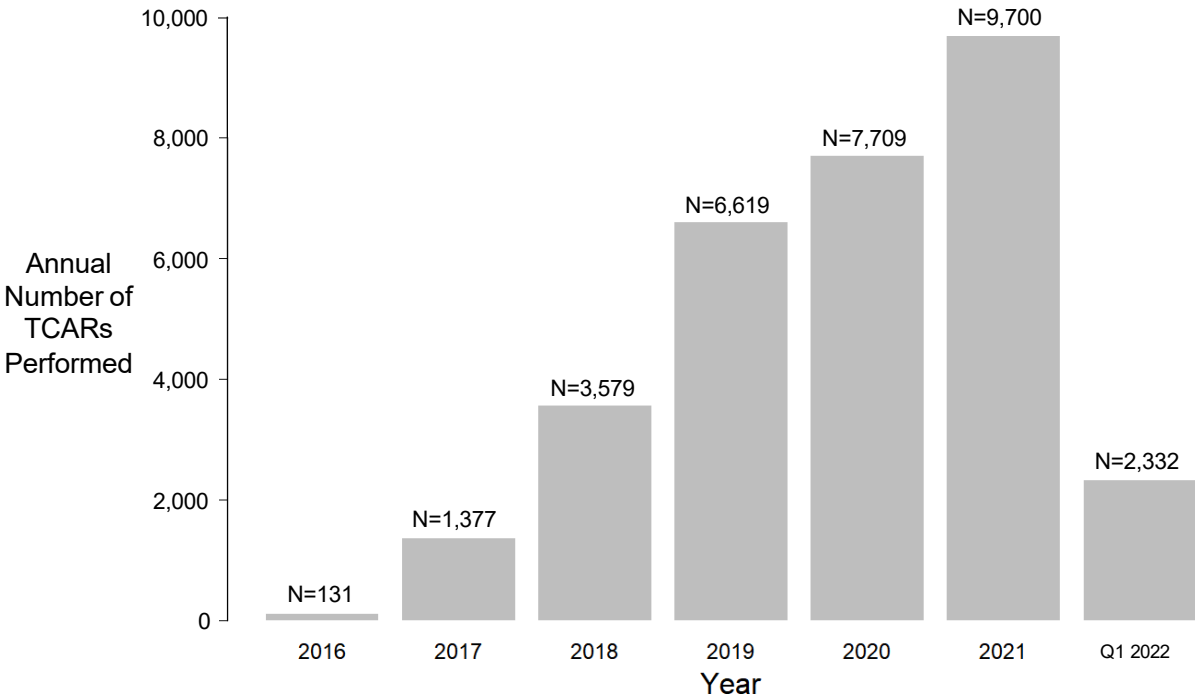


Figure S2: Regional uptake of TCAR overall, in 2017, 2020, and 2022, demonstrating the early uptake in the East, then overtaken by the Southern U.S.

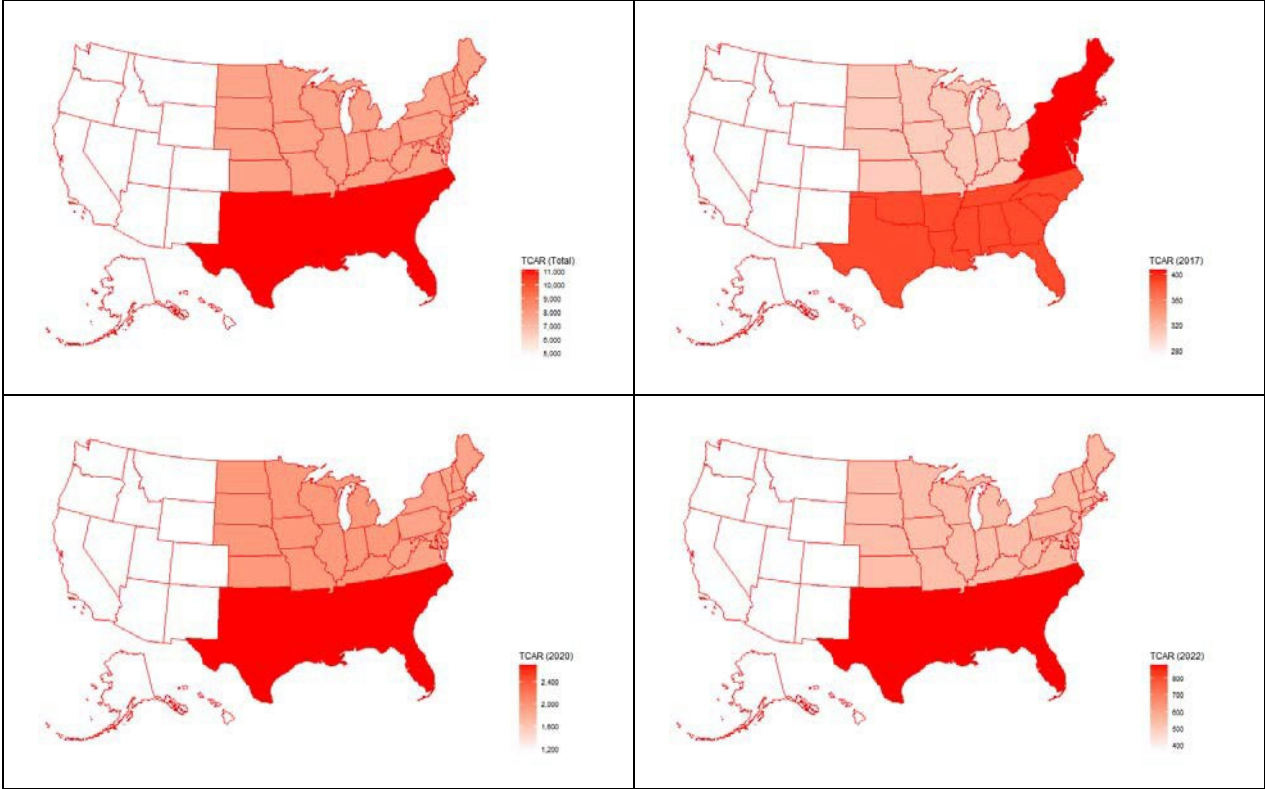


Figure S3: Number of TCARs implanted and the number of centers performing them over time among **high-risk** patients.

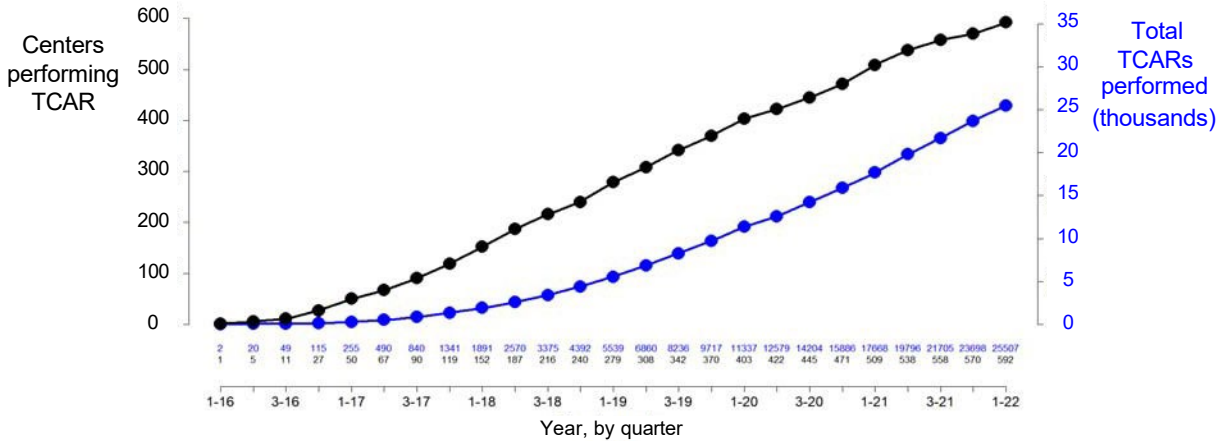


Figure S4: Number of TCARs implanted and the number of centers performing them over time among **standard-risk** patients.

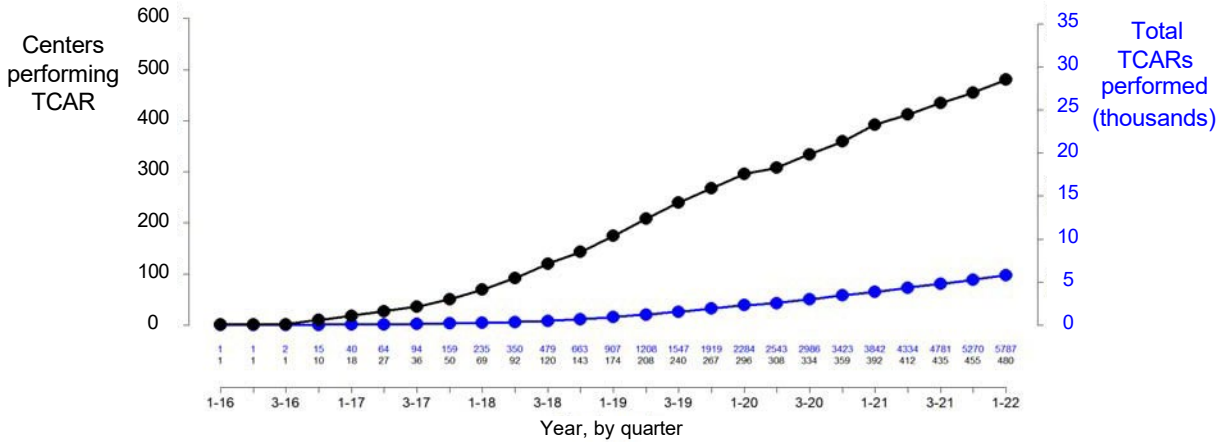


Figure S5: Relative percent market share of TCAR, CEA, and TF-CAS at centers reporting all procedures among high-risk patients.

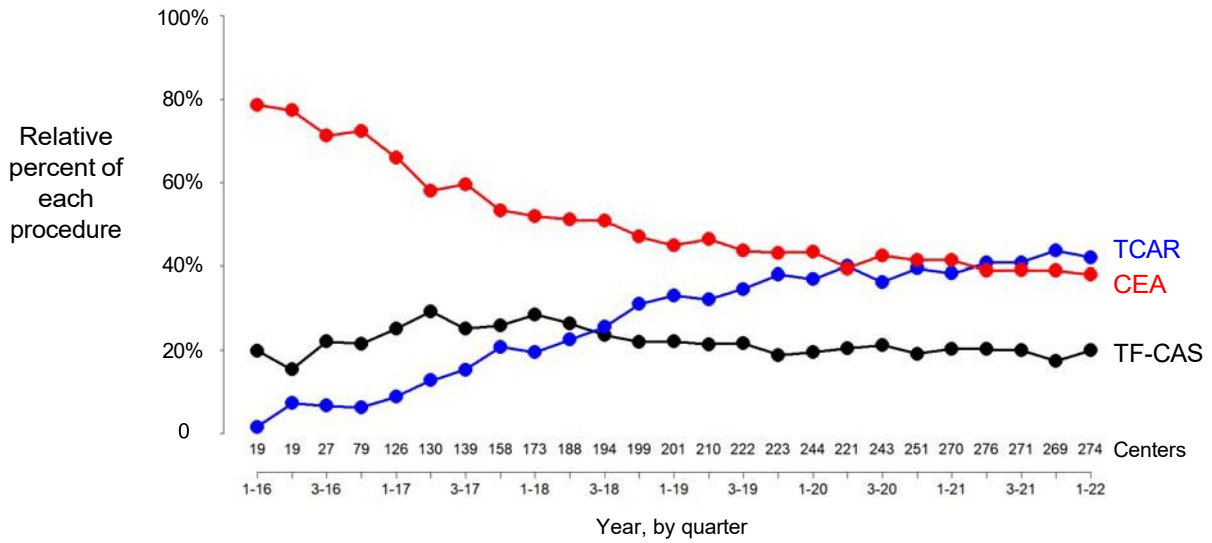


Figure S6: Relative percent market share of TCAR, CEA, and TF-CAS at centers reporting all procedures among **standard-risk** patients.

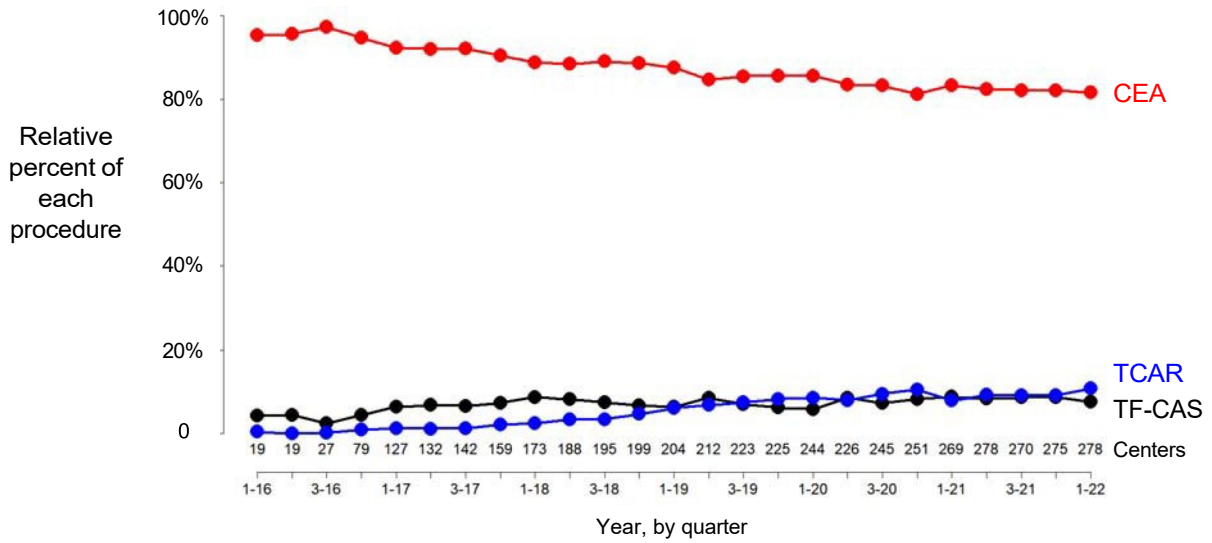
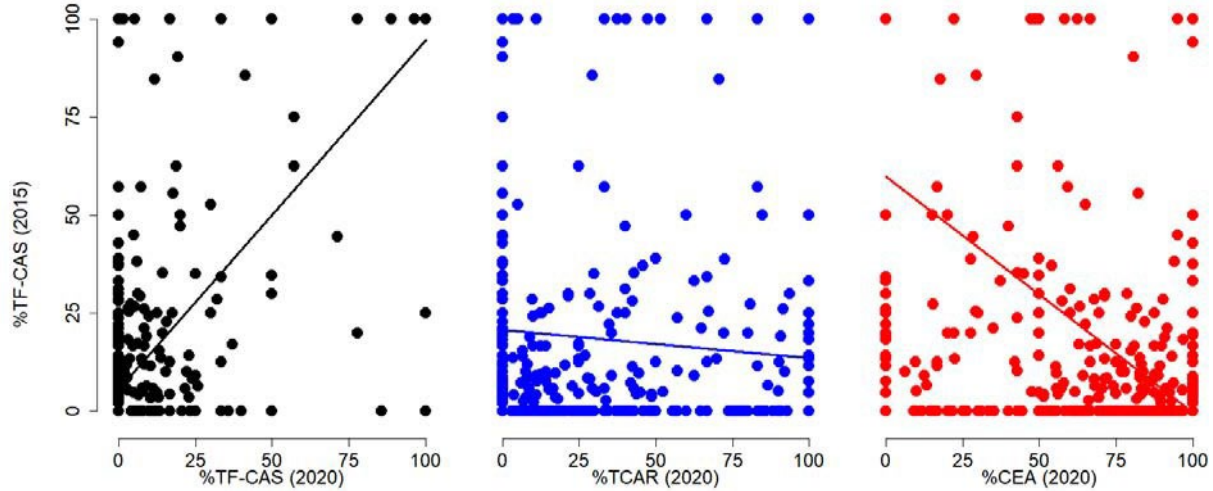


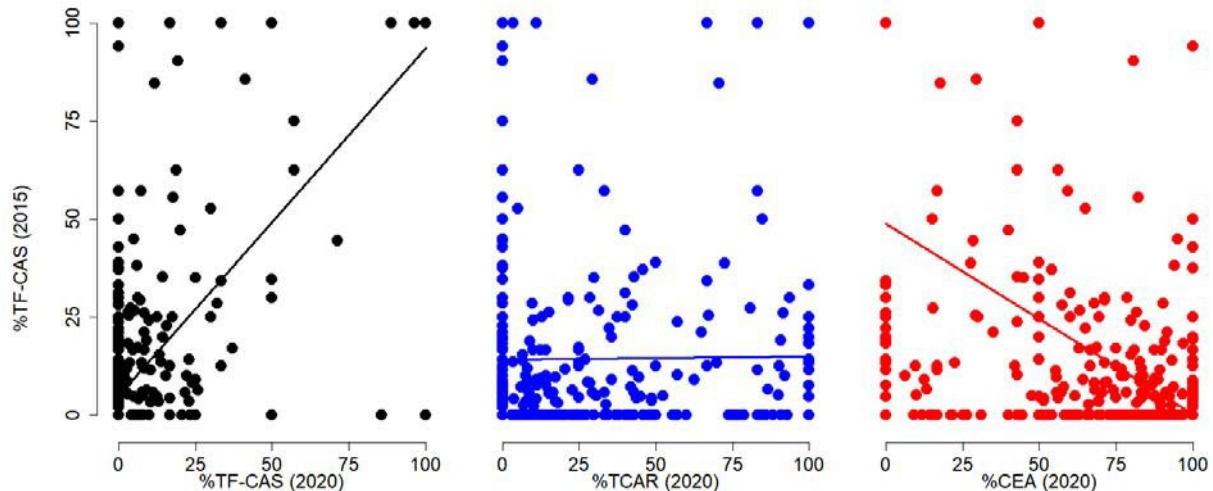
Figure S7: Scatter plot demonstrating the percent of procedures that an individual proceduralist performed in 2015 that were TF-CAS, against the percent of procedures performed by that same person in 2020 that were TF-CAS, TCAR, or CEA among all proceduralists with data in both timepoints (Panel A) and after limiting to proceduralists with at least 5 cases in 2015 (Panel B).

All proceduralists with data in 2015 AND 2020:



1. [Black]. Correlation 0.85 (95% CI: 0.83 to 0.87) p-value < 0.0001
2. [Blue] -0.06 (-0.13 to 0.01) p-value = 0.1055
3. [Red] -0.68 (-0.71 to -0.6) p-value < 0.0001

After excluding proceduralists with less than 5 procedures in 2015:



- 1 [Black] 0.83 (0.80 to 0.85) p-value < 0.0001
2. [Blue] 0.01 (-0.08 to 0.09) p-value = 0.8408
3. [Red] -0.62 (-0.67 to -0.56) p-value < 0.0001

Figure S8: Density of propensity scores of **high-risk** patients receiving TCAR, CEA, and TF-CAS, demonstrating that patients receiving TCAR are similar to either CEA or TF-CAS patients, while patients receiving CEA and TF-CAS are relatively distinct from each other.

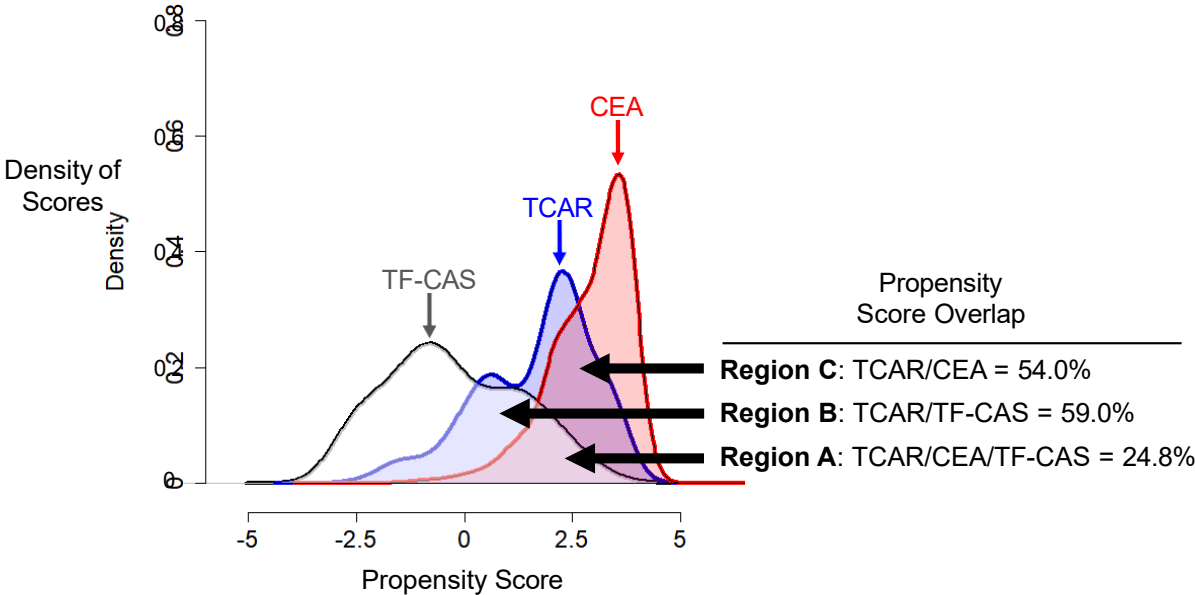


Figure S9: Density of propensity scores of **standard-risk** patients receiving TCAR, CEA, and TF-CAS, demonstrating that patients receiving TCAR are similar to either CEA or TF-CAS patients, while patients receiving CEA and TF-CAS are relatively distinct from each other.

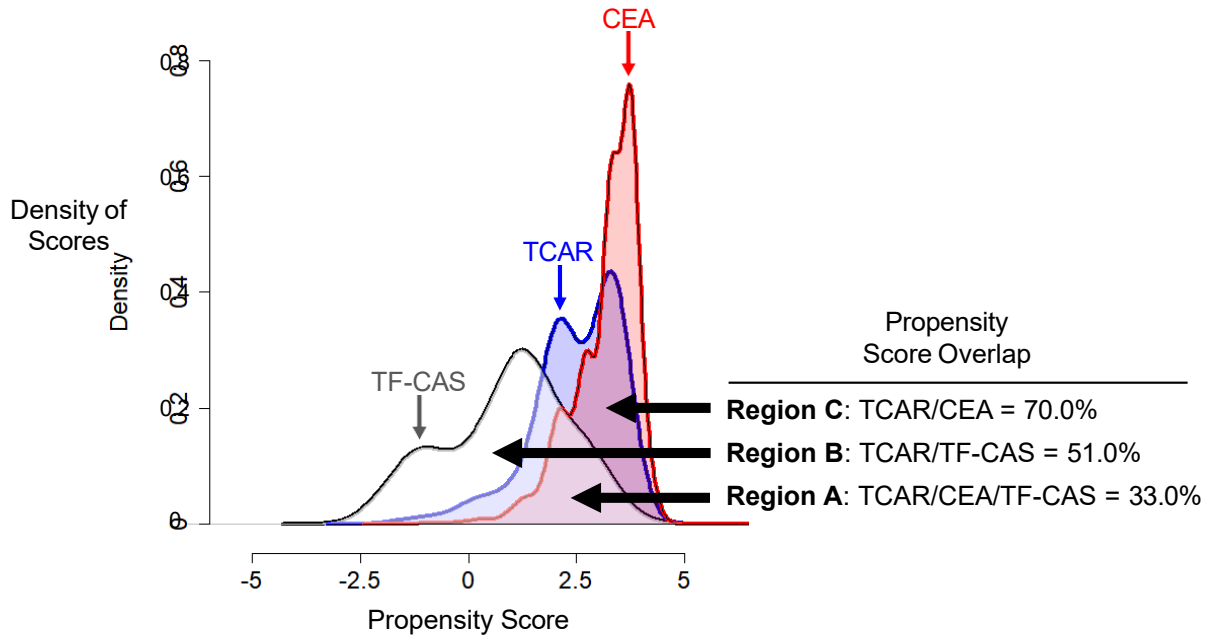
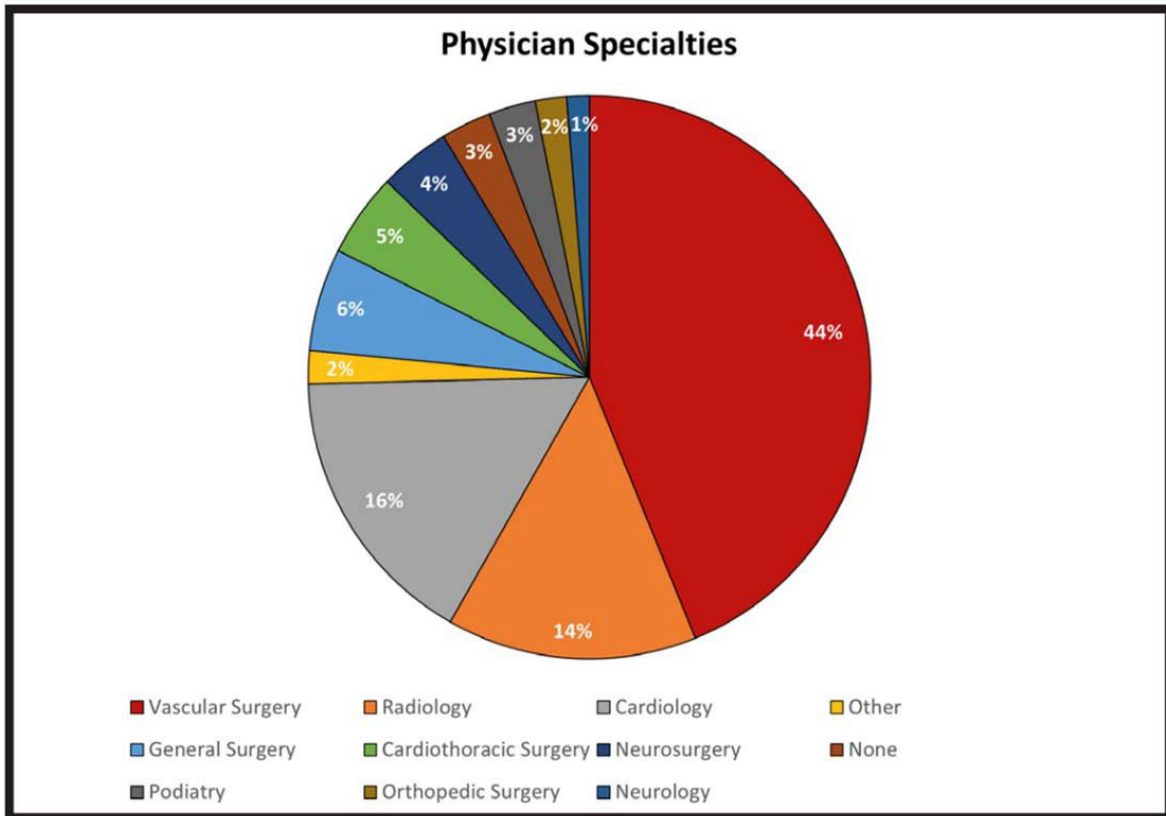


Figure S10: Distribution of SVS VQI Physician Specialties, available at: “www.vqi.org”



Source: Fivos PATHWAYS Data, Jan 2022

Figure 4.3: Distribution of SVS VQI Physician Specialties

Table S1: Characteristics of patients who underwent TF-CAS by year and overall.

Variable	Year														Totals		
	2016		2017		2018		2019		2020		2021		2022 [Q1]				p-value
	n=430	%	n=2525	%	n=3403	%	n=3738	%	n=3716	%	n=5044	%	n=1106	%			
Age mean (SD), years	69.3	8.8	69.7	9.5	70.2	9.6	70.3	9.5	70.3	9.9	70.7	9.9	70.5	9.6	<0.001	70.3	9.7
Female	165	38.4	913	36.2	1191	35.0	1328	35.5	1310	35.3	1855	36.8	389	35.2	0.517	7151	35.8
Race																	
White	377	87.7	2274	90.1	3000	88.2	3324	88.9	3322	89.4	4464	88.6	976	88.3	0.223	17737	88.9
Black or African American	19	4.4	126	5.0	229	6.7	232	6.2	211	5.7	301	6.0	83	7.5	0.020	1201	6.0
Unknown/Other	16	3.7	85	3.4	116	3.4	125	3.3	129	3.5	184	3.7	29	2.6	0.790	684	3.4
Asian	9	2.1	28	1.1	47	1.4	37	1.0	39	1.0	49	1.0	12	1.1	0.271	221	1.1
American Indian / Alaskan Native	6	1.4	6	0.2	7	0.2	11	0.3	7	0.2	27	0.5	3	0.3	<0.001	67	0.3
More than 1 race	2	0.5	3	0.1	1	0.0	7	0.2	5	0.1	10	0.2	1	0.1	0.239	29	0.1
Native Hawaiian / Pacific Islander	1	0.2	2	0.1	3	0.1	1	0.0	2	0.1	6	0.1	1	0.1	0.691	16	0.1
Symptomatic*	223	53.7	1492	60.1	2115	63.4	2245	61.6	2332	64.0	3001	60.8	700	64.6	<0.001	12108	62.0
Stroke	134	31.7	948	37.9	1444	42.9	1549	41.9	1611	43.8	2180	43.6	485	44.1	<0.001	8351	42.2
Cortical TIA	73	17.4	492	19.7	627	18.7	665	18.1	661	18.0	805	16.2	199	18.3	0.009	3522	17.9
Amaurosis	37	8.8	194	7.8	267	8.0	247	6.7	276	7.5	296	6.0	73	6.7	0.004	1390	7.1
Vertebrobasilar or other	15	3.5	84	3.4	89	2.6	113	3.1	117	3.2	124	2.5	31	2.8	0.250	573	2.9
Prior ipsilateral carotid procedure	107	24.9	653	25.9	756	22.2	675	18.1	635	17.1	745	14.8	160	14.5	<0.001	3731	18.7
Prior contralateral carotid procedure	70	16.3	378	15.0	480	14.1	458	12.3	472	12.7	547	10.8	147	13.3	<0.001	2552	12.8
Anatomic high risk	206	48.4	1171	46.6	1456	43.3	1461	39.7	1476	40.1	1767	35.4	374	34.0	<0.001	7911	40.0
Medical high risk	148	34.7	920	36.6	1311	39.0	1446	39.3	1434	39.0	2005	40.2	466	42.3	0.008	7730	39.1
Both	47	11.0	309	12.3	429	12.8	452	12.3	456	12.4	598	12.0	139	12.6	0.931	2430	12.3
Standard risk**	119	27.9	733	29.1	1026	30.5	1229	33.4	1224	33.3	1815	36.4	400	36.3	<0.001	6546	33.1
CAD	200	47.1	1166	46.2	1482	43.6	1750	46.9	1705	45.9	2426	48.2	545	49.4	0.001	9274	46.5
CHF	80	18.6	462	18.3	589	17.3	610	16.3	616	16.6	817	16.2	210	19.0	0.086	3384	17.0
Prior coronary revascularization	171	39.8	971	38.5	1258	37.0	1388	37.1	1296	34.9	1798	35.6	447	40.4	0.003	7329	36.7
HTN	367	86.6	2247	89.1	3022	88.8	3335	89.3	3316	89.3	4532	89.9	990	89.6	0.423	17809	89.3
COPD	109	25.3	731	29.0	924	27.2	1025	27.4	937	25.2	1206	23.9	258	23.4	<0.001	5190	26.0
Oxygen	12	2.8	95	3.8	147	4.3	150	4.0	128	3.4	163	3.2	41	3.7	0.149	736	3.7
Diabetes	169	39.4	973	38.5	1322	38.9	1462	39.1	1477	39.8	2038	40.4	442	40.0	0.703	7883	39.5
CKD	27	6.3	166	6.6	212	6.2	247	6.6	220	5.9	301	6.0	70	6.3	0.851	1243	6.2
Smoking																	
Never	119	27.8	596	23.6	912	26.8	969	26.0	976	26.3	1451	28.8	291	26.4	<0.001	5314	26.7
Prior	118	27.6	727	28.8	921	27.1	1011	27.1	1037	27.9	1296	25.7	298	27.0	0.124	5408	27.1
Current	191	44.6	1199	47.5	1565	46.1	1750	46.9	1701	45.8	2293	45.5	513	46.6	0.629	9212	46.2
Obese	144	34.5	867	34.6	1208	35.7	1356	36.4	1347	36.5	1755	34.9	398	36.2	0.561	7075	35.6
Preop medications																	
Aspirin	376	87.4	2172	86.0	2956	86.9	3225	86.3	3172	85.4	4294	85.2	927	83.9	0.110	17122	85.8
P2Y12 inhibitor	335	78.1	1935	76.7	2602	76.5	2933	78.5	2873	77.4	3904	77.5	859	77.7	0.527	15441	77.4
DAPT	305	71.1	1756	69.6	2396	70.4	2686	71.9	2626	70.8	3541	70.3	770	69.7	0.533	14080	70.6
Statin	353	82.1	2069	82.0	2832	83.3	3118	83.5	3157	85.1	4215	83.6	946	85.6	0.020	16690	83.7
Beta-blocker	230	53.6	1393	55.3	1775	52.2	1983	53.1	1892	51.0	2627	52.1	563	51.0	0.042	10463	52.5
Anticoagulation	53	12.4	292	11.6	440	12.9	497	13.3	540	14.6	762	15.1	191	17.3	<0.001	2775	13.9
ACE inhibitor	226	52.7	1287	51.0	1709	50.2	1788	47.9	1831	49.4	2542	50.4	532	48.2	0.094	9915	49.7
Preop functional status																	
Independent	400	96.4	2408	96.0	3202	95.5	3561	95.8	3533	95.6	4801	95.5	1065	96.4	0.764	18970	95.7
Assist required	14	3.4	96	3.8	149	4.4	148	4.0	149	4.0	216	4.3	37	3.3	0.637	809	4.1
Unable to get out of bed	1	0.2	4	0.2	3	0.1	7	0.2	13	0.4	9	0.2	3	0.3	0.329	40	0.2
Urgency																	
Elective	335	77.9	1937	76.7	2596	76.3	2796	74.8	2669	71.9	3679	73.0	795	71.9	<0.001	14807	74.2
Urgent	80	18.6	494	19.6	668	19.6	771	20.6	837	22.5	1094	21.7	249	22.5	0.009	4193	21.0
Emergent	15	3.5	93	3.7	139	4.1	169	4.5	208	5.6	269	5.3	62	5.6	0.001	955	4.8
General Anesthesia	68	15.8	416	16.5	577	17.0	791	21.2	852	22.9	1124	22.3	247	22.3	<0.001	4075	20.4
Intraoperative heparin	384	96.7	2383	96.7	3282	96.6	3614	97.2	3585	96.8	4839	96.1	1059	95.8	0.131	19146	95.9
Intraoperative protamine	46	13.2	341	15.8	466	16.0	509	15.8	505	15.4	579	13.3	118	12.5	0.002	2564	14.9

* Patients may have more than one symptomatic subtype upon presentation.

** Patients with neither anatomic or medical high risk criteria.

SD: Standard deviation; TCAR, transcatheter carotid artery revascularization ;TF-CAS, transfemoral carotid artery stenting; TIA, transient ischemic attack; Anatomic / Medical high risk as defined by the Centers for Medicare and Medicaid Services; CAD, coronary artery disease; CHF, congestive heart failure; HTN, hypertension; COPD, chronic obstructive pulmonary disease; CKD, chronic kidney disease defined as creatinine >1.7 mg/dL; DAPT, dual antiplatelet therapy, and ACE, Angiotensin-converting enzyme.

Table S2: Characteristics of patients who underwent CEA by year and overall.

Variable	Year		2016		2017		2018		2019		2020		2021		2022 [Q1]		p-value	Totals	
	n=15957	%	n=17624	%	n=18194	%	n=19213	%	n=16656	%	n=18397	%	n=4091	%	n=110,132	%			
Age mean (SD), years	70.4	9.5	70.7	9.6	70.7	9.5	70.8	9.4	70.9	9.2	70.9	9.4	71.0	9.0	<0.001	70.7	9.4		
Female	6320	39.6	6877	39.0	7302	40.1	7531	39.2	6473	38.9	7128	38.7	1628	39.8	0.097	43259	39.3		
Race																			
White	14466	90.7	15858	90.0	16234	89.3	17059	88.8	14840	89.1	16422	89.3	3661	89.6	<0.001	98540	89.5		
Black or African American	802	5.0	862	4.9	871	4.8	892	4.6	771	4.6	884	4.8	200	4.9	0.641	5282	4.8		
Unknown/Other	411	2.6	628	3.6	794	4.4	941	4.9	772	4.6	773	4.2	139	3.4	<0.001	4458	4.0		
Asian	192	1.2	189	1.1	205	1.1	217	1.1	163	1.0	199	1.1	50	1.2	0.570	1215	1.1		
American Indian / Alaskan																			
Native	49	0.3	34	0.2	39	0.2	52	0.3	55	0.3	65	0.4	16	0.4	0.022	310	0.3		
More than 1 race	25	0.2	23	0.1	29	0.2	25	0.1	24	0.1	36	0.2	20	0.5	<0.001	182	0.2		
Native Hawaiian / Pacific Islander	9	0.1	18	0.1	16	0.1	15	0.1	22	0.1	7	0.0	2	0.0	0.053	89	0.1		
Symptomatic*	5374	33.7	6038	34.3	6288	34.6	6806	35.5	6558	39.5	7103	38.7	1598	39.2	<0.001	39765	36.2		
Stroke	2583	16.2	3173	18.0	3477	19.1	3733	19.5	3707	22.3	4116	22.4	933	22.9	<0.001	21722	19.8		
Cortical TIA	1501	9.4	1564	8.9	1530	8.4	1727	9.0	1558	9.4	1665	9.1	373	9.1	0.029	9918	9.0		
Amaurosis	1218	7.6	1233	7.0	1212	6.7	1224	6.4	1213	7.3	1221	6.7	280	6.9	<0.001	7601	6.9		
Vertebrobasilar or other	388	2.4	371	2.1	365	2.0	450	2.3	417	2.5	465	2.5	85	2.1	0.003	2541	2.3		
Prior ipsilateral carotid procedure	330	2.1	361	2.0	326	1.8	294	1.5	278	1.7	259	1.4	49	1.2	<0.001	1897	1.7		
Prior contralateral carotid procedure	2221	13.9	2372	13.5	2503	13.8	2624	13.7	2161	13.0	2402	13.1	509	12.4	0.025	14792	13.4		
Anatomic high risk	791	5.0	763	4.3	731	4.0	695	3.6	595	3.6	582	3.2	116	2.8	<0.001	4273	3.9		
Standard risk**	11298	70.8	12465	70.7	13129	72.2	14094	73.4	12063	72.4	13587	73.9	3026	74.0	<0.001	79662	72.3		
CAD	4291	26.9	4857	27.6	4728	26.0	4925	25.6	4305	25.9	4814	26.2	1066	26.1	<0.001	28986	26.3		
CHF	1809	11.3	2010	11.4	2025	11.1	2265	11.8	2013	12.1	2345	12.8	490	12.0	<0.001	12957	11.8		
Prior coronary revascularization	5548	34.8	6195	35.2	6151	33.8	6484	33.7	5541	33.3	6053	32.9	1269	31.0	<0.001	37241	33.8		
HTN	14208	89.1	15741	89.4	16219	89.3	17150	89.6	14965	90.0	16701	90.8	3705	90.6	<0.001	98689	89.7		
COPD	3674	23.0	4124	23.4	4306	23.7	4483	23.3	3738	22.5	4148	22.6	955	23.4	0.063	25428	23.1		
Oxygen	343	2.2	385	2.2	393	2.2	449	2.3	362	2.2	382	2.1	78	1.9	0.590	2392	2.2		
Diabetes	5717	35.8	6450	36.6	6625	36.4	7092	36.9	6103	36.7	6862	37.3	1565	38.3	0.037	40414	36.7		
CKD	903	5.7	975	5.5	996	5.5	1004	5.2	886	5.3	1018	5.5	222	5.4	0.638	6004	5.5		
Smoking																			
Never	4010	25.1	4509	25.6	4665	25.7	5117	26.6	4429	26.6	4976	27.1	1112	27.2	<0.001	28818	26.2		
Prior	4089	25.6	4405	25.0	4573	25.1	4741	24.7	4174	25.1	4717	25.6	1067	26.1	0.206	27766	25.2		
Current	7848	49.2	8703	49.4	8949	49.2	9350	48.7	8033	48.3	8700	47.3	1912	46.7	<0.001	53495	48.6		
Obese	5514	34.6	6152	34.9	6199	34.2	6630	34.6	5771	34.7	6319	34.4	1391	34.1	0.777	37976	34.5		
Preop medications																			
Aspirin	13272	83.2	14819	84.1	15390	84.6	16207	84.4	14099	84.7	15437	84.1	3436	84.5	0.005	92660	84.2		

P2Y12 inhibitor	5284	33.1	6120	34.7	6642	36.5	7247	37.7	6819	41.0	7657	41.7	1682	41.3	<0.001	41451	37.7
DAPT	4350	27.3	5094	28.9	5658	31.1	6146	32.0	5834	35.0	6569	35.8	1462	35.9	<0.001	35113	31.9
Statin	13183	82.6	14728	83.6	15482	85.1	16578	86.3	14625	87.9	15960	86.9	3577	88.0	<0.001	94133	85.5
Beta-blocker	8830	55.4	9537	54.1	9788	53.8	10431	54.3	8962	53.8	9747	53.1	2110	51.9	<0.001	59405	54.0
Anticoagulation	1119	7.0	1306	7.4	1206	6.6	1308	6.8	996	6.0	997	5.4	262	6.4	<0.001	7194	6.5
ACE inhibitor	8471	53.1	9368	53.2	9738	53.6	10306	53.7	8835	53.1	9933	54.1	2242	55.1	0.120	58893	53.5
Preop functional status																	
Independent	15741	98.7	17354	98.5	17935	98.8	18957	98.7	16450	98.9	18133	98.7	4033	98.7	0.132	108603	98.7
Assist required	197	1.2	246	1.4	218	1.2	231	1.2	168	1.0	235	1.3	47	1.2	0.075	1342	1.2
Unable to get out of bed	10	0.1	12	0.1	8	0.0	15	0.1	14	0.1	10	0.1	6	0.1	0.345	75	0.1
Urgency																	
Elective	13974	87.6	15493	87.9	15838	87.1	16610	86.5	14040	84.3	15689	85.3	3421	83.6	<0.001	95065	86.3
Urgent	1891	11.9	2030	11.5	2236	12.3	2488	13.0	2532	15.2	2630	14.3	648	15.8	<0.001	14455	13.1
Emergent	87	0.5	100	0.6	117	0.6	113	0.6	82	0.5	75	0.4	22	0.5	0.078	596	0.5
General Anesthesia	14630	91.7	16263	92.3	16876	92.8	17970	93.5	15610	93.7	17442	94.8	3903	95.4	<0.001	102694	93.3
Intraoperative heparin	15807	99.1	17459	99.1	18014	99.0	19066	99.3	16516	99.2	18200	98.9	4063	99.3	0.032	109125	99.1
Intraoperative protamine	11338	71.1	12572	71.3	13065	71.8	14001	72.9	12654	76.0	14406	78.3	3316	81.1	<0.001	81352	73.9

* Patients may have more than one symptomatic subtype upon presentation. ** Patients with neither anatomic or medical high risk criteria.

SD: Standard deviation; TCAR, transcarotid artery revascularization; TIA, transient ischemic attack; Anatomic high risk as defined by the Centers for Medicare and Medicaid Services; CAD, coronary artery disease; CHF, congestive heart failure; HTN, hypertension; COPD, chronic obstructive pulmonary disease; CKD, chronic kidney disease defined as creatinine >1.7 mg/dL; DAPT, dual antiplatelet therapy; ACE, Angiotensin-converting enzyme.

Table S3: TCAR uptake over time by region of the United States.

Number of patients receiving TCAR by region

Region	2016	2017	2018	2019	2020	2021	2022	Total
East	55	408	863	1521	1884	2446	550	7727
North	36	308	824	1829	1964	2288	536	7785
South	14	389	1355	2314	2705	3482	882	11141
West	26	272	537	955	1156	1484	364	4794

Number of centers providing TCAR by region

Region	2016	2017	2018	2019	2020	2021	2022	Total
East	14	42	69	94	123	134	109	153
North	6	24	60	103	120	138	117	158
South	6	39	74	108	139	173	140	195
West	3	17	36	55	70	87	66	100

Table S4: Percent of carotid revascularization procedures that were TCAR in 2021/2022 stratified by TF-CAS use in 2015, determining whether centers who use TF-CAS more frequently were also more or less likely to utilize TCAR over time.

Weighted by volume

TF-CAS 2015	N patients	TCAR 2021-2022 Mean [range]
0-10%	31924	20.8% [8.6 – 36.6]
10-20%	21829	18.7% [9.1 – 26.6]
20-40%	18181	20.2% [13.2 – 32.1]
40%-100%	2871	12.5% [6.9 – 13.5]

Unweighted

TF-CAS 2015	N Centers	TCAR 2021-2022 Mean [range]
0-10%	94	21.0% [10.3 – 40.0]
10-20%	33	18.6% [9.3 – 27.5]
20-40%	36	20.3% [12.4 – 31.3]
40%-100%	9	12.7% [0.0 – 13.5]

Table S5: Risk of in-hospital stroke or death after TCAR when stratified by proceduralist- or center-level annual TCAR volume.

	Proceduralist (TCAR)	Site (TCAR)
<11	272 (1.89%)	108 (1.91%)
11-20	136 (1.47%)	153 (1.90%)
>20	115 (1.47%)	162 (1.46%)
p-Value -unadjusted	0.0136	0.0066
p-Value – adjusted for center	0.0031	0.1700
p-Value – fully adjusted	0.0005	0.0660