Title

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IP203

Using Machine Learning to Predict Outcomes Following Carotid Artery Stenting

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Objectives: Carotid artery stenting (CAS) carries important perioperative risks. Outcome prediction tools may help guide clinical decision-making but remain limited. We developed machine learning (ML) algorithms that predict 30-day outcomes following transfemoral CAS.

Methods: The National Surgical Quality Improvement Program (NSQIP) targeted vascular database was used to identify patients who underwent transfemoral CAS between 2011-2021. Input features included 36 preoperative demographic/clinical variables. The primary outcome was 30-day major adverse cardiovascular event (composite of stroke, myocardial infarction [MI], or death). The secondary outcomes were 30-day stroke, MI, death, carotid-related morbidity, other morbidity, non-home discharge, and unplanned readmission. Our data were split into training (70%) and test (30%) sets. Using 10-fold cross-validation, we trained six ML models using pre-operative features (Extreme Gradient Boosting [XGBoost], random forest, Naïve Bayes classifier, support vector machine, artificial neural network, and logistic regression). The primary model evaluation metric was area under the receiver operating characteristic curve (AUROC). Model robustness was evaluated with calibration plot and Brier score. Variable importance scores were calculated to determine the top 10 predictive features. Performance was assessed on subgroups based on age, sex, race, ethnicity, symptom status, stent type, and urgency.

Results: Overall, 2,093 patients underwent transfemoral CAS during the study period. Thirty-day MACE occurred in 130 (6.2%) patients. The best performing prediction model for 30-day MACE was XGBoost, achieving an AUROC (95% CI) of 0.93 (0.92-0.94) (Fig 1). In comparison, logistic regression had an AUROC (95% CI) of 0.67 (0.65-0.68) and existing tools in the literature demonstrate AUROCs ranging from 0.58-0.74. For secondary outcomes, XGBoost achieved AUROCs between 0.86-0.97. The calibration plot showed good agreement between predicted and observed event probabilities with a Brier score of 0.02 (Fig 2). The top three predictive features in our algorithm were: (1) symptomatic carotid stenosis, (2) age, and (3) American Society of Anesthesiologists classification. Model performance remained robust across demographic and clinical subpopulations.

Conclusions: Our ML models accurately predict 30-day outcomes following transfemoral CAS using preoperative data, performing better than logistic regression and existing tools. They have potential for important utility in guiding risk mitigation strategies for patients being considered for transfemoral CAS to improve outcomes.

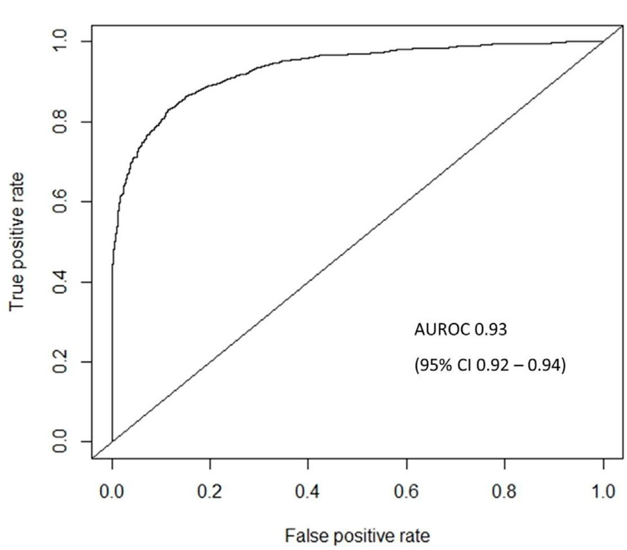

Fig 1. Receiver operating characteristic curve for predicting 30-day major adverse cardiovascular events following carotid artery stenting using Extreme Gradient Boosting (XGBoost) model. *AUROC*, Area under the receiver operating characteristic curve; *CI*, confidence interval.

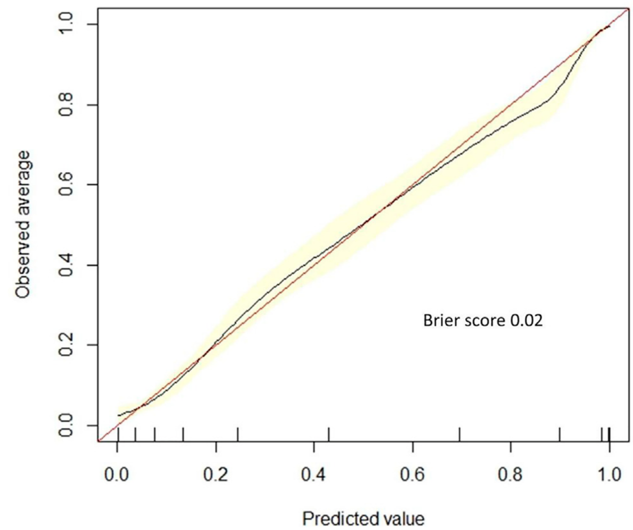

Fig 2. Calibration plot with Brier score for predicting 30-day major adverse cardiovascular events following carotid artery stenting using Extreme Gradient Boosting (XGBoost) model.

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IP205

The Impact of Postoperative Stroke and Myocardial Infarction on 1-Year Mortality Following Carotid Revascularization Using the VQI Database

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Objectives: Postoperative stroke and myocaradial infarction (MI) are associated with devastating postoperative morbidity and mortality, therefore limiting the protective effect of carotid revascularization procedures. Moreover, there seems to be a relation between the severity of stroke and MI and the type of carotid revascularization technique. We aim to investigate the impact of in-hospital stroke or MI on 1-year mortality following carotid endarterectomy (CEA), transfemoral carotid artery stenting (TFCAS), and transcarotid artery revascularization (TCAR).

Methods: This is a retrospective analysis of patients undergoing CEA, TFCAS, and TCAR in the VQI database (2016–2023). Our primary outcome is 1-year mortality in patients who developed in-hospital stroke or MI following carotid revascularization. Kaplan-Meier survival estimate, and multivariable Cox regression analysis were applied to calculate hazard ratios (HRs) after adjusting for potential confounders. Additionally, we conducted sub- analyses based on patients' symptomatic status.

Results: Our study included 125,657 (62%) CEA, 25,529 (12.6%) TFCAS, and 51,567 (25.4%) TCAR. The hazards of 1-year mortality after in-hospital stroke

Table. Adjusted hazard ratios (aHRs) for 1-year mortality after in-hospital stroke or in-hospital MI following carotid revascularization

	CEA		TFCAS		TCAR	
	Stroke vs no stroke		Stroke vs no stroke		Stroke vs no stroke	
	aHR (95% CI)	*P*-value	aHR (95% CI)	*P*-value	aHR (95% CI)	*P*-value
All patients	5.9 (5.1-6.8)	<.001	4.2 (3.7-5.3)	<.001	5.2 (4.1-6.5)	<.001
Symptomatic	4.9 (3.9-6)	<.001	4.3 (3.1-5.7)	<.001	4 (2.9-5.6)	<.001
Asymptomatic	7.1 (5.8-8.8)	<.001	4 (2.7-5.8)	<.001	6.8 (5-9.1)	<.001
	MI vs no MI		MI vs no MI		MI vs no MI	
	aHR (95% CI)	*P*-value	aHR (95% CI)	*P*-value	aHR (95% CI)	*P*-value
All patients	3.8 (3.1-4.6)	<.001	3.5 (2.3-5.5)	<.001	5.1 (3.6-7.2)	<.001
Symptomatic	3 (2.2-4.1)	<.001	4.2 (2.6-6.7)	<.001	4.9 (3-8.1)	<.001
Asymptomatic	4.5 (3.5-5.6)	<.001	2.4 (0.9-6.5)	.098	5.1 (3.3-8.1)	<.001
	TCAR vs CEA (CEA is ref.)		TFCAS vs CEA (CEA is ref.)		TCAR vs TFCAS (TFCAS is ref.)	
After in-hospital Stroke	aHR (95% CI)	*P*-value	aHR (95% CI)	*P*-value	aHR (95% CI)	*P*-value
All patients	0.93 (0.73-1.2)	.55	1.5 (1.1-2.1)	.003	0.7 (0.55-0.94)	.015
Symptomatic	1.1 (0.7-1.5)	.81	1.7 (1.1-2.5)	.013	0.6 (0.34-0.85)	.004
Asymptomatic	0.8 (0.6-1.3)	.3	1.3 (0.8-2)	.3	0.95 (0.6-1.5)	.82
After in-hospital MI	aHR (95% CI)	*P*-value	aHR (95% CI)	*P*-value	aHR (95% CI)	*P*-value
All patients	1.4 (0.9-2.3)	.1	2.3 (1.2-4.2)	.007	0.7 (0.36-1.5)	.3
Symptomatic	1.6 (0.93-3.5)	.2	3.9 (1.8-8.3)	<.001	0.6 (0.2-0.9)	.116
Asymptomatic	1 (0.6-1.8)	.9	0.95 (0.3-2.7)	.9	1.6 (0.5-4)	.3

*Adjusting for the following confounders: age, gender, race, ethnicity, obesity, dialysis, diabetes, hypertension, smoking, CAD, prior CHF, COPD, CABG/PCI, prior contralateral CEA/CAS, ipsilateral occlusion, prior ipsilateral CEA/CAS, procedure urgency, anesthesia, ASA class, preoperative medications, insurance.

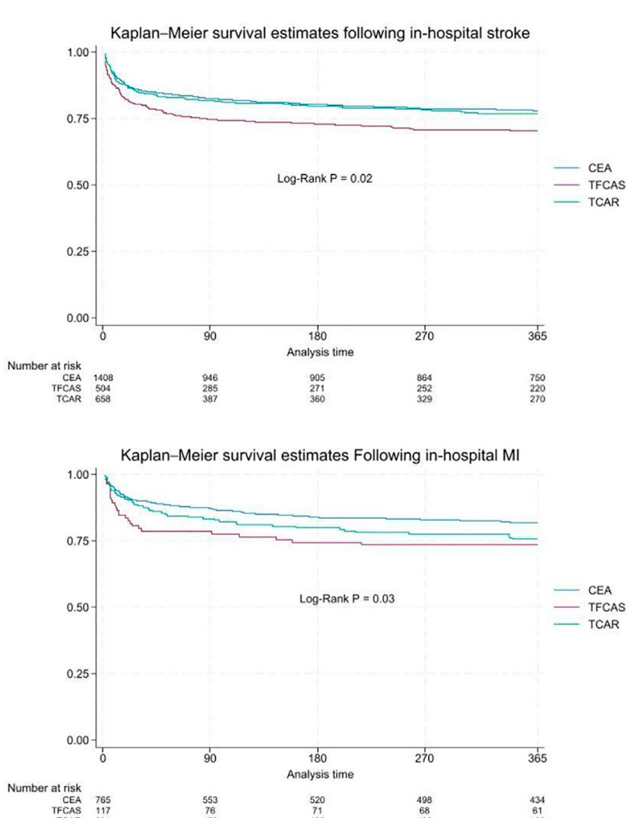

Fig.

were higher following CEA (aHR, 5.9; 95% CI, 5.1-6.8; *P* < .001), TFCAS (aHR, 4.2; 95% CI, 3.7-5.3; *P* < .001), and TCAR (aHR, 5.2; 95% CI, 4.1-6.5; *P* < .001). The hazards of 1-year mortality after in-hospital MI were also higher following CEA (aHR, 3.8; 95% CI, 3.1-4.6; *P* < .001), TFCAS (aHR, 3.5; 95% CI, 2.3-5.5; *P* < .001), and TCAR (aHR, 5.1; 95% CI, 3.6-7.2; *P* < .001) (Table). This trend persisted in sub-analysis based on symptomatic status. At 1-year, TFCAS showed the lowest survival following in-hospital stroke or MI (Fig). Among patients who developed in-hospital stroke, there was no significant difference in 1-year mortality between TCAR and CEA (aHR, 0.93; 95% CI, 0.73-1.2; *P* = .55). Conversely, TFCAS was associated with a 50% higher hazard than CEA (aHR, 1.5; 95% CI, 1.1-2.1; *P* = .003). TCAR was associated with 30% reduction in this hazard compared to TFCAS (aHR, 0.7; 95% CI, 0.55-0.94; *P* = .015). Among patients who developed in-hospital MI, no significant difference was found between TCAR and CEA. However, TFCAS was associated with more than double the hazard of 1-year mortality compared to CEA (aHR, 2.3; 95% CI, 1.2-4.2; *P* = .007) (Table).

Conclusions: This large multicenter study reveals critical insights into the impact of in- hospital major adverse events on 1-year survival following carotid revascularization. The analysis indicates a significant increase in the hazards of 1-year mortality following in- hospital stroke and MI. In patients who developed in-hospital stroke or MI, there was no significant difference in 1-year survival between TCAR and CEA. On the contrary, TFCAS was associated with significant higher mortality compared to CEA, indicating worse stroke or MI initially. On the other hand, TCAR was associated with better survival compared to TFCAS. The study highlights the importance of appropriate revascularization method selection to improve 1-year survival.

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IP207

Outcomes of Redo vs Primary Carotid Endarterectomy in the TCAR Era

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