Semi-Automated Software Analysis of CT Scans Can Determine Carotid Plaque Morphology

Rohini J. Patel, MD, MPH; Mahmoud B. Malas, MD, MHS
Division of Vascular Surgery, Department of Surgery, University of California San Diego School of Medicine
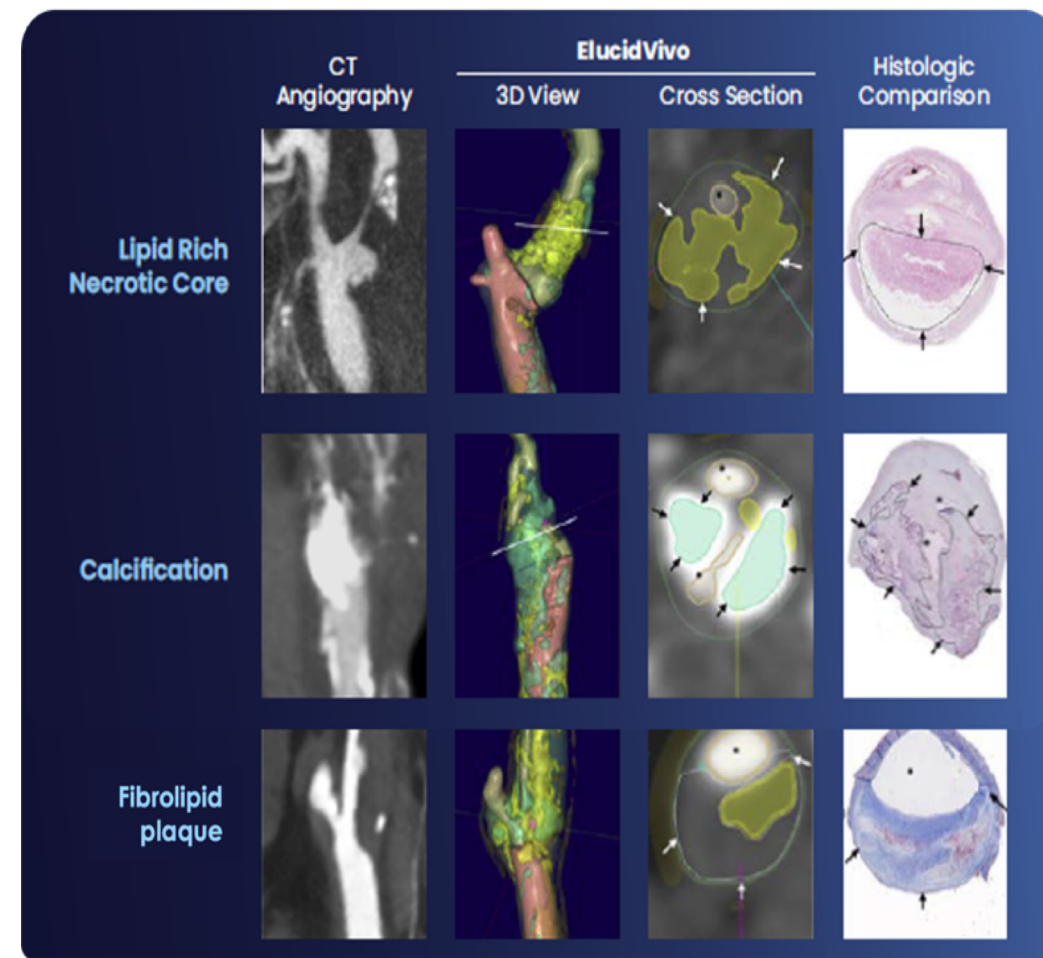
UC San Diego
SCHOOL OF MEDICINE

Background

- Gold standard for carotid artery stenosis: NASCET using carotid duplex criteria
- Few studies have assessed plaque morphology as an additive tool for stroke prediction
- Multiple studies have shown that stenosis alone is not a sensitive marker for stroke prediction
- Simultaneous evaluation of plaque morphology and geometry can lead to better risk stratification
- Supplemental software employing artificial intelligence (AI) for the assessment of atherosclerotic plaque is an emerging technology to improve the diagnostic and prognostic abilities of radiologic imaging with precise decision-making algorithms
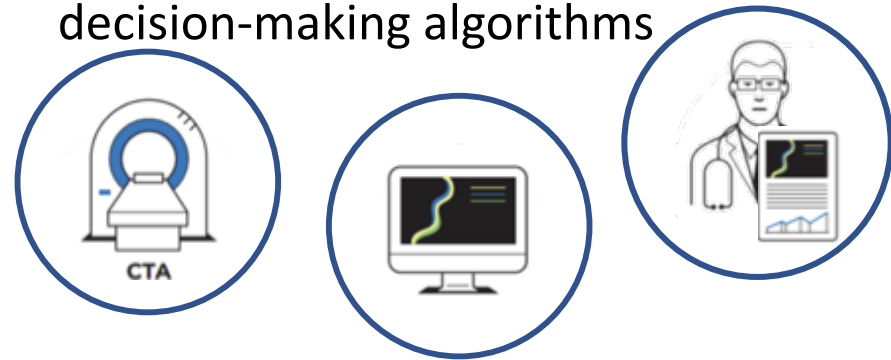
Objective

- Our study uses an AI software in conjunction with a patient's computed tomography angiography (CTA) scan of the neck to create a 3D model of the carotid artery and assess plaque morphology including the volumes of calcification, intraplaque hemorrhage, matrix, and perivascular adipose tissue
- Our goal was to create a predictive model and risk score inclusive of plaque morphology

Methods

- Retrospective review of a single tertiary institution
- 2010 to 2021
- Inclusion Criteria: CT angiography head/neck and diagnosis of carotid artery stenosis
- Dataset divided into two separate training and test sets
- Each scan was run through a third-party software to create a 3D image for plaque visibility and analysis
- A stepwise backward regression to select variables for inclusion in our prediction models
- Model discrimination was assessed with receiver operating characteristic curves (AUC) and the discrimination slope
- Calibration was performed and the model with the least Akaike Information Criterion (AIC) was selected
- The risk score was modeled from the Framingham Study
- Primary outcome was all cause mortality and stroke

Results

- Training Set: n=243 (50.1%)
- Test Set: n=242 (49.9%)
- No significant difference in demographic, risk factors, or plaque morphology software variables

Risk Score

RISK FACTOR	Patient A Example*	Patient B Example**
Age	3	0
Sex	0	3
Stroke History	0	0
TIA History	0	0
BMI Category	-1	-6
COPD History	0	0
Hyperlipidemia	0	0
Matrix	1	0
Perivascular Adipose Tissue	1	0
Lipid Rich Necrotic Core	0	-1
TOTAL SCORE	4	-4
Predicted Mortality/Stroke	30.4%	<1.0%

*74M with history of diabetes, former smokers, normal weight, without previous TIA/stroke, and over 75th percentile matrix, PVAT
**60F with history of HTN, former smoker, overweight, without previous TIA/stroke and over 75th percentile LRNC
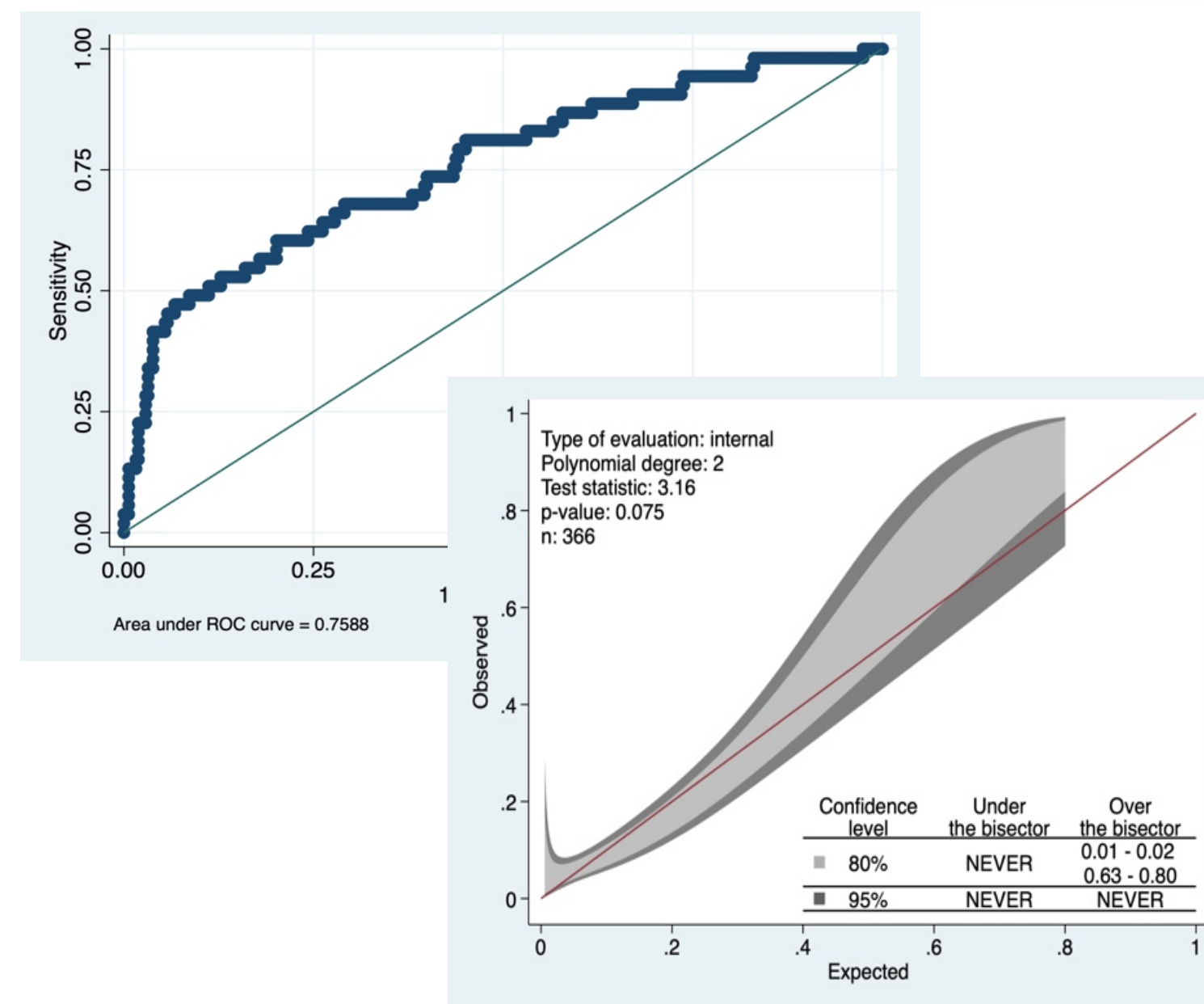
Model: Clinical & Plaque Morphology Variables

Age, Sex, Matrix Volume, History of TIA/Stroke, BMI, Perivascular Adipose Tissue, Lipid Rich Necrotic Core, COPD and HLD
AUC of 0.759 and the least AIC of 277.6

Risk Factors	Categories	Points
Age	≤60 years	0
	>60-70 years	2
	>70-80 years	3
	>80 years	16
Sex	Male	0
	Female	3
Stroke History	No	0
	Yes	4
TIA History	No	0
	Yes	3
Body Mass Index	Underweight (<18.5)	0
	Normal (18.5 to <25)	-1
	Overweight (25 to <30)	-6
	Obese (≥30 kg/m²)	-10
COPD History	No	0
	Yes	6
Hyperlipidemia	No	0
	Yes	-2
Matrix	≤75th percentile	0
	>75th percentile	1
Perivascular Adipose Tissue	≤75th percentile	0
	>75th percentile	1
Lipid Rich Necrotic Core	≤75th percentile	0
	>75th percentile	-1

Conclusion

- Largest single institution study looking at plaque morphology and semiautomated software data extraction
- Models demonstrate that combining both clinical factors and plaque morphology creates the best model to predict a patient's risk for all-cause mortality and stroke
- Goal: externally validate tool in order to use the semiautomated software to identify patients with high-risk plaque or even track plaque progression and regression with treatment