Quantitative Image Analysis:

Use of Siemens i-flow Technology
AI guided carotid stenosis evaluation

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Disclosures

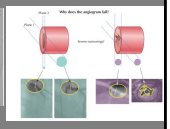
- Medtronic, inc
  compensation for education, speaking

- Cook, inc
  compensation for training

-Gore, inc
  compensation for education, speaking

-Haemonetics, inc.
  scientific advisory board

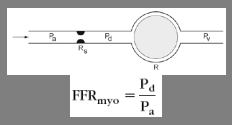
Qualitative and Inadequate Analysis of Vascular Lesions



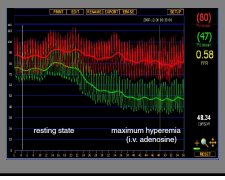
Hemodynamic Features
- Flow reversal
- Volume
- Velocity
- Wall shear stress
- Energy loss
- Pressure gradient

- Lack of Quantitative Analysis of Lesion Severity
- Qualitative measures of lesion severity
- Rely on 2-D angiograms
- No physiologic measurement
- When is the lesion "adequately treated"

Coronary Interventions



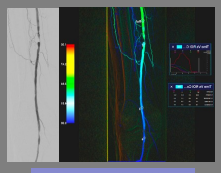
$$FFR_{myo} = \frac{P_d}{P_a}$$



- FFR-quantitative measure of lesion severity
- Clinically useful
- Can effectively analyze data and interventions
- Standardized to allow comparative studies

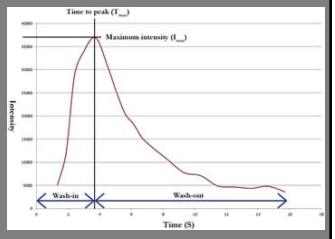
Quantitative Analysis of Vascular Lesions

- IVUS
- Fluorescence
- FFR
- Siemens i-Flow
- CTA



What Is *i-flow*?

- Parametric color coding of each pixel in DSA
- Time delay from injection to opacification
- Generates TAC
- Can be used in "real time" to guide intervention
- Calculate decay of contrast and TTP in specific region of interest



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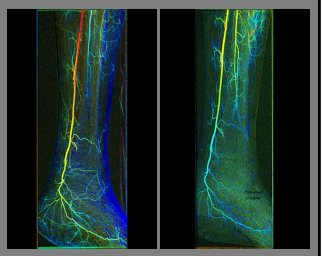
Siemens *I-flow* Offers Assessment of Flow Characteristics

- Use available DSA images without additional radiation and contrast agent
- Evaluation of inflow and outflow in individual selectable regions
- Visualize effectiveness during treatment



Calculate TTP and Decay of Contrast in Specific Region of Interest

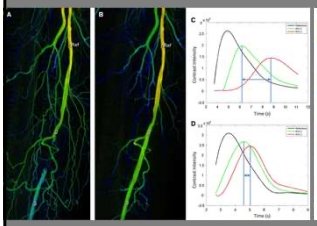


Table 2. Pre- and post-intervention parameters.

	Pre-intervention (n=47)	Post-intervention (n=47)	p value
Decay time ± SD, s			
$T_{80\%}$	1.03±0.62	0.31±0.19	<.001
$T_{80\%}$	1.68±0.9	0.57±0.21	<.001
$T_{70\%}$	2.24±1.17	0.7±0.22	<.001
$T_{60\%}$	2.53±1.22	0.76±0.16	<.001
$T_{50\%}$	2.89±1.31	0.82±0.14	<.001
Decay intensity ± SD (%)			
I_{1s}	13.66±0.11	31.38±19.32	<.001
I_{2s}	31.09±17.08	57.15±20.65	<.001
I_{3s}	45.38±18.1	69.96±21.89	<.001
I_{4s}	53.58±19.5	76.29±15.6	<.001
I_{5s}	52.18±23.45	82.1±13.74	.02
AUC	2.81±0.9	2.05±0.82	<.001
ABI/TBI	0.33±0.26	0.62±0.28	<.001

ABI/TBI = ankle brachial index/toe brachial index; AUC = area under curve; SD = standard deviation.

Cardiovasc Intervent Radiol. 2017 Aug;40(8):1147-1154.

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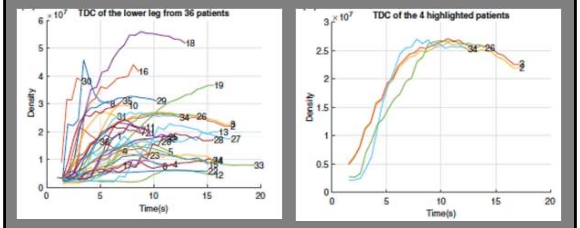
Flow Patterns Can Vary



•Similar DSA images
•Similar ABI pre-procedure

Vascular 29(3)

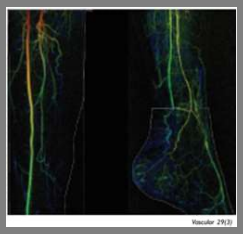
Limitations and Validation

Standardize contrast administration and image acquisition

Longer follow-up

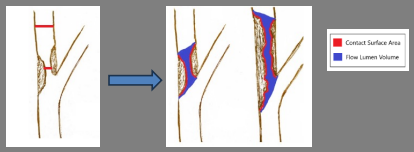
Determine which parameter is most predictive of which outcome (TLR, amputation etc)

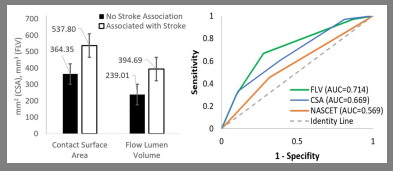
Prospective data needed



Vascular 29(3)

Improved Risk Stratification of Carotid Lesions



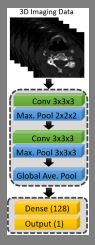


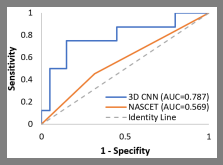
(Left) Increased plaque contact surface area (CSA) and flow lumen volume (FLV) in carotid arteries are associated with stroke. (Right) ROC curves suggest that FLV and CSA both outperform NASCET criteria as predictors of stroke.

Improved Risk Stratification of Carotid Lesions

Test the hypothesis that 3D imaging and patient medical data together can provide information for accurate prediction of stroke risk

Preliminary Data





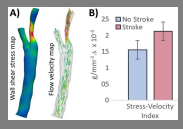
Feasibility of applying 3D CNN to our data and showed the proof of concept that relevant anatomic features can be extracted by a deep learning framework towards stroke prediction.

- 111 training dataset
- 28 cross-validation dataset

Auto Segmentation and Clinical Compatibility

Patient	Bifurcation		End of plaque		Right or Left	CSA	Lumen Volume	Thrombus Volume	Calcification Volume
	N°slice	z	N°slice	z		mm2	mm3		
1	234	195.8	274	215.8	L	195	498.7	669.9	NA
2	244	931.8	288	953.8	L	136	486.8	NA	297.3
3	207	1342	223	1351	R	29	62.53	39.73	132.7
4	251	945.5	302	971	L	225	292.6	382.3	237
5	335	1112	348	1118	R	44	152.4	26.55	141.7
6	366	1115	428	1140	R	124	257	81.8	360.9
7	No Seg								
8	241	949.2	252	955.8	R	25	17.42	66.87	3.74
9	279	1115	299	1127	R	150	165.3	355	36.41
10	283	161.1	306	174.9	L	122	203.2	363.8	44.96
11	212	154.3	220	159.1	R	64	58.23	NA	126.7
12	254	1156	262	1161	R	36	42.6	131.8	24.44

Hemodynamic Features Identified



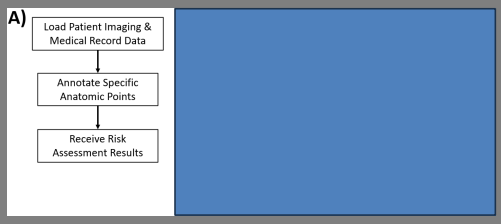
A) Example CFD simulation results from one patient case, **B)** Preliminary analysis in 13 patients suggests discriminating potentials of a hemodynamic indicator.

"stress-velocity index" spatially averaged wall shear stress magnitude divided by the spatially averaged velocity magnitude

Adding hemodynamics-based input information in an AI algorithm can improve stroke prediction accuracy

Automated and Quantitated Lesion and Treatment Analysis

Create automation software and user interface compatible with clinical translation



A) What the user sees, B) Workflow of the automation software under the hood (transparent to the user). Task 3.1 will involve developing the workflow on the left column where Task 3.2 will add the components on the right