



T2 Relaxometry Based CSF Fraction (CSFF) Mapping is a Better Biomarker for Brain Drainage Pathology Than DTI-based Free Water (DTI-FW) Mapping

Liangdong Zhou, Thanh Nguyen, Yi Li

Radiology, Weill Cornell Medicine, New York, NY, United States



Declaration of Financial Interests or Relationships

Speaker Name: Liangdong Zhou

I have no financial interests or relationships to disclose with regard to the subject matter of this presentation.



Hypothesis

- The perivascular space (PVS) is filled with cerebrospinal fluid (CSF)-like free water.
- PVS plays a role of pathway for the clearance of metabolites. Enlarged PVS due to blockage of CSF will damage the clearance function.
- CSF fraction map measured by T2-relaxometry is a biomarker of PVS. DTI-FW contains more than CSF free water.



Methods: T_2 relaxometry based water mapping (CSFF)

- The total water in the brain was modeled as a three-compartment model:

$$S(TE) = A_{my}e^{-TE/T_{2,my}} + A_{ie}e^{-TE/T_{2,ie}} + A_{csf}e^{-TE/T_{2,csf}}. \quad [1]$$

where A_{my} , A_{ie} , A_{csf} are components for myelin, intro-extra, and CSF water.

- Data fitting can be done using nonlinear least square:

$$\mathbf{x} = \operatorname{argmin}_{\mathbf{x}} \sum_{n=1}^N \|S(\mathbf{x}, TE_n) - S_{measure}^n\|_2^2 + \lambda \|\nabla_s \mathbf{x}\|_2^2 \quad [2]$$

- The free water (cerebrospinal fluid fraction, CSFF) is defined as:

$$CSFF = A_{csf} / (A_{my} + A_{ie} + A_{csf}) * 100. \quad [3]$$

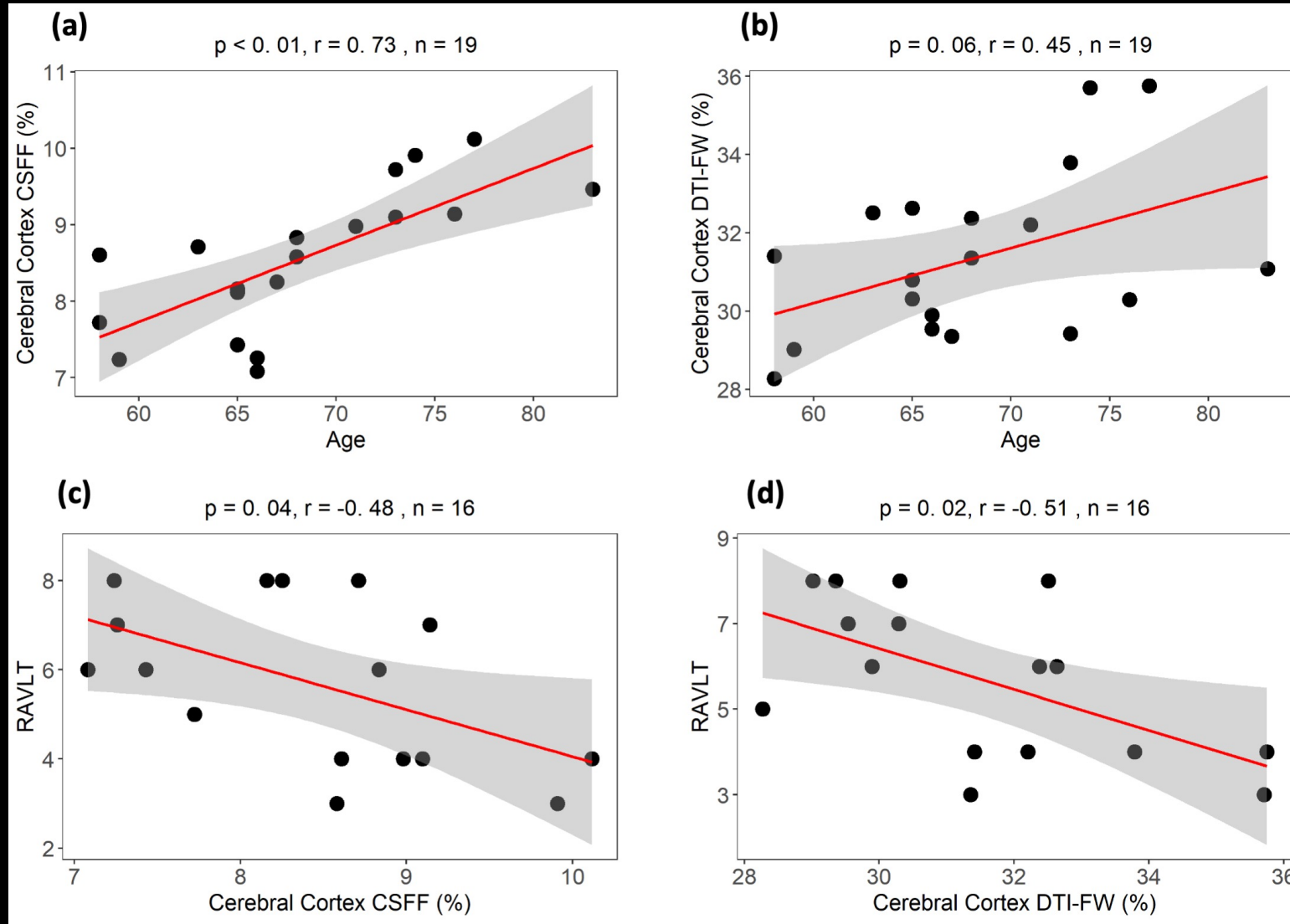


Methods: Subjects

- 19 subjects age ranges from 55 to 82 years old were scanned with MRI FAST-T2, DTI, PC-MRI, among those 16 have done cognitive test, 8 received PiB PET scan and 10 received MK6240 PET scan.
- Multi-echo T2 data was acquired with Fast Acquisition with Spiral Trajectory and adiabatic T2prep (FAST-T2) sequence at 3T. TEs = 0, 7.6, 17.6, 67.6, 147.6, 307.6 ms. Corresponding T1w, T2w, and T2FLAIR were also acquired at the same session for the anatomical structure and disease diagnosis.



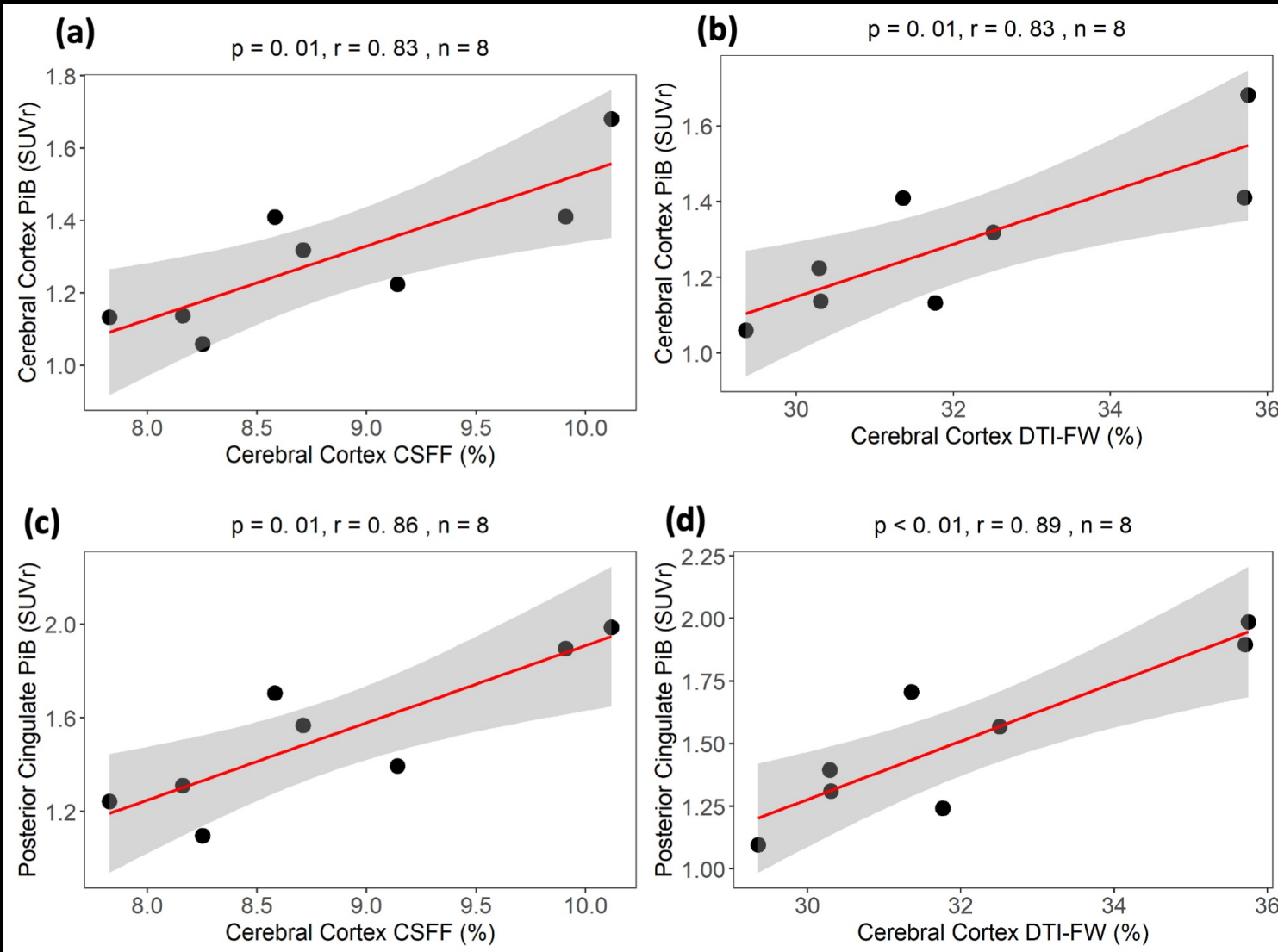
Results: Free water vs age, and cognitive function



- (a) CSFF vs Age
- (b) DTI-FW vs Age
- (c) CSFF vs Cognitive function
- (d) DTI-FW vs Cognitive function



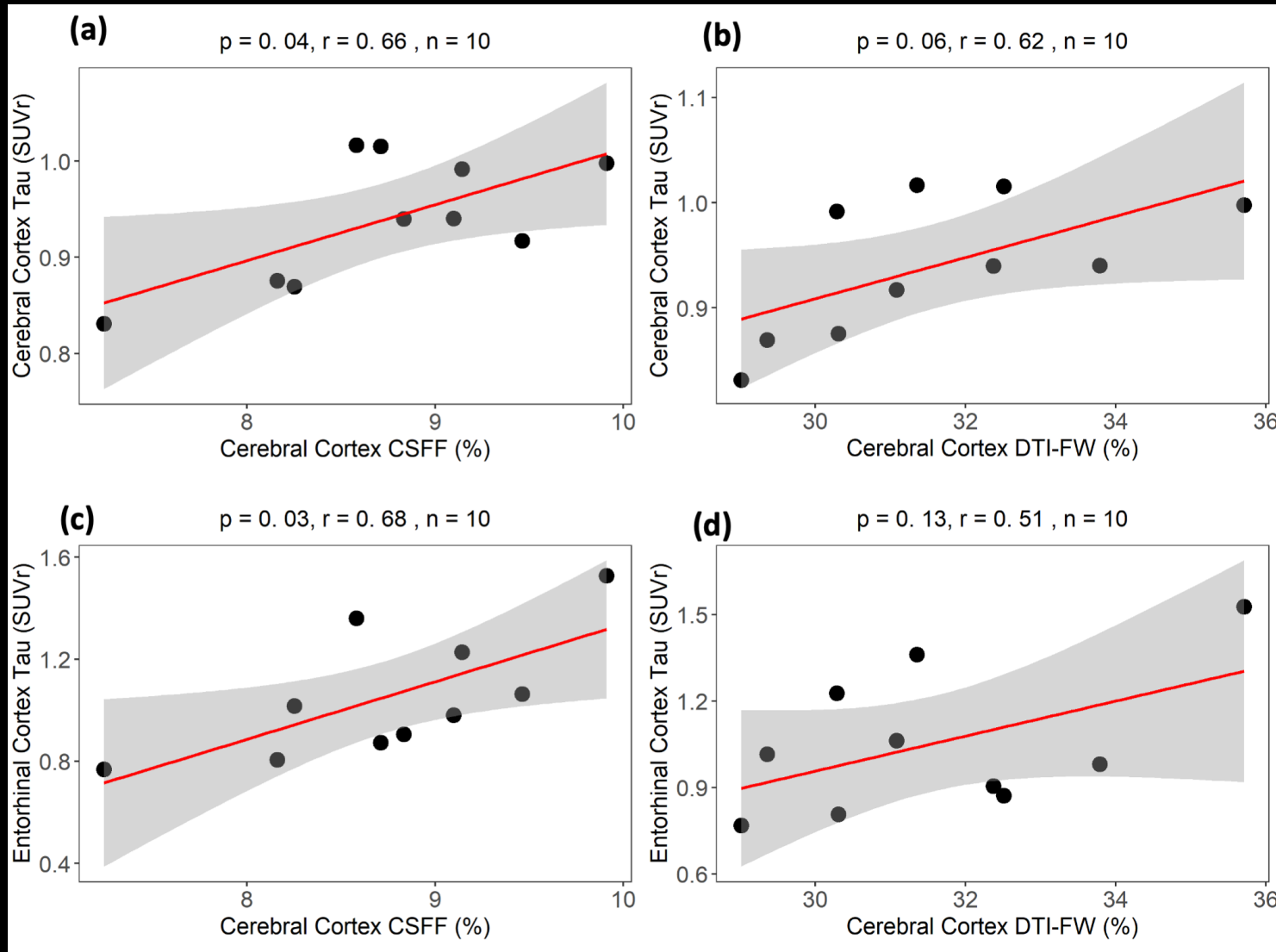
Results: Free water with A-beta deposit



- (a) CSFF vs GM A-beta deposit
- (b) DTI-FW vs GM A-beta deposit
- (c) CSFF vs PC A-beta deposit
- (d) DTI-FW vs PC A-beta deposit



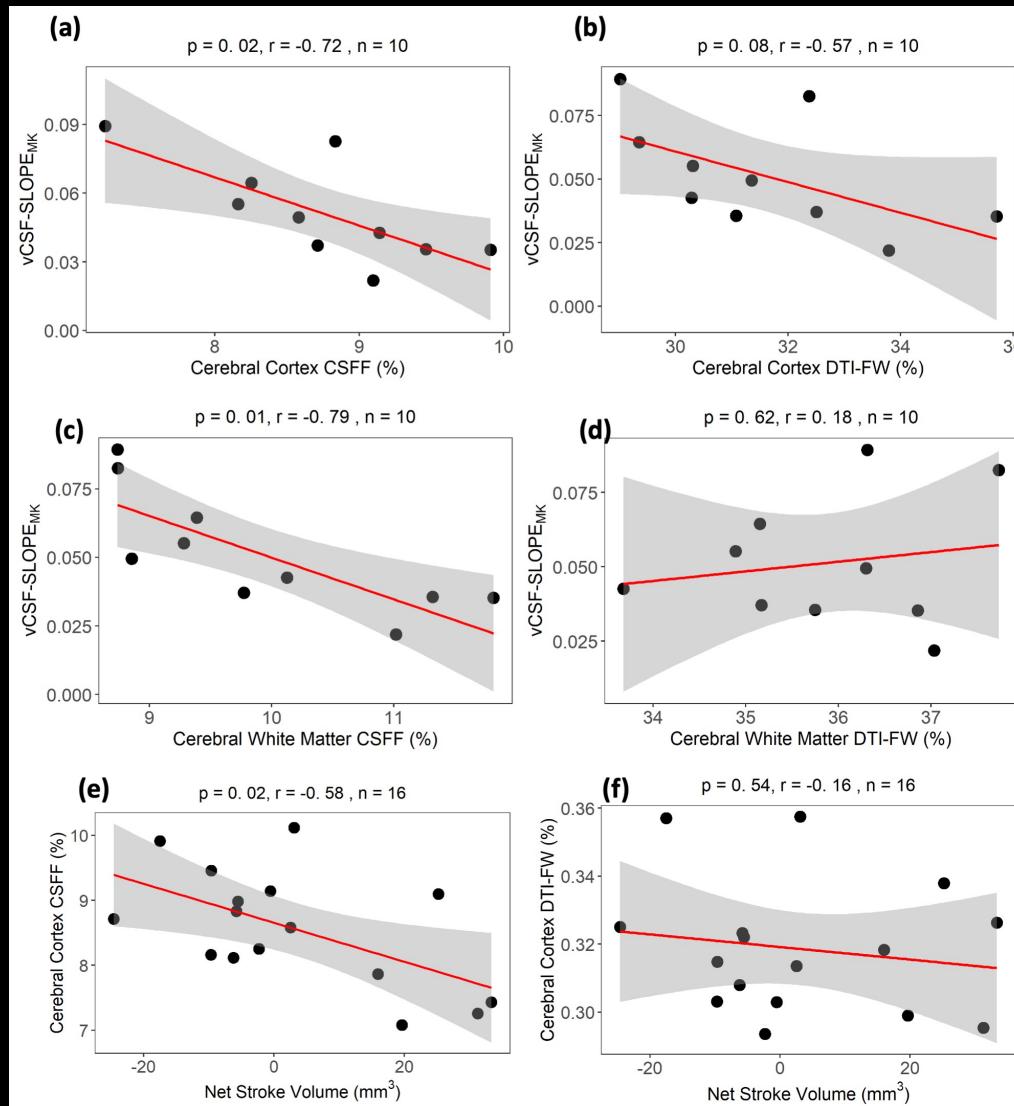
Results: Free water with tau deposit



- (a) CSFF vs GM tau deposit
- (b) DTI-FW vs GM tau deposit
- (c) CSFF vs Ent tau deposit
- (d) DTI-FW vs Ent tau deposit

Program No. 4375 CSF fraction VS DTI-FW

Results: Free water with brain clearance slope, and aqueduct CSF flow



- (a) GM CSFF vs vCSF slope
- (b) GM DTI-FW vs vCSF slope
- (c) WM CSFF vs vCSF slope
- (d) WM CSFF vs vCSF slope
- (e) CSFF vs stroke volume
- (f) DTI-FW vs stroke volume



Results: summary

		Age	RAVLT Score	vCSF-Slope MK6240	Net Stroke Volume	Cerebral Cortex PiB (SUVR)	Posterior Cingulate (SUVR)	Cerebral Cortex Tau (SUVR)	Entorhinal Cortex Tau (SUVR)
Cerebral cortex CSFF	p	<0.01	.004	0.02	0.02	0.01	<0.01	0.04	0.03
	r	0.73	-0.48	-0.72	-0.58	0.83	0.86	0.66	0.68
	R ²	0.50	0.22	0.47	0.28	0.64	0.68	0.36	0.39
Cerebral Cortex DTI-FW	p		0.02			0.01	<0.01		
	r		-0.51			0.83	0.89		
	R ²		0.29			0.64	0.74		
Cerebral white matter CSFF	p			0.01					
	r			-0.79					
	R ²			0.57					
Cerebral white matter DTI-FW	p								
	r								
	R ²								



Conclusions

- Multi-echo spiral T2 relaxometry provides a way to quantify the parenchymal CSF free water.
- CSFF is more sensitive than DTI-FW in all the tested measures, including age, cognitive function, A-beta deposit, tau deposit, vCSF and stroke volume.
- CSFF can be a new biomarker to monitor the glymphatic clearance function and may help us better understand the neurodegenerative diseases.



Thank you for watching.

liz2018@med.cornell.edu