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MRI-based parenchyma CSF fraction (CSFF) mapping is a potential biomarker of brain drainage function: a multimodal imaging study

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Declaration of Financial Interests or Relationships

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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 so that can be used to estimate the brain clearance function.

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Methods: T2 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:

$$\boldsymbol{x} = \ argmin_{\boldsymbol{x}} \sum_{n=1}^{N} ||S(\boldsymbol{x}, TE_n) - S^n_{measure}||_2^2 + \lambda\left|\left|\nabla_s \boldsymbol{x}\right|\right|_2^2 \quad [2]$$

- 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.

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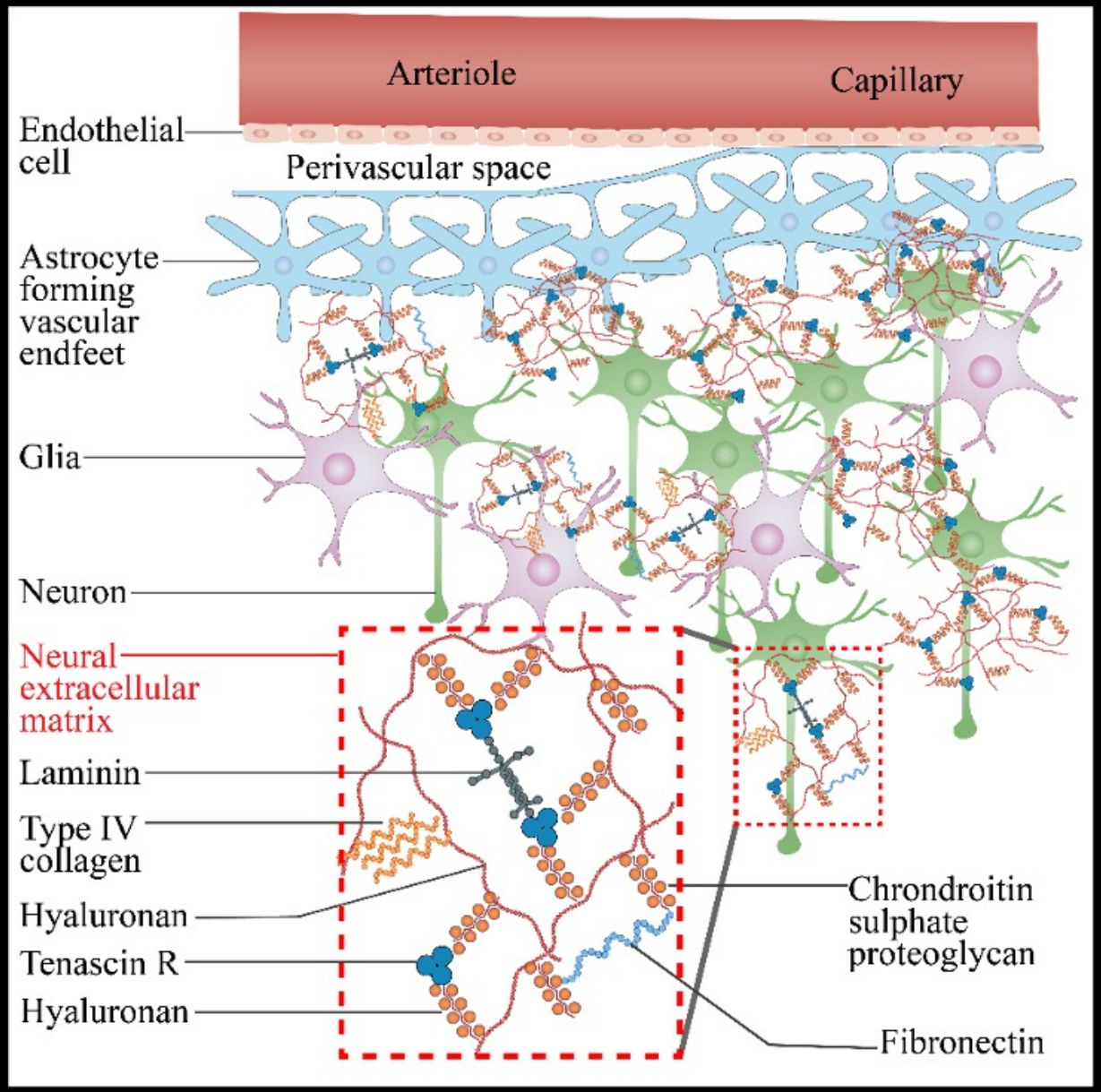
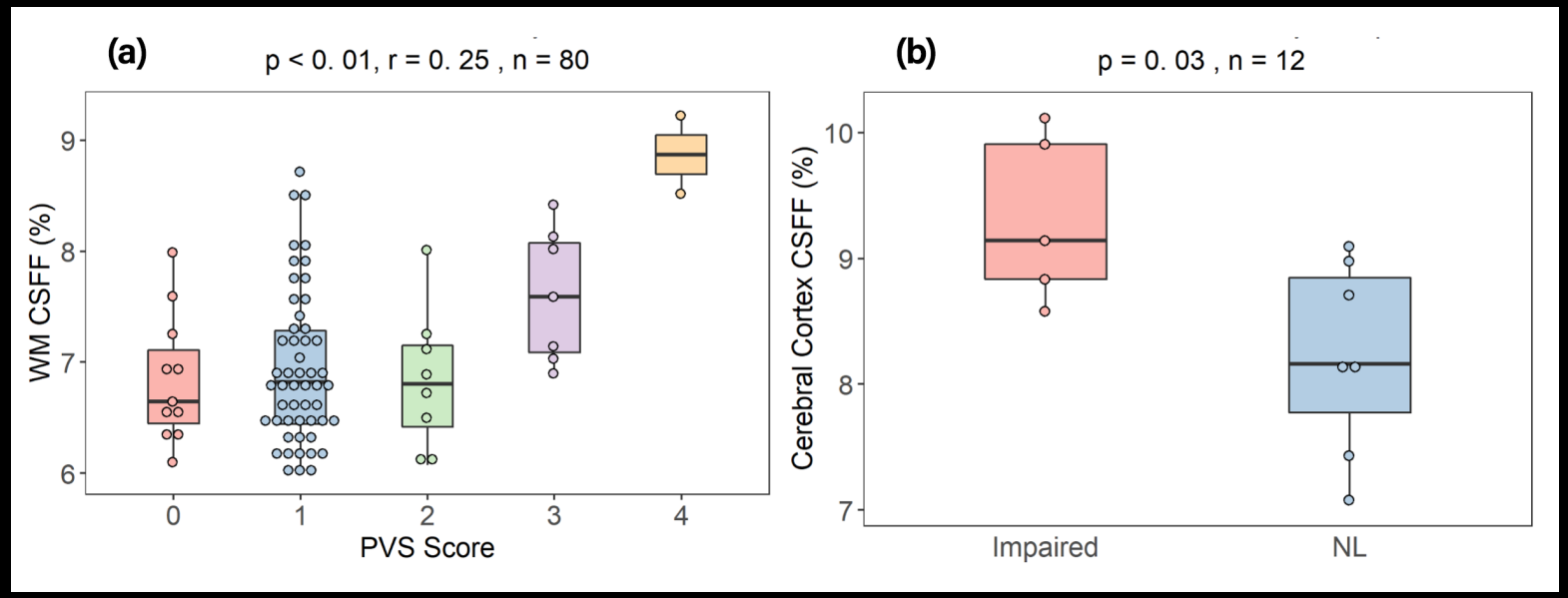
Results: CSFF mechanism



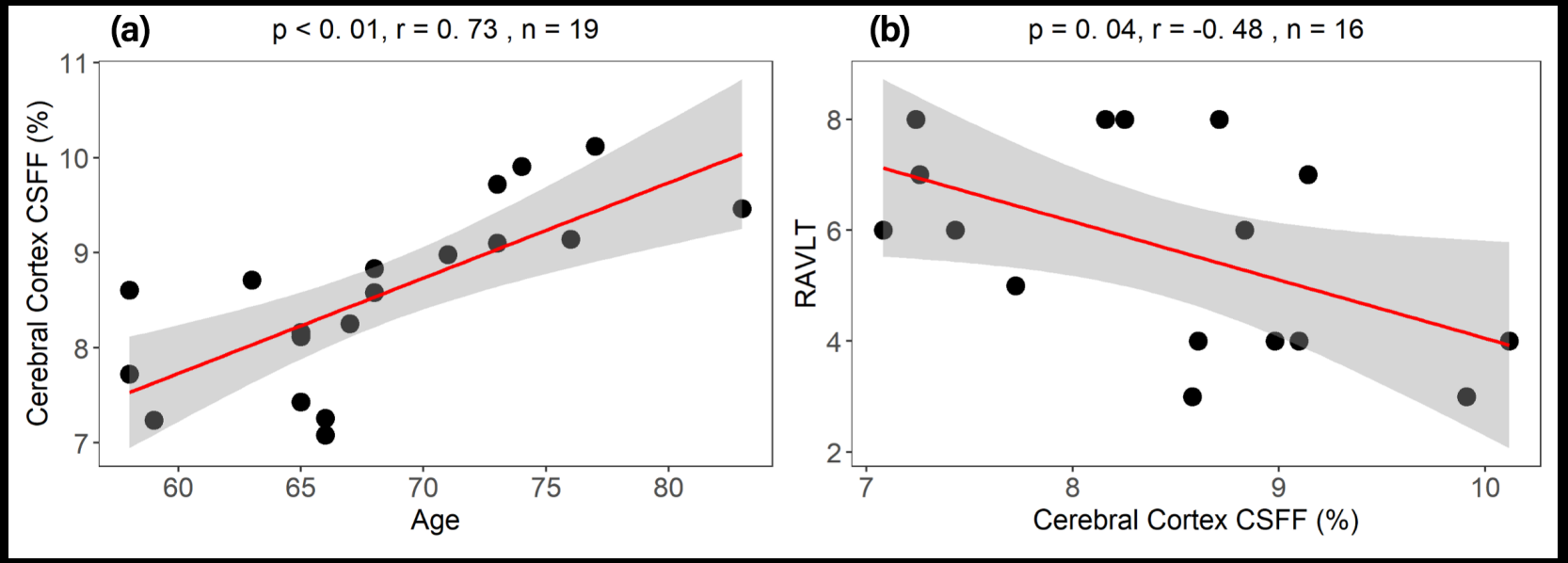
CSFF is a mapping of free water with long T2 time (T2>200ms).

Results: CSFF with PVS, and subject types



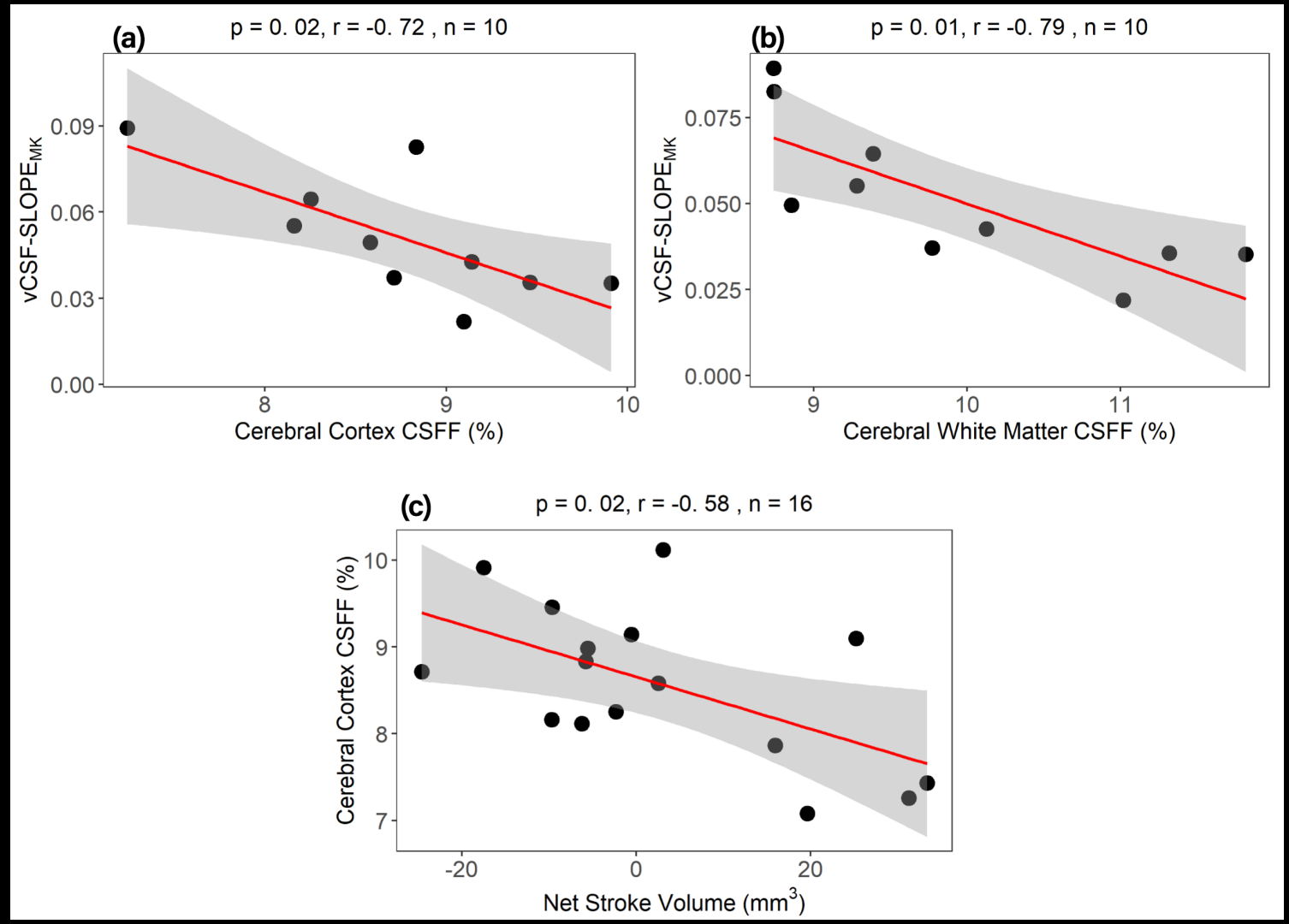
(a) CSFF vs PVS score
(b) CSFF vs subject types

Results: CSFF with Age, and Cognitive function



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

Results: CSFF with vCSF, and Stroke volume



(a) GM CSFF vs vCSF
(b) WM CSFF vs vCSF
(c) CSFF vs Stroke volume

Results: CSFF with A-beta, and Tau deposit

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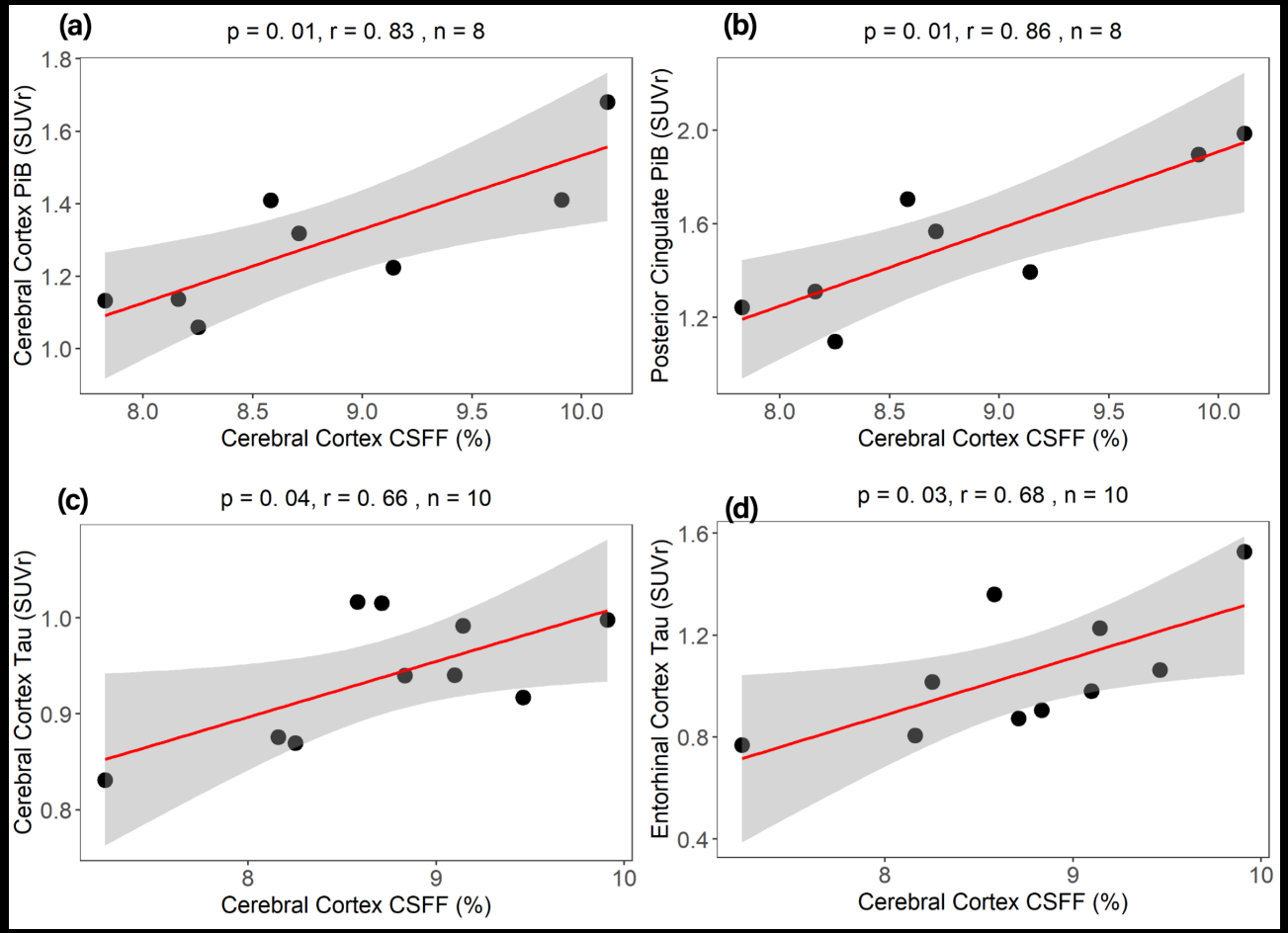

(a) CSFF vs GM A-beta deposit
(b) CSFF vs PC A-beta deposit
(c) CSFF vs GM Tau deposit
(d) CSFF vs Ent Tau deposit

Conclusions

- Multi-echo spiral T2 relaxometry provides a way to quantify the parenchymal CSF free water.
- CSFF is correlated to PVS load, Age, and cognitive function and able to distinguish MCI and NL.
- CSFF is associate to the brain clearance, stroke volume, A-beta and Tau deposit.
- CSFF can be a new biomarker to monitor the glymphatic clearance function and may help us better understand the neurodegenerative diseases.

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Thank you for watching.

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