NYU Langone Health

CAI²R Center for Advanced Imaging Innovation and Research

In vivo mapping of hippocampal venous vasculature and oxygen saturation using dual-echo SWI and QSM on 7T:

a potential marker for neurodegeneration in hippocampus

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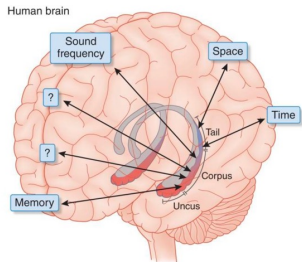
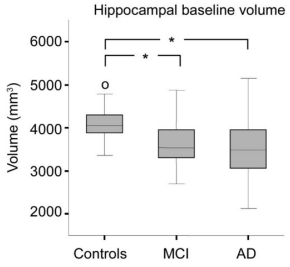
Hippocampal degeneration and cognitive impairment:

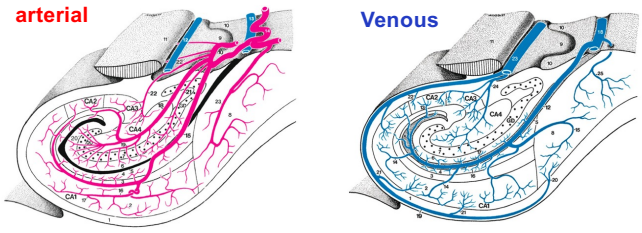




Henneman et al, Neurology (2009)

The hippocampus is a forebrain structure which is part of the limbic system, the hippocampus is involved in memory encoding and storage.

(**hippocampus atrophy is key biomarker for AD**)



Duvernoy. The Human Hippocampus. (2013)

The hippocampal vasculature has played an important role in supporting the normal functioning of hippocampus through complexed vascular network. Hippocampal atrophy is closely related to oxygen metabolism changes in hippocampus.

(**Neurodegeneration leads to less oxygen consumption**)

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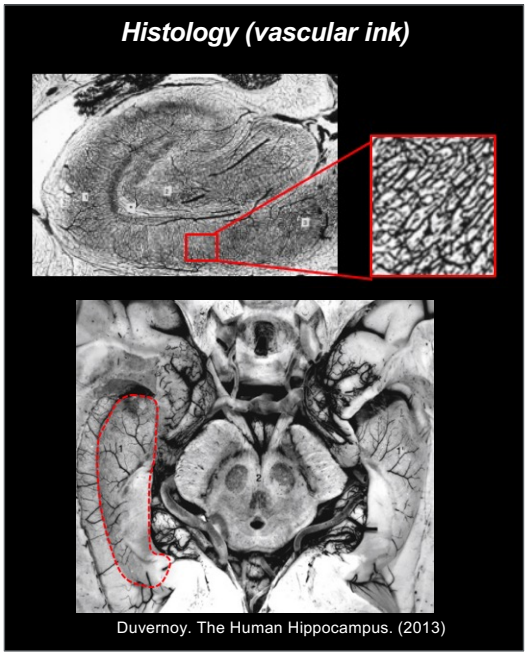
In vivo characterization of hippocampus vascular system: small vessels



Most of the hippocampal vasculatures are studied using histology staining of **cadaver brain**

↓

Morphology of late stage (*post-mortem)* vessels
(No physiological information – oxygen utilization)

↓

In vivo evaluation of **early** vascular changes using conventional MRI technique is still technically challenging.

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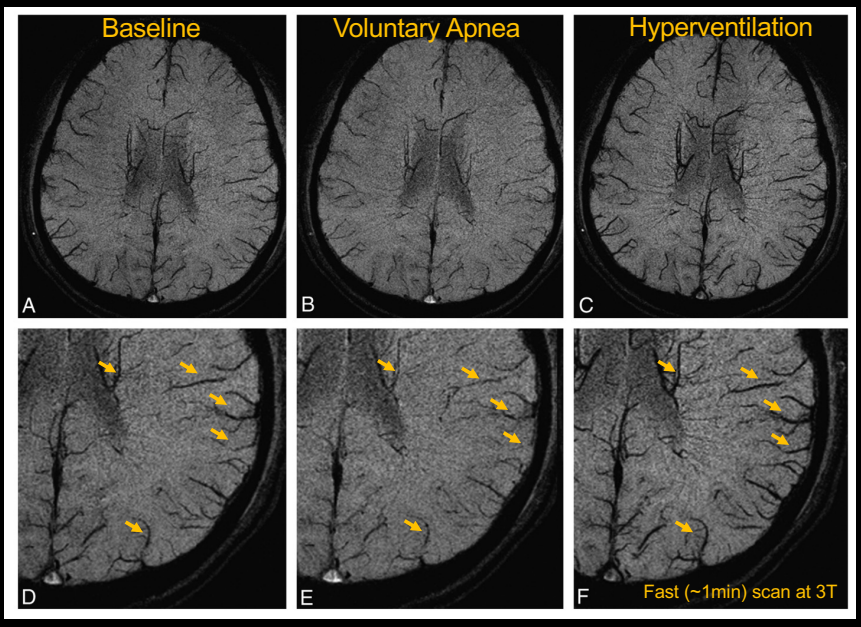
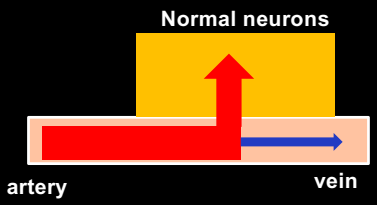
SWI is sensitive in detecting changes in oxygen metabolism



- Blood CO_2 level increased during apnea, leading to arterial vasodilation.



- SWI is sensitive to changing venous oxygenation level through contrast of venography.

Chang et al. AJNR (2014)

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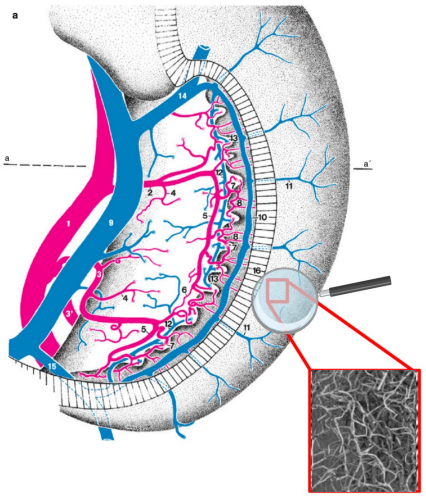
In vivo mapping of hippocampal venous system and oxygen utilization

Main goals:

1. To map the venous drainage pathway of hippocampus in vivo at 7T.

2. To characterize the oxygen utilization of hippocampus using venous density measures and venous susceptibility from SWI and QSM.

3. Initial clinical application of using venous susceptibility at 3T scanner in a cohort of elderly.



Capillary network

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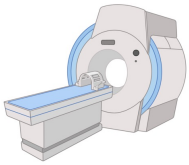
Materials and methods:



7T scanner (14 healthy volunteers)

15 mins scan 3D-GRE (no contrast)

PRE

Ferumoxytol-infusion (IV injection)

POST

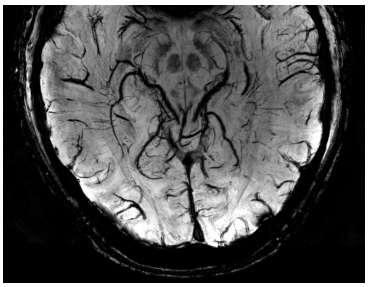
15 mins scan 3D-GRE (post-contrast)

T1-MPRAGE

- **Dual echo FC-3D-GRE (TE1/TE2 = 7.5ms/15ms)**
- **Spatial resolution: 0.25mm × 0.25mm × 1mm**
- **Pre-Contrast GRE:**

1) TE1 for QSM to estimate venous susceptibility;

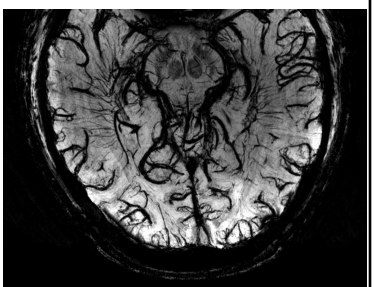
2) TE2 for SWI to delineate hippocampus venous system



Venous system only
✓venous susceptibility

Day 3 10:10am by Sagar Buch

S15 – Imaging Methods for Neurodegenerative Diseases



Arterial and venous system
✗ Venous susceptibility

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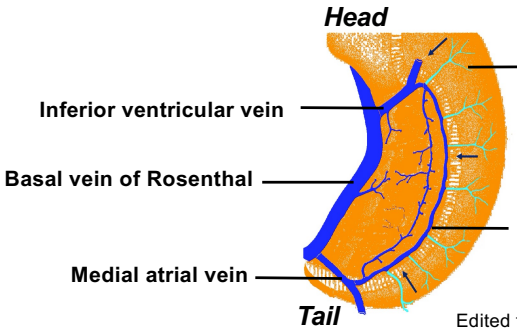
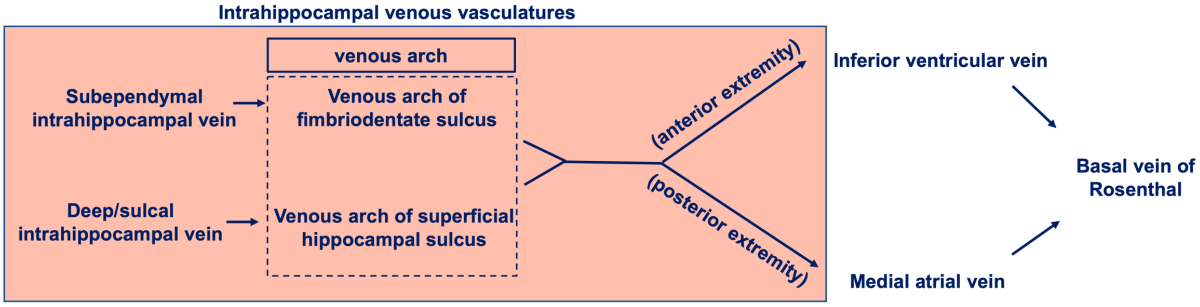
Hippocampal venous system and drainage pathways:



Edited from Duvernoy's hippocampus drawing



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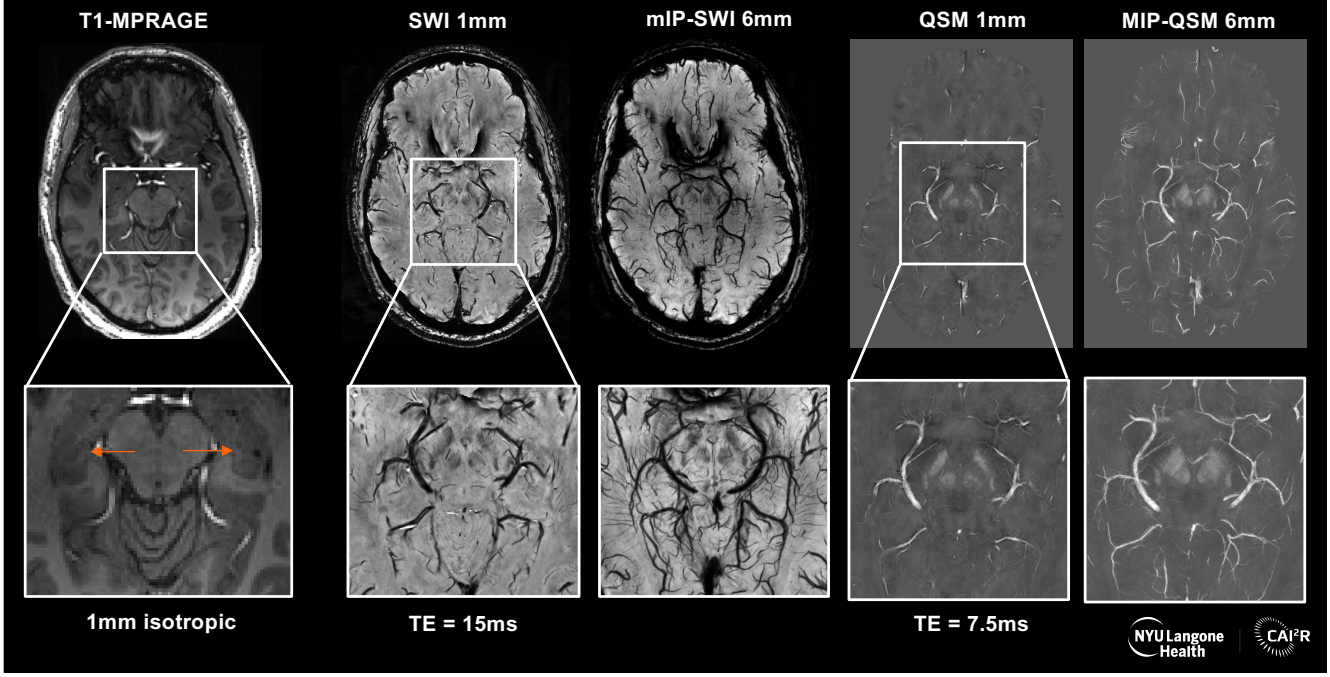
Hippocampus venous vasculature from high resolution SWI images on 7T:



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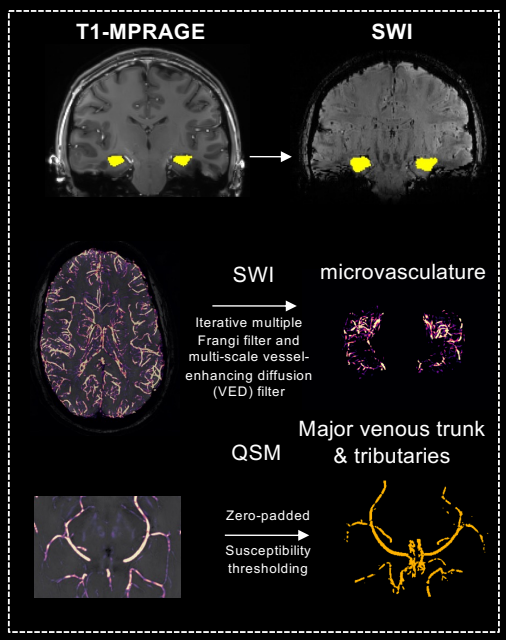
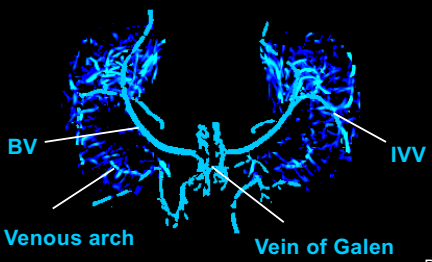
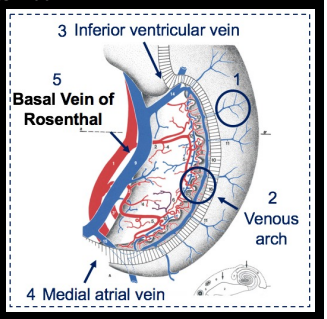
Hippocampus venous vasculature from high resolution SWI images on 7T:

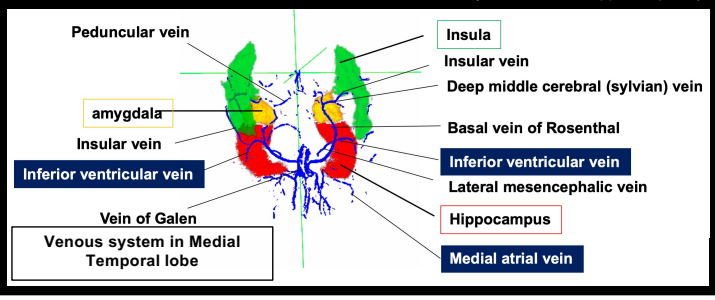


Hierarchical network of hippocampal venous vasculature reconstructed using SWI/QSM at 7T





Duvernoy. The Human Hippocampus. (2013)



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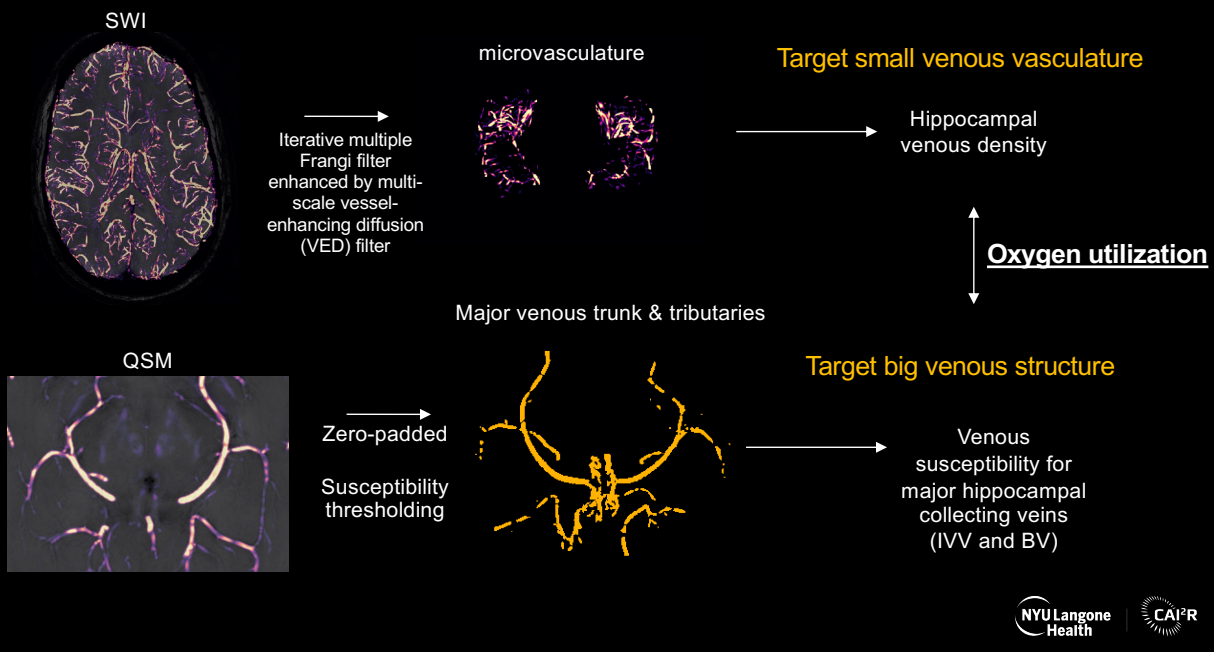
Two approaches for probing hippocampal vascular mapping and oxygen metabolism:



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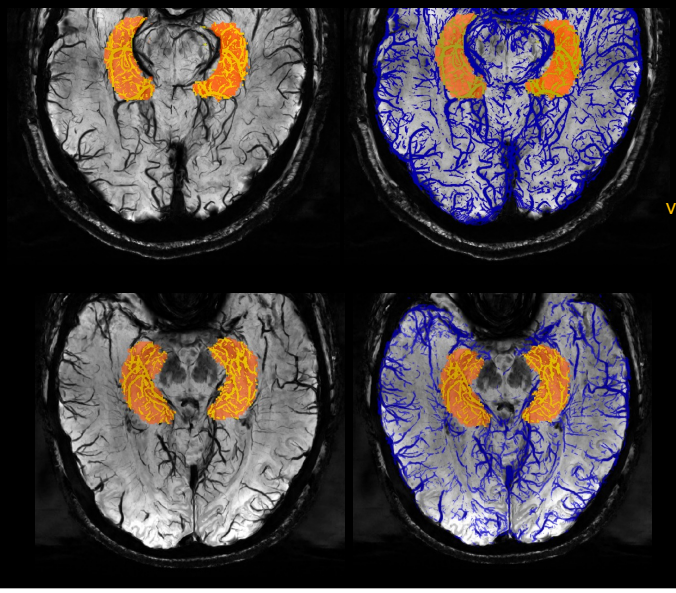
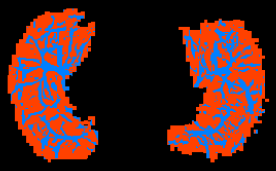
Hippocampal venous density:

Hippocampus venous vasculatures



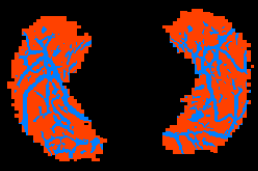
Hippocampus venous vasculatures



venous density of right hippocampus: 0.114

venous density of left hippocampus: 0.1202

Hippocampus venous vasculatures



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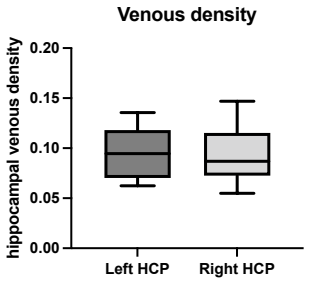
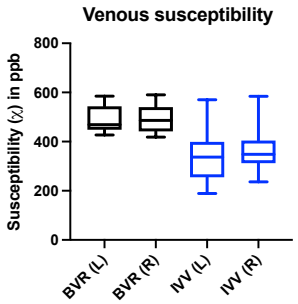
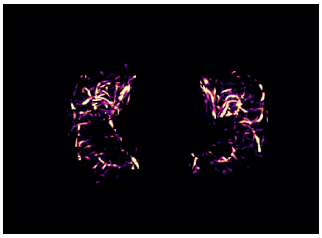
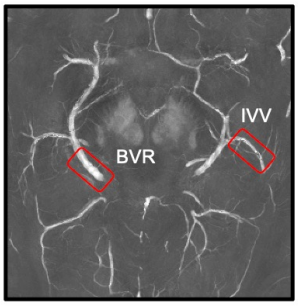
Hippocampal venous density and venous susceptibility in IVV/BVR:









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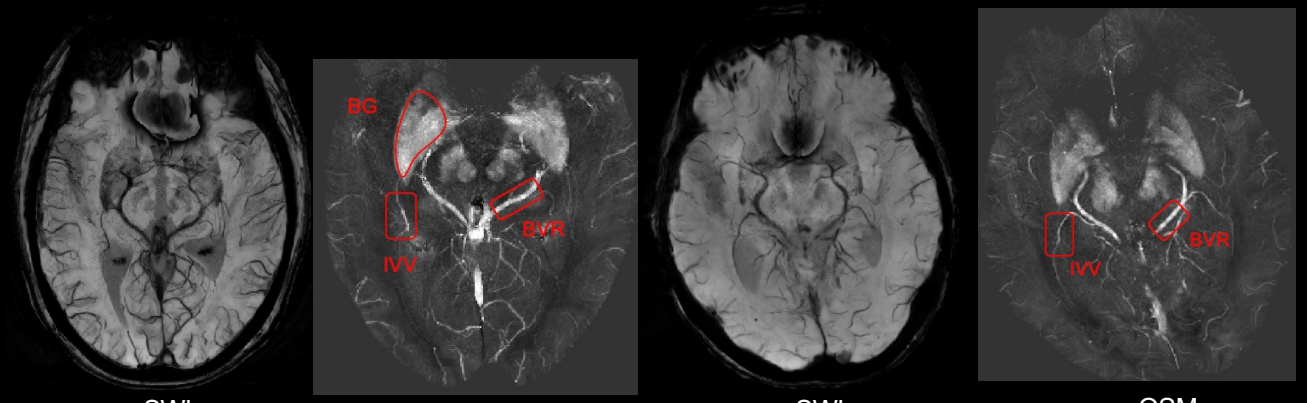
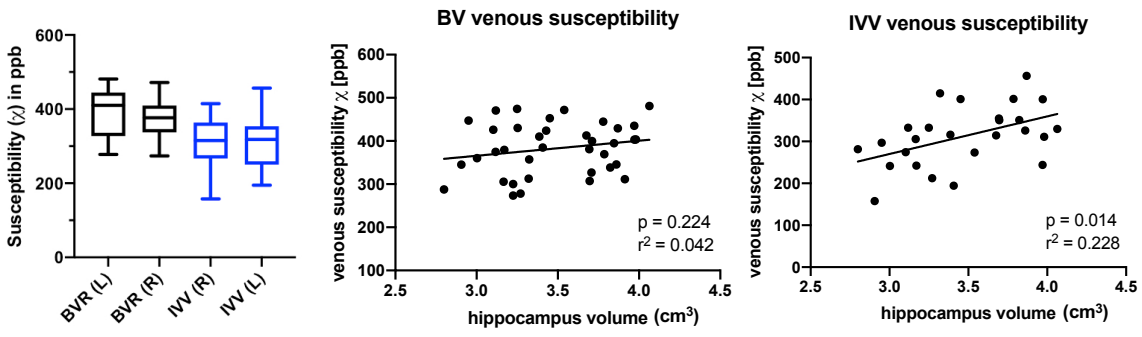
An initial clinical study: venous susceptibility from BV and IVV in the elderly

- *19 elderly participants (age: 75.1 ± 5.3 year old) at 3T Prisma scanner.*
- *Sequence: T1-MPRAGE (1mm iso), SWI and QSM maps reconstructed from GRE*



- *Clinical scans with 3min20s acquisition time, echo time (TE = 20ms) – 7T is 14mins16s.*
- *Resolution: 0.5*0.5*2mm (matrix size: 512*512*48)*

An initial clinical study: venous susceptibility from BV and IVV in the elderly



- venous susceptibility requires cautious interpretation as it has mixed effect from a lot of factors (partial volume with different venous diameter and oxygen saturation level changes).
- If the diameter of IVV is close or smaller to voxel size, the PVE is challenging to remove.

Summary:

1. Reconstruction of hierarchical network of venous system and drainage pathway in hippocampus in healthy volunteers.

2. Characterize venous oxygenation level in hippocampus using hippocampal venous density in terms of small veins and venous susceptibility in terms of large veins.

3. Implementing venous susceptibility on elderly populations with neurodegenerative features in hippocampus.

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Acknowledgements:

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Thank you for your attention!

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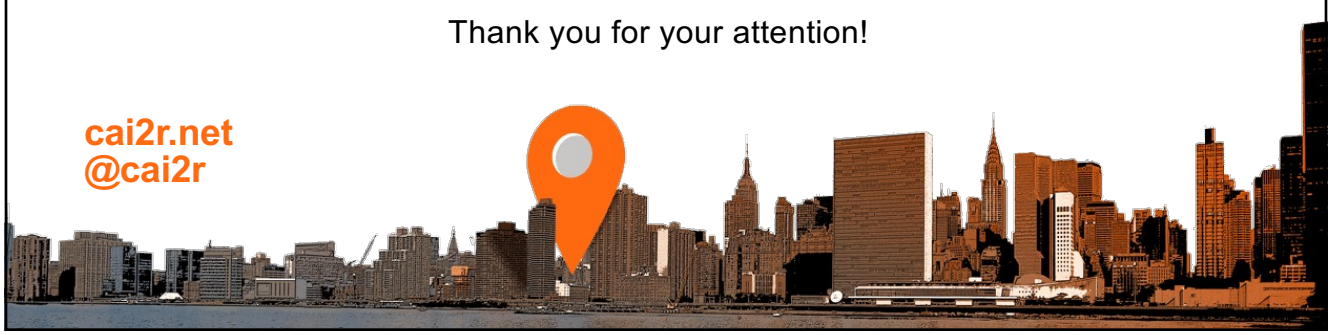

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