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Multimodal Imaging Analysis for Brain Clearance: PET Imaging Based Clearance Slope, FASTT2 MRI-based Parenchyma CSF fraction, and DTI-based ALPS-index

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Abstract Text:

Background: Glymphatic clearance is important to maintain brain health, which depends on two interconnected fluid systems: the novel glymphatic system and the traditional well-characterized CSF system[1]. There are several imaging tools have been developed to evaluate the glymphatic function in the human brain, however each method providing only a limited perspective into glymphatic system[2]. A proper imaging tool should consider both circulation pathway of the bulk CSF flow, and a complex PVS network parallel to the microvascular structure. We developed and tested an imaging package including vCSF, CSFF, and DTI-ALPS, to investigate the ventricular CSF turnover rate, perivascular CSF flow and brain parenchymal CSF fraction.

Method: A total of 23 subjects (F=16, M=7, NL=17, MCI=6) age from 63 and 82 years (mean=69.3, std=5.1). PET MK6240 was acquired for lateral ventricle CSF clearance measure[3] (vCSF), and MRI FASTT2 and DTI was acquired for CSF fraction[4] (CSFF) and diffusion tensor imaging along perivascular spaces[5] (DTI-ALPS) index, respectively. Precisely, vCSF was calculated as the slope of 10 to 30min lateral ventricle TAC normalized by 1-4min whole brain AUC. CSFF was fitted using three compartment model with 6 TEs = 0, 7.5, 17.5, 67.5, 147.5, 307.5 ms. DTI-ALPS was calculated by mean(D_{x_proj},D_{x_assoc})/mean(D_{y_proj}, D_{z_assoc}), where Dx, Dy and Dz are the diffusivity along x-, y- and x-axis, and the projection, association regions.

Result: Figure 1-3 shows vCSF, DTI-ALPS and CSFF. Figure 4 shows Parenchymal CSFF negative correlates with DTI-ALPS (r = -.51; p=.01 n=23), suggesting link between glymphatic system dysfunction and increased cerebral CSFF. Figure 5 shows ventricular CSF turnover rate (vCSF) negative correlates CSFF (r = -.53; p=.01 n=23).

Conclusion: Our preliminary results showed that ventricular CSF turnover rate (vCSF), perivascular CSF flow (DTI-ALPS) and brain parenchymal CSF fraction (CSFF) are correlated to each other and indicate the connection between the glymphatic system and the traditional CSF system. The complementary imaging approaches could lead to a much greater understanding of glymphatic clearance, and facilitate a more complete perspective on both glymphatic pathology and function alterations.

Reference: **1**. JM.Wardlaw,2020. **2**. M.Niazi,2018. **3**. Y.Li, 2022. **4**. L.Zhou, 2021. **5**. T.Taoka, 2017

Tables and Figures:

Figure1 vCSF.png (216.8KB)

Figure 1. Dynamic PET tracer clearance for calculating the vCSF
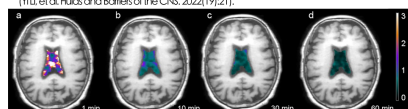(Yi Li, et al. Fluids and Barriers of the CNS. 2022(19):21).

Figure2 DTI-ALPS map.png (582.2KB)

Figure 2. DTI-ALPS mechanism.
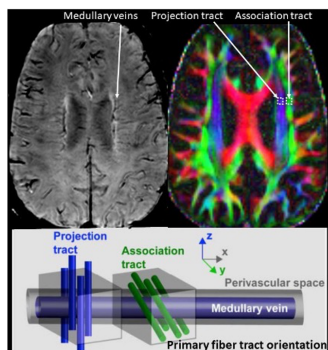(Toshiaki Taoka, et al. Jpn J Radiol. 2022;40:147–58.)

Figure3 CSFF map.png (207.1KB)

Figure 3. CSFF map reconstructed from MRI FASTT2.
(Liangdong Zhou, et al. Alzheimer's Dement.2021;17.
Liangdong Zhou, BioRvix:2021.02.01.429067, 2021)
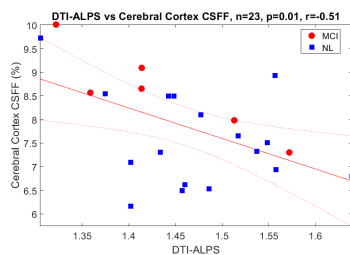

Figure4 CSFF vs DTI-ALPS.png (63.9KB)

Figure 4. DTI-ALPS index versus cerebral cortex CSFF. A negative correlation between them is observed showing that a lower diffusivity along perivascular space is corresponding to a higher CSFF. Note that a higher CSFF implies more severe PVS dilation and bulk flow obstruction in parenchyma.
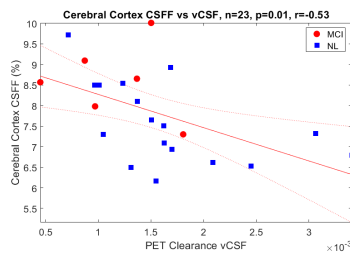
Figure5 CSFF vs vCSF.png (71.2KB)

Figure 5. Ventricle CSF clearance slope (vCSF) versus cerebral cortex CSFF based on MR FASTT2. Negative correlation between them is observed indicating the correspondence between higher parenchyma perivascular space and lower clearance function in the lateral ventricle. Note that blue square indicates health control and red dot means clinically diagnosed MCI.

Title:
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Do you plan to upload figures or tables to supplement your abstract text?
Yes

Theme:
Biomarkers

Topic:
Neuroimaging

Sub Topic:
Multi-modal comparisons

Learning Objectives:

Update your understanding of glymphatic clearance from multimodal imaging perspective.
Estimate the clearance function using MRI based CSFF and DTI-ALPS, and PET based vCSF.
Differentiate the healthy control and mild cognitive impaired patients.

Keywords:
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