An Image-Based Method for Calculating BBB Leakage Rate

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Abstract

Blood brain barrier(BBB) leakage plays an important role in the patients with early Alzheimer disease. BBB is a collection of cells in brain that separates the blood from the brain parenchyma. When BBB is harmed, it loss it's ability to keep substance influenced brain tissue, therefore would cause dementia.

In this research, we take a series of MRI images, and use the difference of pixel intensity between images to calculate the leakage rate by Patlak approach, and plot the histogram to obtain the sum of the amount of leakage.

Key words:
BBB leakage, Patlak Graphical model, Alzheimer disease

References

[1]Blood-Brain Barrier Leakage in Patients with Early Alzheimer Disease Radiology Vol. 281, No. 2 (2016)

Methodology

In the beginning to calculate the BBB leakage from images, a preprocessing process is needed. Since image intensity in MRI image is relative, thus we have to normalized each image by dividing the pixel value of fat before we apply the model. After correction, a widely used graphical model, which is known as Patlak Graphical model, was applied for analyzing the amount of leakage.

First, we speciy the region of plasma (ROP) as our reference and the region of interest(ROI) that is going to be analyzed.

The relative concentration $C(\boldsymbol{r},t)$ is modeled by the contrast with the initial intensity, i.e.,

$$C(\boldsymbol{r},t) = -\frac{1}{T_e}\ln\left(\frac{S(\boldsymbol{r},t)}{S(\boldsymbol{r},0)}\right),$$

where T_e is the echo time, and $S(\boldsymbol{r},t)$ is the intensity at point $\boldsymbol{r}$ at the time t. Denote the average relative concentration of ROP as

$$C_p(t) = \frac{\iint_{\boldsymbol{r}\in \mathrm{ROP}} C(\boldsymbol{r},t)\,dA}{\iint_{\boldsymbol{r}\in \mathrm{ROP}} dA}.$$

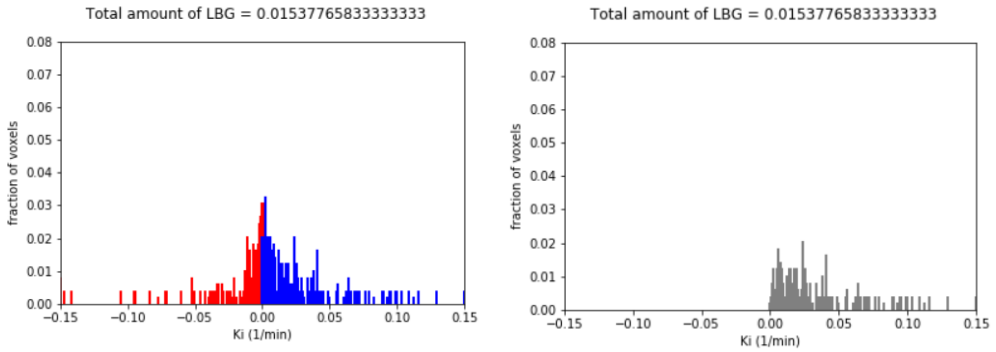
The Patlak model states as follow:

$$C_i(\boldsymbol{r},t) = K(\boldsymbol{r})\int_0^t C_p(\tau)d\tau + V(\boldsymbol{r})\cdot C_p(t),$$

where $V(\boldsymbol{r})$ is the direct injection rate from $C_p(t)$ and $K(\boldsymbol{r})$ is the average rate of leakage from accumulate contraction.

After we have obtained $K(\boldsymbol{r})$ of every pixels in ROI, therefore we plot the histogram to compute the amount of the leakage in the region.

Result



Left : Histogram of Ki in the region of LBF

Right hand side: Subtract positive part with negative part

Conclusion and Acknowledgements

During this method to compute the amount of BBB leakage, the method was highly rely on the resolution of image. We here only have the image size 128*128, which cause difficulty to mark the region accurately

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