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Diagnosing Neuropathy Early with QUTE-CE MRI

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Abstract

The physiological trademark of Neuropathy is vascular abnormality[1]; however, we are currently incapable of detecting such changes in the brain. Thus, diseases such as Alzheimer's disease are only detected after the onset of debilitating symptoms. We are developing a method for early detection of these disease indications so that people can be treated in the early stages of disease progression. We aim at the market for preventative and diagnostic care by establishing a new test neuropathic prognosis.

Background

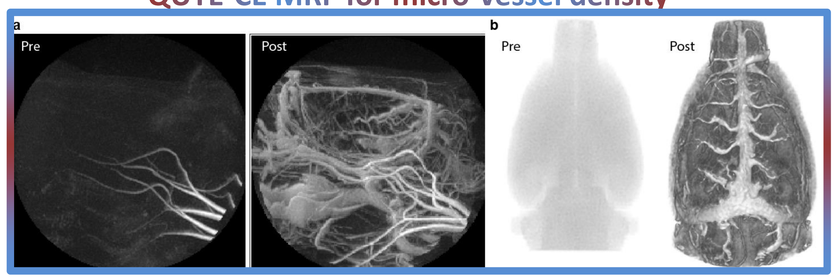
- Currently, dynamic susceptibility contrast (DSC) MRI is the gold standard for measuring cerebral blood volume (CBV) values. However, this method requires accurate determination of the arterial input function (AIF), which typically has 15-30% error[2].
- Thus, there is an obvious need for an accurate and robust measure of cerebral vascularity.

Methods

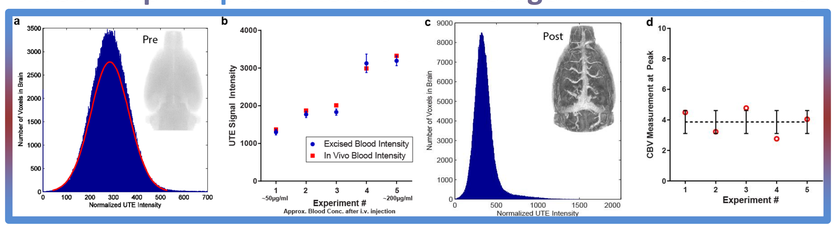
We have developed a new technique, Quantitative Ultra-short TE Contrast-Enhanced (QUTE-CE) MRI [3], that utilizes the UTE sequences with SPIONs and leads to vascular images with unprecedented clarity and definition. The ultra-short TE (10-100us) limits susceptibility dependent signal dephasing and is insensitive to blood flow. We quantify the signal to CBV through established MR equations.

Results

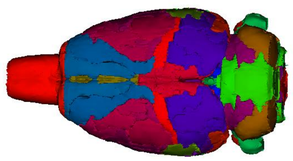
QUTE-CE MRI for micro-vessel density



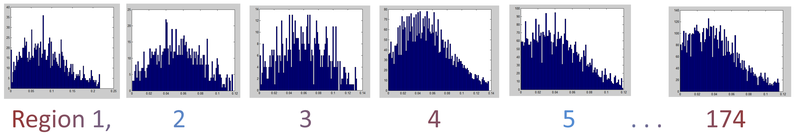
Proof of principle: Whole brain average micro-vasculature



Identifying Regional abnormalities: Part-by-part



An anatomical brain atlas developed by the CTNI separates the brain into 174 different regions containing 600,000 voxels!



Those voxels each contain the absolute micro-vascular density in percent blood volume with 150µm³ resolution!

How does it work?

$$v_B = \frac{I_{(QUTE-CE)} - I_T}{I_B - I_T}$$

- Measure healthy brains for acceptable deviations
- Compare subject for statistical difference

Discussion and Impacts

- There currently isn't any technique for quantifying brain health in absolute terms. Current techniques only measure relative changes.
- This modality could create an entirely new space in quantitative clinical diagnostics.
- A simple brain scan could reveal a variety of diseases, or at least throw up a red flag, since all brain diseases are accompanied by vascular abnormalities.

Conclusions

We have developed a novel MRI imaging modality, QUTE-CE, which is capable of absolutely quantifiable measurements with contrast agents. We utilize the FDA approved nanopharmaceutical ferumoxytol to identify with high degree of certainty the cerebral blood volume throughout the entire rat brain. We establish a vascular atlas of normal micro-vascular densities and use this to detect neuropathy. Currently we have a study involving APOE4 positive rats and data has not yet been published.

References

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2. T. E. Yankeelov and J. C. Gore, "Dynamic Contrast Enhanced Magnetic Resonance Imaging in Oncology: Theory, Data Acquisition, Analysis, and Examples.," *Curr. Med. Imaging Rev.*, vol. 3, pp. 91–107, 2009.
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