様　式　C－１９、F－１９、Z－１９　（共通）

科研費 KAKENHI

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研究課題名（和文）A novel, non-invasive, MRI based approach to the measurement of OEF, CBF and CMRO2 in the human brain.

研究課題名（英文）A novel, non-invasive, MRI based approach to the measurement of OEF, CBF and CMRO2 in the human brain.

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研究成果の概要（和文）：本研究課題で開発したOEF画像の後処理法を用いて、健常者を対象とした覚醒下麻酔中データに適用し、OEF計測が可能であることを示した。引き続き研究課題として、ASLを用いたより正確なCBF測定法の開発が必要となるが、当初予定していた本学7T MRIによるASL撮像が不可能となり、共同研究先のマンチェスター大学の3T MRIを用いて、マルチバンド法とLook Locker readoutを用いたASL撮像法の開発を試みた。本技術が開発されれば、全脳領域におけるCBF測定が可能となる。しかし、本科研費研究期間内のみでは、全脳のCBF測定技術の開発までには至らず今後も研究開発を行う予定としている。

研究成果の概要（英文）：OEF post processing techniques were demonstrated in a healthy population during concious sedation (Goodwin et al 2014). Subsequent work focused on development of CBF measurement using ASL MRI; necessary for developing a combined imaging approach to CMRO2 measurement. However, there were several technical limitations. Initial efforts focused on ASL using 7T MRI, but it became apparent that this approach was no longer available option with our current 7T system. Instead, collaborative work commenced on development of 3T ASL with multi-banding and Look Locker readout. This involved 6 months in the University of Manchester, UK. If successful, this technique would increase brain coverage allow CBF arrival time measurement. A number of experiments were carried out to try and establish this method, in collaboration with Philips engineers, and a number of technical challenges were discovered, which ultimately were not resolved prior to the end of the Kakenhi period. This research is ongoing.

研究分野： MRI brain imaging

キーワード： SWI　OEF　CBF　ASL　multi-banding　CMRO2

１．研究開始当初の背景

Prior to commencing research on this project, a method of Oxygen Extraction Fraction (OEF) measurement based on susceptibility-weighted imaging (SWI) had been developed, to demonstrate changes in oxygen on a hemispheric basis. Additionally, Arterial Spin Labelling (ASL) had been developed and was an established technique on lower magnetic field scanners, for the measurement of blood flow, and had also been used in conjunction with functional MRI to measure changes in the cerebral metabolic rate of oxygen (CMRO2).

The combination of SWI OEF maps and ASL CBF maps had not been demonstrated as a means for calculating CMRO2. And particularly as a high field MRI technique, which offered potential benefits in regard to signal to noise gains and increased susceptibility effects.

２．研究の目的

To Combine SWI and ASL MRI to obtain OEF and CBF measurement; the combination of which can be used to obtain estimates of CMRO2, which can be visually mapped. Thereby providing an alternative and possibly complimentary alternative to the gold standard PET imaging method.

３．研究の方法

OEF mapping using SWI is based on differences in measured phase due to differences in susceptibility resulting from oxygenation level in the brain (Figure 1).

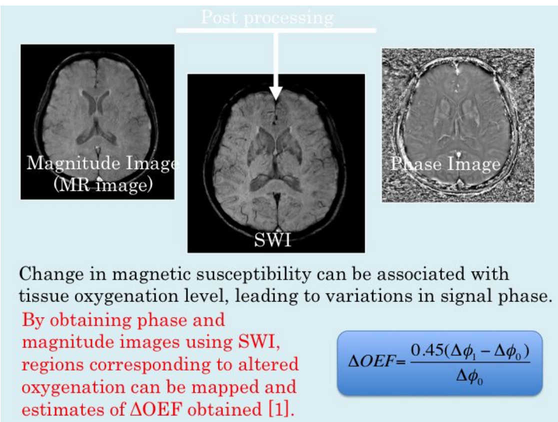

Figure 1. Basic principle for obtaining OEF from SWI.

The basic principle of CBF measurement using ASL is the subtraction of images with magnetically labeled arterial blood from those with non-magnetically labeled arterial blood. The resultant image represents the arterial blood only without any static tissue. After repeating a number of times, an average image representing CBF can be obtained (Figure 2).

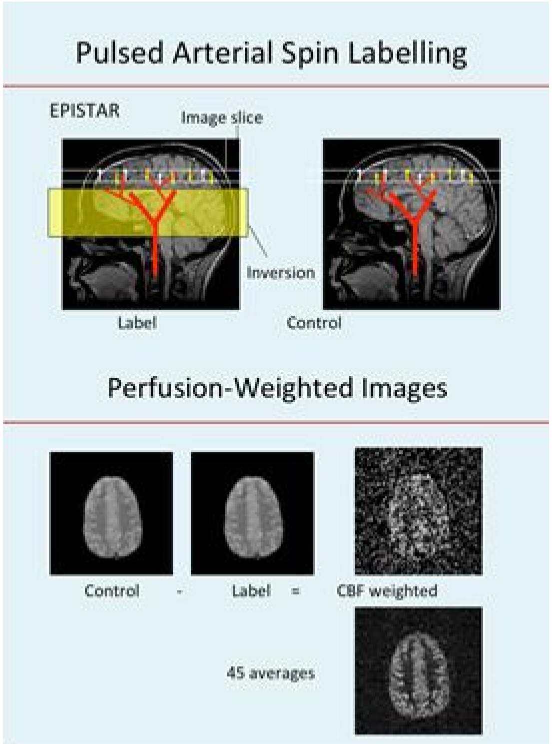

Figure 2. Principle of CBF measurement using ASL

Estimation of CMRO2 from these two image protocols is based on the relationship:

$$OEF = CMRO2 / CBF. Ca$$

where Ca represents arterial oxygen concentration, which can be estimated during scanning through end tidal monitoring. This is a post processing step and is dependent on successful acquisition of OEF and CBF maps.

４．研究成果

Advancement in the methodology of regional OEF values was developed and published, demonstrating changes in OEF in response to anesthesia (Figure 3).

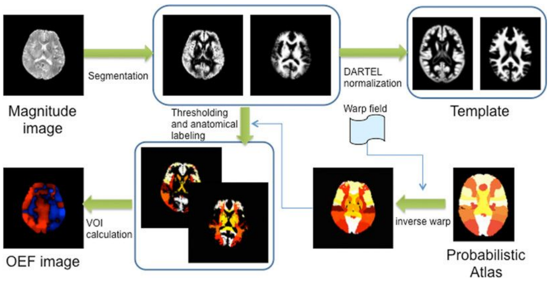

Figure 3. Implementation of VOI OEF measurement protocol based on SWI images.

Using this technique, a number of brain regions were uniquely identified as showing significant reduction in OEF during conscious sedation with midazolam and propofol (Figure 4).

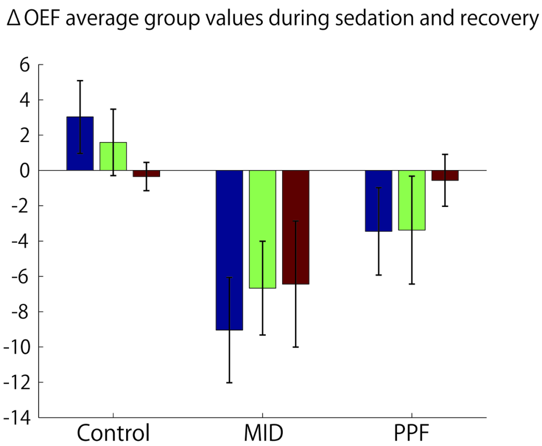

Figure 4. Average OEF changes of 17 separate grey matter regions demonstrates change in OEF at three time point; during, after 10 mins, and after 30 mins of sedation recovery.

A key component of this project was the development of CBF maps at with 7T ASL. The development this protocol was limited due to technological reasons. It was found that without additional hardware capable of magnetically labelling the inflowing blood, no useable CBF maps could be obtained. As a result, a number of experiments were carried out exploring the use of a novel multi-banding technique with 3T MRI as well as SWI. A number of issues were also faced with this technique related to the reconstruction of images on the MRI system (Figure 5).

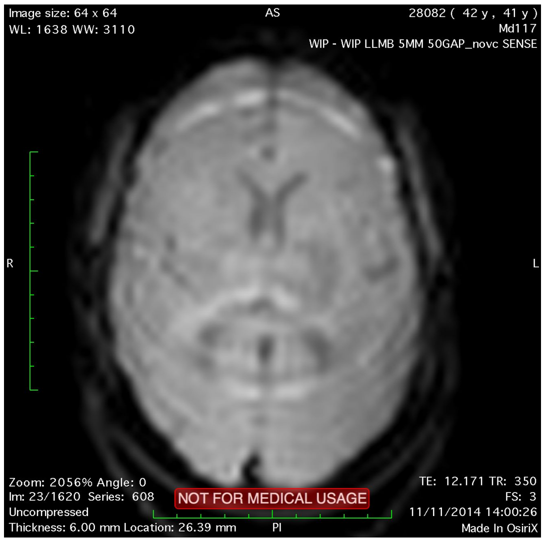

Figure 5. Multi-banding ASL image – 3T

Essentially, multi-banding utilizes simultaneous acquisition of multiple slices, which then need to be reconstructed as separate slices. This process was both computationally demanding and prone to ringing artefacts, as seen in figure 3. As a result, no useable CBF maps could be produced at the time of completion of this research grant.

5．主な発表論文等
（研究代表者、研究分担者及び連携研究者には下線）

〔雑誌論文〕（計 1 件）

① Goodwin JA, Kudo K, Shinohe Y, Higuchi S, Uwano I, Yamashita F, Sasaki M: Susceptibility-Weighted Phase Imaging and Oxygen Ex-traction Fraction Measurement during Sedation and Sedation Recovery using 7T MRI. J Neuroimaging. 2014 (Epub ahead of print) [査読あり]
DOI: 10.1111/jon.12192

〔学会発表〕（計 1 件）

① Goodwin J, Kudo K, Shinohe Y, Uwano I, Yamashita F, Matsumura Y, Metoki T, Ogasawara K, Ogawa A, Sasaki M: Susceptibility Weighted Imaging Based Approach to ΔOEF Quantification Using Propofol and Midazolam as Potential OEF Modulators. ISMRM (International Society for Magnetic Resonance in Medicine), Salt Lake City, USA, 2013.4

〔図書〕（計 0 件）

〔産業財産権〕
○出願状況（計 0 件）

○取得状況（計 0 件）

〔その他〕
なし

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