Improvements of quantitative oxygenation levels in venous blood (Y_v) measurements based on QUIXOTIC

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Target Audience: Basic researchers who are interested in sequence development, quantitative imaging and molecular imaging.

Introduction and Purpose

In pathologies such as Alzheimer's disease, the cerebral metabolic rate of oxygen consumption ($CMRO_2$) is known to show changes[1,2,3]. Thus, the knowledge of quantitative values of $CMRO_2$ is of great interest in order to track and dynamically adapt the treatment. Additionally, changes in $CMRO_2$ are an active area in diabetes research where the central nervous system is thought to play an integrative role. In recent decades, radioactive tracers such as ^{15}O were used to quantify $CMRO_2$ with PET imaging with the method being regarded as the gold standard. However, such methods are complicated and expensive as a consequence of the short half-life (2min) of ^{15}O and inherently include radiation exposure. Direct measurements of increased oxygen metabolism and a detailed knowledge of quantitative values for $CMRO_2$ derived from NMR/MRI experiments may help to study brain activity in disorders such as the ones alluded to above. One promising method, based on changes of the spin-spin relaxation rate, T_2, of venous blood as a function of oxygenation, is called QUIXOTIC [4]. The original published method makes use of single- and multi-echo spin echo (SE). In this preliminary study we demonstrate the feasibility of a faster multi-echo SE imaging scheme with higher resolution. The preliminary results reported here are thus a first step in creating an experimental protocol capable of using a hybrid MR-PET scanner altogether with ^{15}O-PET as a gold standard and comparing MRI against it for future quantitative evaluation of $CMRO_2$ without the need for radioactive ^{15}O.

Methods

T_2 relaxation rates of venous blood of a single healthy male volunteer were acquired *in vivo* with written, informed consent at a 3T Tim-Trio MRI system (Siemens AG, Erlangen, Germany). The method published by Bolar et.al. makes use of a SE echo train to quantify T_2 combined with a venular targeted velocity selective spin labeling (VT-VSSL) to have signal of venous blood only. Details can be found in Bolar et.al.[4] To achieve a short echo-spacing, low resolution and parallel imaging techniques are necessary, reducing the highly sought after SNR at the same time. In our approach, multishot EPI readouts are used to reduce the readout time and thus to shorten the echo-spacing, hence accomplishing a significantly higher resolution (4x4x10mm nominal compared to 7.8x7.8x10mm with 40 averages each) in a total measurement time of 5:22min (TR=2s) per control/tag dataset.

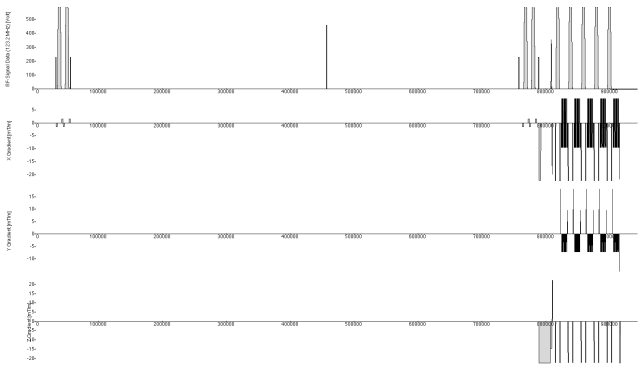

Figure 1: Sequence diagram of QUIXOTIC sequence

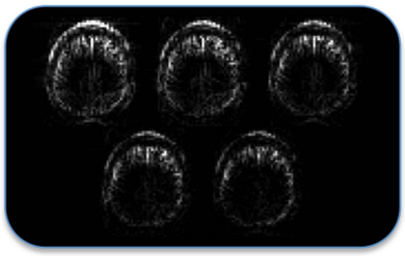

Figure 2: QUIXOTIC mean difference images at five different echo times (top left to lower right: TE=20ms;40ms;60ms;80ms;100ms)

Results

Applying an exponential fit to the five different echo times of the venous-blood-only voxels results in a mean value of T_2=87ms. Assuming a normal Haematocrit (Hct) of 0.46, this would result in a Y_v=0.76. Both values are in good agreement with the values given in the literature[4].

Discussion / Conclusion

In this preliminary study it has been shown that it is possible to acquire QUIXOTIC based Y_v values in a shorter acquisition time and with a higher spatial resolution than the published method. Further development of the method will lead to higher accuracy and faster acquisition techniques, enabling $CMRO_2$ quantification and comparison to the gold standard ^{15}O measurements from *simultaneous* MR-PET. Furthermore, this imaging scheme is currently being implemented in combination with the TRUST method[5]. Simultaneously performed PET and MR measurements will enable a valuable comparison and will thus pave the way for the use of MRI in the evaluation of $CMRO_2$ in a variety of diseases.

References

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