Low-power stochastic decoupling for ^{13}C MRS of human TBI patients

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Introduction

Traumatic brain injury (TBI) is a major health problem worldwide and is the leading cause of mortality and disability of young adults in the developed world. Abnormalities in brain energy metabolism have been reported following injury, such as an increased reliance on glycolysis as a means of producing cerebral energy.^{13}C magnetic resonance spectroscopy (MRS) allows measurement of in vivo relationship between neurotransmission and neuroenergetic pathways, making this technique ideal for quantifying the extent of these changes in human brain energy metabolism following TBI.

The position in the substrate where ^{13}C is enriched determines the chemical information obtainable and dictates the complexity of the experimental set up. [2- ^{13}C]glucose labels the downstream cerebral metabolites in the carboxylic/amide positions. The advantage here is twofold; only low-power RF decoupling is needed to remove the weak long-range J-couplings, improving spectral resolution and signal to noise ratios (SNRs), additionally there is no overlapping between down-stream ^{13}C-labelled metabolite peaks and the endogenous subcutaneous lipids' signals.

Methods

Measurements from a natural abundance aspartate/glutamine phantom were performed with a Siemens 3T MAGNETOM Skyra MR system using a Rapid dual-tuned Flex transmit/receive surface coil. A pulse-acquire sequence was modified to generate a stochastic decoupling waveform based on Li et al (2007)[1]. Decoupling performance of standard WALTZ-4 and stochastic decoupling were compared at varying RF decoupling powers.

Results

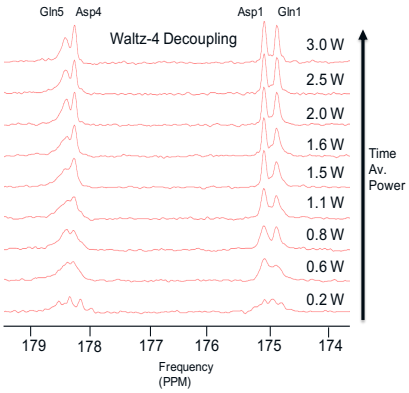

Fig 2. ^{13}C spectra acquired using WALTZ-4 decoupling at varying decoupling RF powers

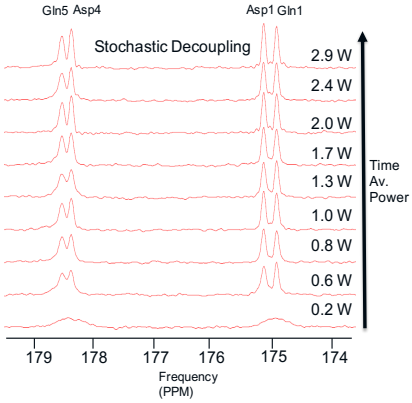

Fig 1. ^{13}C spectra acquired using stochastic decoupling at varying decoupling RF powers.

WALTZ-4 decoupling (Fig 1.) spectrally resolved the glutamine C5 (Gln5) and Aspartate C4 (Asp4) at a decoupling RF field strength (γB_2) of 179 Hz (2.0 W) while the stochastic decoupling scheme (Fig. 2) achieved this at a much lower γB_2 of 93 Hz (0.6 W).

Discussion

Glutamine (Glu) C5 resolution is critical as it provides a means to measure the glutamate/glutamine cycle – a major metabolic pathway. Gln C5 requires the most effective off-resonance proton decoupling performance due to the large spectral range of J-coupled protons (5.46 ppm). Figs. 1 and 2 show that the stochastic decoupling sequence resolves metabolite peaks at much lower RF powers.

Conclusion

Here, we have developed and shown that a pseudo-stochastic wave form based on the technique of Li et al. (2007) outperforms the standard WALTZ-4 decoupling technique at very low decoupling RF powers. We now plan to use stochastic decoupling in our novel in vivo [2-^{13}C]glucose infusion study on human TBI patients. These low RF powers will allow for simple translation to 7 T within SAR limits.

Reference

1. Li, S., Yang, J. & Shen, J. Novel strategy for cerebral 13C MRS using very low RF power for proton decoupling. *Magn. Reson. Med.* **57,** 265–271 (2007).