Assessment of the SAR and decoupling parameters calibration for {^{1}H}-^{13}C MRS at 3.0 T

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Introduction

Broadband proton decoupling (PD) is a useful technique for *in vivo* ^{13}C MRS [1]. The SNR may be improved by using a stronger magnetic field, however, since the PD power demanded correlates with a square of the Larmor frequency, safety issues must be considered. As a safety guideline, the IEC has defined the limits of the SAR and temperature rise induced by RF irradiation. In this study, we present a safety assessment procedure for *in vivo* proton decoupled ^{13}C MRS ({^{1}H}-^{13}C MRS) with a clinical 3.0 T MR system. The temperature rises inside an agar gel phantom were monitored for evaluating the safety levels of RF power in the human body and the PD conditions in a glucose phantom with various PD parameters were systematically investigated.

Material & Methods

All MR experiments were performed with a 3.0 T GE Signa equipped with a second RF channel exciter for PD (WALTZ-4 [2]). A ^{1}H/^{13}C dual transmit/receive surface coil was prepared. The SAR distribution of the agar gel phantom was adjusted to that of human muscle at 128 MHz. As a glucose phantom, unlabeled glucose was dissolved in water (1.67 mol/kg). Since the PD period was synchronized to the ^{13}C FID acquisition period, the parameters of the ^{13}C FID sampling points and the ^{13}C observation bandwidth were defined. From the ^{13}C liver spectra of two volunteers, it was confirmed that all peaks of glucose and its derivatives can be covered within 8 kHz. The FID was about 0.050 sec. Therefore, the PD period was determined to be 0.064 sec. TR of 1 sec and PD power below 63 W were employed for all experiments so that the SAR was reduced to below 10 W/kg.
The temperature changes in the agar phantom were monitored during the {^{1}H}-^{13}C experiment (68 min 32 sec) at the PD power of 50.1 W. A fluoroptic probe with four thermo-sensors (LUXTRON) was inserted perpendicular to the coil surface, where the strongest PD power was observed. Each of the thermo-sensors was located at a depth of 5, 10, 15 and 20 mm from the surface.
By changing the PD parameters, {^{1}H}-^{13}C MRS of the glucose phantom was studied. The 90^o pulse length of WALTZ-4 was varied from 0.5 to 9.5 msec at 0.5 msec interval and the PD power from 3.2 to 50.1 W at 1dB intervals. The center frequency was always set to the water proton resonance (4.73 ppm).

Results

Fig 1 shows the temperatures rises inside the agar gel at each depth during the {^{1}H}-^{13}C MRS experiment. The maximum temperature increase was approximately 0.7 °C at the depth of 5 mm at 68 min. At a pulse length of 1.0 ms, all glucose signals were decoupled when over 20.0 W of power was applied (Fig 2). On the other hand, decoupling required over 6.3 W at lengths of 7.5 to 9.5 msec. At pulse lengths of between 1.0 and 7.5 msec, 6.3 to 20.0 W was needed to achieve the decoupling.

Discussion and Conclusion

The maximum temperature rise in the agar gel phantom was 0.7 °C even with a PD power of 50.1 W. It was confirmed that the heating effect was within the acceptable range for human subjects defined by the IEC. Since the scan time of {^{1}H}-^{13}C MRS is assumed to be less than 15 min in clinical use, the heating effect may be negligible. In our previous report [3], the maximum temperature rise of the agar phantom was about 5.3 °C under the experimental conditions of the current study except for decoupling period of 0.256 sec (SAR: 16.52). These results indicated that direct measurement of the temperature change is still useful since the temperature rise is not necessarily proportional to the decoupling period.
With a shorter pulse length, more PD power was required to obtain the same signal intensities because of the wider range of frequency decoupling and the power dispersal at each frequency. The power needed to decouple all glucose signals with pulse lengths of 7.5 – 9.5 msec was threefold that at 1.0 ms. The glucose phantom test will be useful for optimizing the PD conditions and confirmed the validity of the pulse width, RF power and center frequency that the range of the PD frequencies covers all metabolites of interest.
In conclusion, it was demonstrated that {^{1}H}-^{13}C MRS using a 3.0 T MR system is potentially useful for *in vivo* dynamic monitoring of metabolites with these preparatory phantom tests. Several clinical applications have been reported using natural abundance {^{1}H}-^{13}C MRS at 1.5 T. At 3.0 T, more detailed information on ^{13}C metabolites can be obtained to clarify the dynamics.

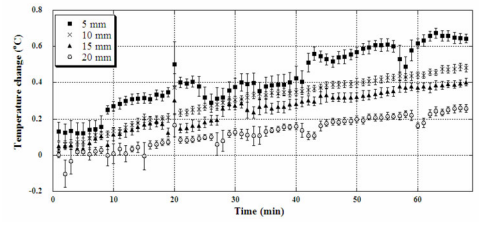

Fig 1. The temperature rises in the agar gel phantom at each depth from the coil surface during a proton decoupled ^{13}C MRS experiment with a decoupling power of 50.1 W.

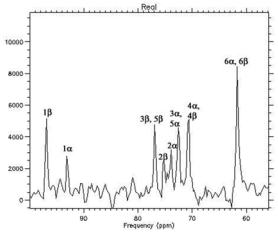

Fig 2. ^{13}C MR spectra of glucose phantom: decoupling power of 50.1 W and the 90^o pulse length of WALTZ-4 of 1.0 msec.

References

1. Waugh JS. ***JMR*** 1982;**50**:517.
2. Shake AJ et al., ***JMR*** 1983;**53**:313.
3. Matsuda T et al., ***12th ISMRM*** 2004: p2442.