Establishing the Safety of Clinical ^{13}C MRS with Proton Decoupling

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Introduction:

^{13}C-^{1}H decoupling technique is well known to enhance signal intensity and spectral resolution. However we need to pay compensation for this useful technique, which is temperature elevation in human body. To use 13C MR spectroscopy for clinical, we have to design the method not to increase temperature in the body. When we apply typical pulse sequence for ^{13}C-^{1}H, two levels proton RF power are applied. One has high peak power irradiation and another has low power for NOE. High peak power is applied during collection of 13C NMR signals. Shorter sampling duration allows less temperature increase. In order to minimize sampling duration, we studied effectiveness of pre-measurement of FID length. An agar phantom was used to measure temperature elevation with two different irradiation periods. And decoupling effect and change of signal intensity were measured on proton-decoupled 13C spectra acquired from the calf muscle of volunteers.

Materials & Methods:

All studies were performed on a 3.0 T MR scanner (GE Signa VH/i). A dual paddle coil (GE Medical Systems) is used for transmit and receive. The proton coil dimensions were 185mm x 110mm; the 13C coil was 85mm x 75mm. The proton decoupler is a stand-alone accessory provided by GE, which is hard wired to give a bi-level WALTZ-4 of 1msec durations sequence with 10% of full decoupling power during relaxation intervals to maintain NOE. 13C spectra were acquired with the conditions of 248micro sec hard pulse excitation, 8000Hz spectral width and one sec TR.

Pre-measurement of RF irradiation periods: 13C FID signal was measured from human liver to determine ideal RF irradiation periods. 2048 points were sampled.

Heating measurement experiments with agar phantom: Measurement was performed at the point where the temperature probe was inserted in agar phantom. The temperature of the probe was monitored during the proton decoupled 13C MRS experiment for seventy minutes. Temperature probe was inserted into an agar gel phantom above the ^{1}H and ^{13}C coil element in the expected position of the hottest VOI. The decoupling periods of 64msec and 256msec were tested under the 48dBm decoupling RF power.

Volunteer Study: Proton decoupled in vivo calf muscle 13C spectra were obtained from two healthy volunteers. The parameters for 13C were data sampling point 512 and the number of excitations 64. For ^{1}H, decoupling RF period 64msec and decoupling power 48dBm were applied.

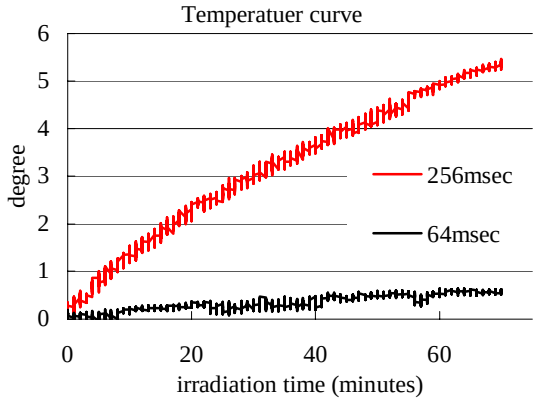

Fig1. Observed temper of an agar phantom. The upper line obtained under the 256msec decoupling periods under the 48dBm decoupling RF power..

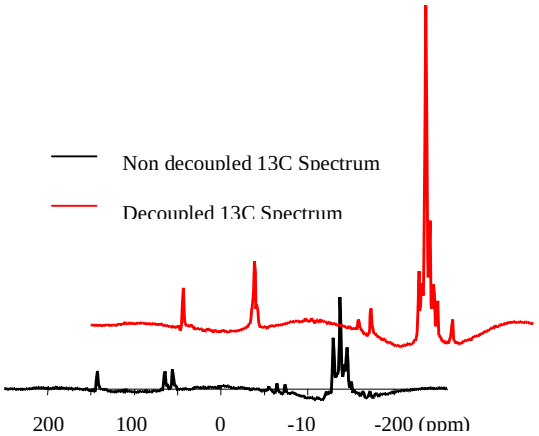

Fig2. 13C spectra from the calf muscle of a volunteer. Upper spectrum is proton decoupled. 64msec decoupling RF period and 48dBm decoupling power was used.

Results:

In vivo ^{13}C NMR signal disappeared about in 50msec. We determined data sampling period of 64msec. This means high power RF period for proton decoupling is 64msec. Figure 1 shows the temperature change curves of agar phantom under the proton decoupling. In one-hour proton decoupled ^{13}C MRS experiment, the temperature of the agar phantom increased about 0.6 ^{o}C with the proton decoupling time of 64msec, whereas it was 5.0 ^{o}C that with 256 ms. This means shorter data acquisition time is effective to reduce temperature elevation. Proton decoupled 13C spectrum of the calf portion from a volunteer is given in Fig2 (74sec acquisition). The effects of decoupling and about 3 times large signal intensity are seen clearly.

Discussion and conclusions:

When proton-decoupling period was increased by four, the temperature rose by about a factor of eight a in a phantom over 1 hour (Fig.1). Minimize decoupling period was more effective in order not to elevate temperature generated by second channel RF excitor. We determined decoupling time to 64msec by observing the 13C FID in vivo. When we obtained the spectrum from normal temperature patient under the above-mentioned conditions, it is thought that protein denaturation is not incurred in cells during heat shock at proton decoupler because elevation of temperature is below 1^{o}C under the one-hour examination from our heating experiments. We performed how to measure optimized sampling duration using pre-measurement of FID from human and measured FID length was useful for volunteer scan to minimize temperature elevation.