Proton T₂ measurement of Lactate in Brain Tumors at 3T

Akshay Madan¹, Sandeep Ganji¹, Zhongxu An¹, Elizabeth Maher¹, and Changho Choi¹
¹UT Southwestern Medical Center, Dallas, Texas, United States

TARGET AUDIENCE: MR spectroscopists and Neuro-oncologists/radiologists.

PURPOSE: Lactate (Lac) is elevated in tumors and has been extensively studied because of its potential use in clinical diagnosis. Lac has a prominent resonance at 1.31 ppm which appears as a doublet at short echo times. This signal is overlapped with lipid signals which are also elevated in many tumors, thus Lac is often measured using long echo times, at which the Lac signal at 1.31 ppm becomes an inverted doublet while the lipid signal remains positive and is markedly attenuated due to the effects of short lipid T₂. We aim to accomplish precise measurement of Lac T₂ and absolute quantification of its concentration with corrections for the T₂ relaxation effects.

METHODS: In vivo T₂ of Lac was measured in 18 glioma patients, the set of gliomas comprised 10 low grade (4 grade II oligodendrogliomas, 4 grade II astrocytomas and 2 grade II oligoastrocytomas) and 8 high grade gliomas (5 grade III anaplastic oligodendrogliomas, 2 grade III anaplastic oligoastrocytomas and 1 grade III anaplastic astrocytoma). Written informed consent was obtained prior to in vivo scans. All experiments were carried out on a 3T scanner (Philips Medical Systems Inc) using a body coil for RF transmission and an 8-channel phased-array coil for reception. Water-suppressed metabolite data and unsuppressed water data were acquired using single voxel PRESS sequence from a T₂w FLAIR hyperintensity region at 8 echo times (TE = 58, 88, 118, 148, 178, 208, 238, 268 ms). The voxel size was 20x20x20 mm³ and TR = 2 s. The number of sampling points were 2048 with a spectral width of 2500 Hz. For each TE, 16 signal averages were recorded. Water signal was suppressed using a four-pulse scheme. The total scan time for T₂ measurement was 5 minutes. Residual water signal was removed using the HL-SVD filter of JMRUI. Data was apodized with a 2-Hz exponential filter. Eddy current compensation and frequency drift corrections were performed using in-house Matlab programs. Spectral fitting was performed using the LCModel software. The basis function for fitting included numerically calculated model spectra of 22 brain metabolites calculated using published chemical shift and J coupling constants with volume localization RF and gradient pulses. The metabolite signal estimates from LCModel were fitted to a monoexponential curve as a function of TE’s to obtain the T₂ value. A two tailed unpaired t-test was performed to determine whether the estimated T₂ values differed between the tumor grades and subtypes.

RESULTS AND DISCUSSION: Figure 1 (a) and (b) shows the phantom and in vivo spectra respectively along with LCModel fits and residuals. The in vivo data was obtained from a FLAIR enhancing region (tumor mass) in a subject with grade III anaplastic oligoastrocytoma. The signal strength of the singlets (NAA, Cr, Cho) reduced with increasing TE due to T₂ relaxation whereas for Lac the signal strength as well as the spectral pattern varied with TE due to T₂ signal decay and the J coupling effects. The calculated Lac signals at 1.31 ppm shown in Figure 1 (c) are nearly identical with the spectral pattern in the phantom data. The experimental spectra were well reproduced by LCModel fit at all TE’s with very small residuals. Figure 2 (a) and (b) shows the monoexponential fittings for the singlets and the Lac multiplet for the data in Figure 1. Signal decay vs. TE was well represented by monoexponential fits, giving coefficients of determination (R²) close to unity. The T₂ of Lac in phantom was 621 ms. The T₂’s of Lac, tCr and tCho in the tumor were estimated to be 252 ms, 153 ms and 291 ms respectively. Figure 3 shows the T₂ values and the coefficient of determination (R²) for Lac, tCr and tCho in the tumor spectra from figure 1. The T₂ values and the coefficient of determination (R²) are also shown.

CONCLUSION: The Lac T₂ was similar between tumor grades and subtypes. The T₂ of Lac was estimated to be 246 ± 20 ms, which can be used to correct for the T₂ relaxation effects and quantify Lac in all tumors.


ACKNOWLEDGEMENTS: This study was supported by NIH CA159128 and CPRIT RP101243.