Model-Based Reconstruction of Hyperpolarized [1-^{13}C]-Pyruvate

James Bankson[1], Christopher Walker[1], Wolfgang Stefan[1], David Fuentes[2], Matthew Merritt[3], Yunyun Chen[4], Craig Malloy[3], Dean Sherry[3], Stephen Lai[4], and John Hazle[1]

[1]*Department of Imaging Physics, UT MD Anderson Cancer Center, Houston, TX, United States,* [2]*UT MD Anderson Cancer Center, Department of Imaging Physics, Houston, TX, United States,* [3]*Advanced Imaging Research Center, UT Southwestern Medical Center, Dallas, TX, United States,* [4]*Department of Head & Neck Surgery, UT MD Anderson Cancer Center, Houston, TX, United States*

Target Audience

This work may be of interest to scientists that are developing substrates for hyperpolarized MRI or developing new strategies for imaging these agents.

Purpose

Dissolution dynamic nuclear polarization provides more than 10,000-fold increase in signal from key metabolic agents such as [1-^{13}C]-pyruvate[1]. Hyperpolarized (HP) pyruvate is the most widely studied HP agent to date because of its favorable kinetics, relatively long T_1, and the central role of pyruvate in metabolism. HP pyruvate of particular interest in oncology[2] because metabolism is often altered in cancer and affected by therapy. Imaging of HP agents such as pyruvate is challenging due to the transient and non-renewable signal enhancement that is depleted with each excitation pulse. We describe a constrained reconstruction algorithm that combines prior spatial information from ^{1}H MRI and a kinetic model (Figures 1-2) to minimize new information that must be encoded and measured from observations of HP pyruvate and its metabolites.

Methods

The kinetic model and constrained reconstruction algorithm were implemented in Matlab. The kinetic model was tested against a variety of animal models using dynamic pulse-acquire spectroscopy (TR 2s, 10°-15° excitation). For imaging, a radial multi-band frequency encoded spectroscopic imaging sequence[3] (TR/TE 750ms/165ms, 20° excitation, 3cm FOV) was used to acquire data from anesthetized tumor-bearing animals following administration of 80mM HP pyruvate (200uL). Constrained reconstruction enforced consistency between prior information and observations that were spatially and temporally under-sampled.

Results

The two-compartment model of Figure 1 agreed very well with dynamic spectroscopic observations from a variety of animals models (Figure 2). The constrained reconstruction algorithm allowed estimation of dynamic image data as spatially and temporally continuous functions (Figure 3).

Discussion & Conclusion

The model-based constrained reconstruction algorithm improved our ability to visualize dynamic evolution of HP pyruvate and lactate from undersampled imaging data. This framework can be integrated with alternative models and/or imaging strategies to allow optimized distribution of spatial and temporal sampling for HP MRI.

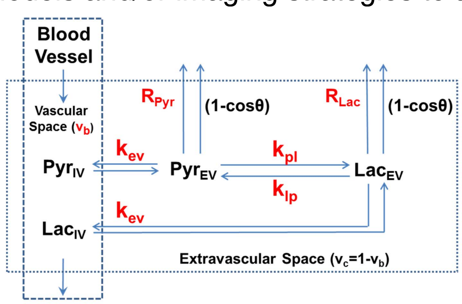

Figure 1. Kinetic model with two physical (intra-/extravascular) and two chemical compartments (pyr/lac).

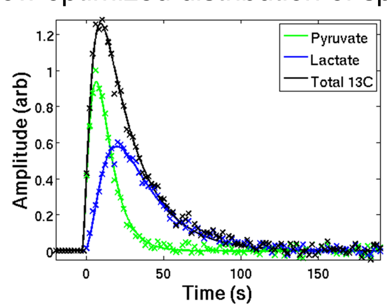

Figure 2. Kinetic model (line) agrees with observations (symbols) from many models.

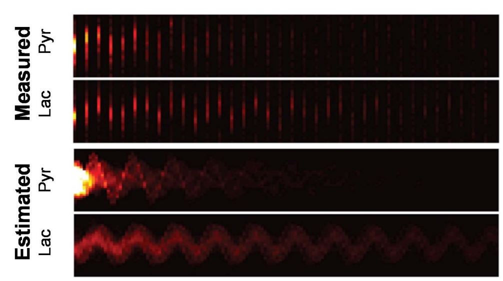

Figure 3. Undersampled (top) and resampled (bottom) sinograms from constrained reconstruction.

References

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