Ultrafast 3D Imaging of Hyperpolarized 13C In Vivo

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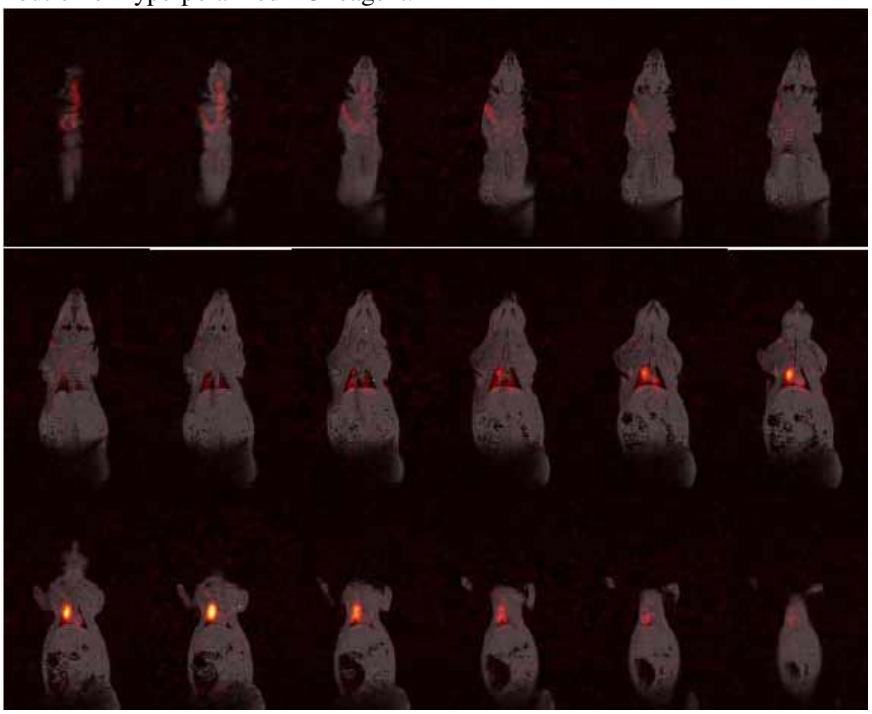
Objective: Develop a fast 3D MR imaging method for providing maximum intensity projection (MIP) angiographic images using hyperpolarized ^{13}C-labeled reagents *in vivo*.

Background: : PASADENA (Parahydrogen And Synthesis Allow Dramatically Enhanced Nuclear Alignment) or PHIP (Parahydrogen Induced Polarization) method of enhancing nuclear spin polarization has recently been improved and demonstrated to produce ^{13}C polarizations (P) of order unity for the nascent products of molecular addition by parahydrogen. MR imaging performed immediately following hyperpolarization provides a sensitivity that is ~10^4 times greater than the signal from the same population of molecules at equilibrium. This corresponds to a usable signal-to-noise ratio for a single repetition of this experiment that would otherwise require 10^8 repetitions (at least 10^8 s = 3 years). Thus, hyperpolarized reagents may allow real-time MR imaging of circulation, uptake and changes in metabolite concentrations *in vivo* .

Materials and Methods: To facilitate routine PASADENA trials, GE Healthcare, Malmo has developed an automated polarizer for the initial steps of synthesis and polarization transfer, presently installed at the Huntington Medical Research Institutes, Pasadena. The polarizer was individually optimized for the production of two hyperpolarized water soluble molecules; a: ^{13}C 2-hydroxyethylpropionate , b: ^{13}C sodium cis-fumarate. Fast multiple-phase 3D-FIESTA ^{13}C imaging was performed on a clinical GE 1.5T scanner before, during and after injection of the hyperpolarized molecule into the jugular vein of rats.

Results: The transient 3D-FIESTA ^{13}C MR imaging technique acquired 24 sequential 3D data sets of images in 1.5 minutes and were obtained with a single injection of hyperpolarized reagent. The MIP images derived from the 3D-FIESTA images demonstrate the extent of signal enhancement in the cardiopulmonary circulation. Figure 1 below shows representative ^{13}C 3D-FIESTA 0.3 second time-lapse images overlaid on 18 coronal proton images to demonstrate the anatomical distribution of hyperpolarized ^{13}C reagent.



Conclusion: A 3D-FIESTA sequence was effective for imaging hyperpolarized ^{13}C reagents produced in a custom-built parahydrogen polarizer enhancing SNR 25,000-fold. *In vivo* signal enhancements in PASADENA exceed 2000-fold.

Reference: Bhattacharya, P.; Harris, K.; Lin, A. P.; Mansson, M.; Norton, V.; Perman, W. H.; Weitekamp, D. P.; Ross, B. D. (2005) *MAGMA*, 18.5.

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