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Experimental approaches to cardiac imaging with hyperpolarized [1-^{13}c]pyruvate: a feasibility study in rats with a 3T clincal scanner

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Introduction

The use of animal models in basic and preclinical sciences offers the possibility of testing new biomarkers, as well as to obtaining predictive model of the compound distribution and profile.

Purpose

This study was designed to evaluate the performances of a clinical 3T scanner together with a Dynamic Nuclear Polarization for ^{13}C metabolic imaging in rats.

Methods

Animal model

10 healthy rats (350±20g) were examined with ^{1}H MR imaging and hyperpolarized ^{13}C MRS. The rats were sedated with infusion of Zoletil (50 mg/kg/h i.v.) and injected intravenously with 2 mL of 80 mM [1-^{13}C]pyruvate over 5 s; ECG, temperature, respiration and blood pressure from femoral vein catheter was monitored by SA instruments (SAI Inc).

Polarization

[1-^{13}C]pyruvate hyperpolarization was performed with a *Hypersense* DNP polarizer (Oxford Inst.Ltd.). The formulation contained 80 mM [1-^{13}C]pyruvate, 40 mM TRIS buffer, 0.27 mM Na_2EDTA, 41 mM NaCl, and 5 μM Dotarem (Guerbet). The solution was isotonic (290mOsm) and pH ~ 7.6 at ~ 37 C

MRSI

The experiments were performed at 3T GE Signa HDx (GE Healthcare) scanner with a ^{13}C dual-tuned rat coil. High resolution anatomical images were acquired in all three planes using a fast-spin echo sequence. ^{13}C dynamic spectra were acquired using elliptic-FIDCSI (GE Healthcare) pulse sequence without phase-encodings (bandwidth 5000Hz, 256 pts, 10° FA). For spatial information the same elliptic-FIDCSI sequence, with a bandwidth= 5000, 256 pts, TR=80msec, FA=10°, 10mm axial slice, 80x80 mm FOV and phase encoding matrix 16x16 was used.

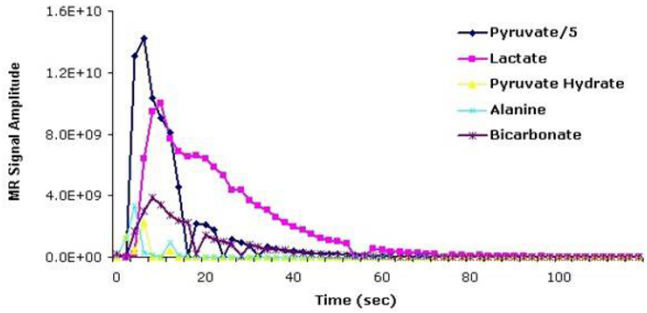

Figure 1

Data processing

Data processing was performed by using Matlab® and jMRUI software tools. Pyruvate, lactate, and bicarbonate were estimated using the AMARES algorithm of jMRUI and the metabolic curves and maps were generated.

Results

Dynamic curves of pyruvate and its metabolites are shown in Figure 1. The [1-^{13}C]pyruvate, [1-^{13}C]pyruvate hydrate, ([1-^{13}C]lactate, [1-^{13}C]alanine and [1-^{13}C]bicarbonate have been detected in the heart volume. The dynamic curves demonstrated that the conversion of [1-^{13}C]pyruvate to its metabolites occurred within a timeframe of 40 s after the injection. 2D CSI maps are reported in Figure 2. The images depict the combined effect of metabolism, blood flow and T_1 relaxation.

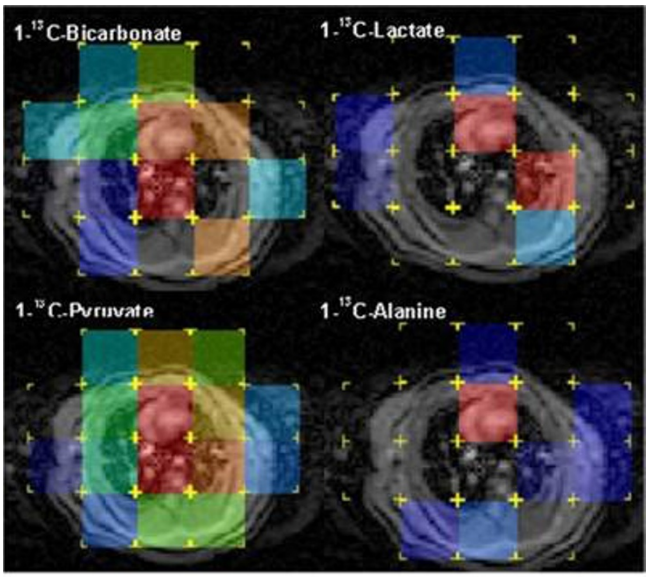

Figure 2

Conclusions

The spatial localization of ^{13}C metabolite in the rat heart can be achieved at 3T clinical scanner with a multiple voxel peak analysis with some limitations (spatial resolution). The feasibility of the same approach can be explored in larger compartments (liver, skeletal muscle) for small animal.