

Hyperpolarization [1-¹³C] pyruvate magnetic resonance spectroscopy imaging to detect metabolic changes in liver in a high-fat diet rat model

Joao Piraquive Agudelo¹, Shubhangi Agarwal¹, Ting Sun¹, Robert Bok¹, John Kurhanewicz¹,
Cornelius Von Morze² and Michael Ohliger¹

¹ Department of Radiology and Biomedical Imaging, University of California

² Biomedical Magnetic Resonance Laboratory, Washington University School of Medicine

Introduction

Non-alcoholic fatty liver disease (NAFLD) is the most common cause of chronic liver dysfunction and a significant public health problem worldwide with substantial rise in prevalence over the last decades. Non-alcoholic steatohepatitis (NASH) is the progressive and severe form of NAFLD. The key histological features of NASH include macrovesicular steatosis, ballooning degeneration of hepatocytes and inflammation. Patients with NASH show much higher risk of clinically significant and progressive liver fibrosis and cirrhosis, and potentially to hepatocellular carcinoma (HCC). The purpose of this study is to determine if HP ¹³C magnetic resonance spectroscopy imaging (MRSI) can be used for noninvasive diagnosis and monitoring of liver injury by measuring the conversion [1-¹³C]pyruvate-to-lactate.

Methods

NAFLD was induced in ten Zucker diabetic fatty rats by using a methionine-choline deficient diet (MCD), which is high in fat. MRSI acquisitions in rat livers were performed on a 3T Bruker system with a ¹H transmit-receive volume coil and a quadrature coil for ¹³C experiments. All rats were imaged in two time points, before and after 16 weeks, under MCD diet. For each experiment, 2.3 mL 80mM [1-¹³C]pyruvate was injected intravenously over 12s and the images were acquired 20s after the start of the injection. A spiral chemical shift imaging (CSI) with a slice thickness of 8 mm, field of view 60 x 60 mm² with a matrix size of 128 x 128, flip angle of 5° and 15 dynamic points, was acquired over 45s. ¹³C metabolite maps were generated by integrating the spectral peaks of each metabolite over time.

Results

Preliminary MRSI results, obtained from the baseline, showed the conversion of pyruvate to lactate and alanine in rat livers. The ratios lactate/pyruvate and alanine/pyruvate were 0.44 ± 0.22 and 0.36 ± 0.19 , respectively.

Conclusion

The present study is focused on using HP ¹³C MRSI to detect noninvasively metabolic changes in rat livers fed with a high fat diet. The metabolite ratios will be calculated for rats after 16 weeks on diet and compared with those obtained from the baseline.

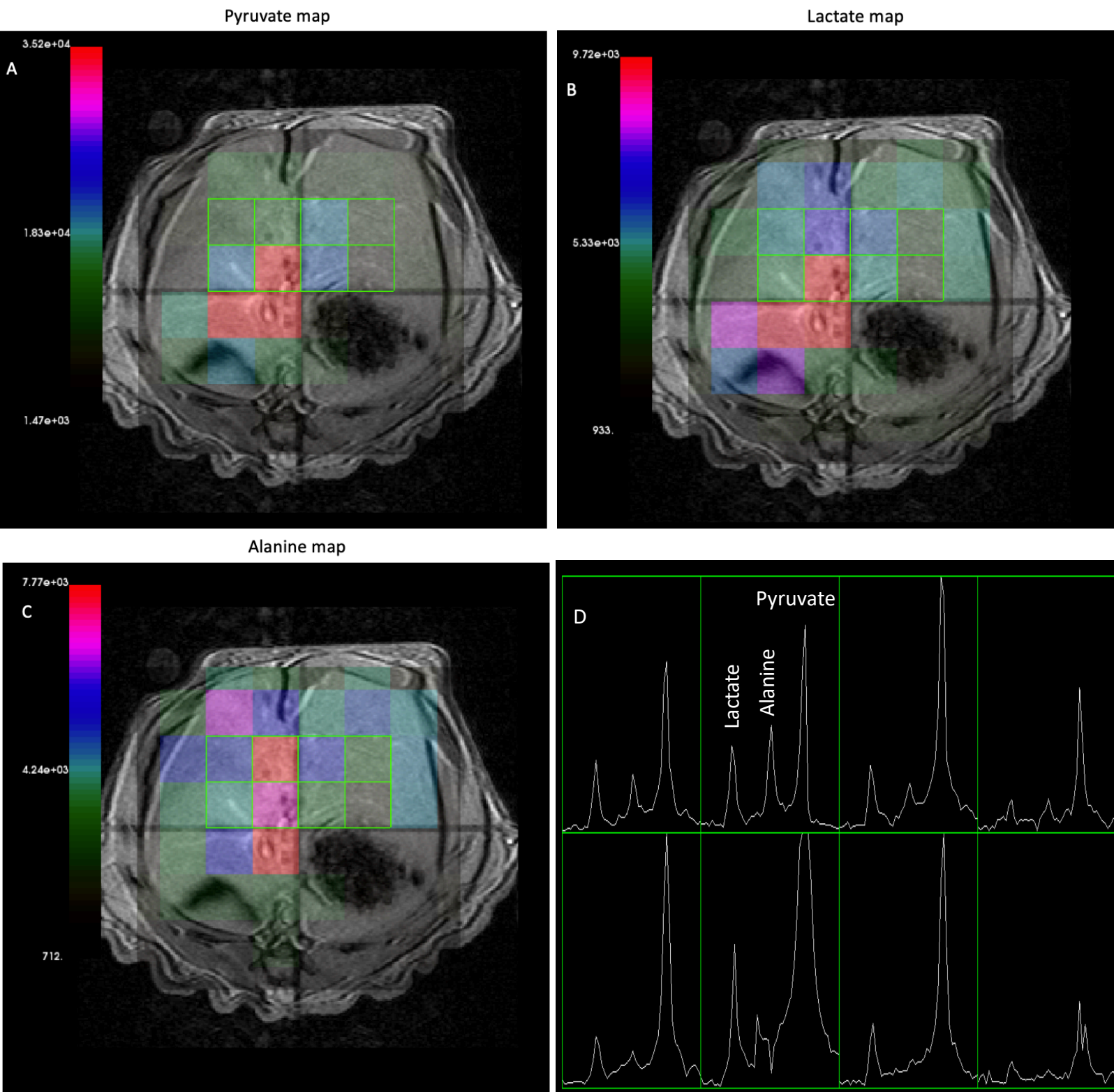


Figure 1. Pyruvate (A), lactate (B) and alanine (C) maps are shown overlaid on ^1H axial anatomic image of a rat liver. (D) shows localized spectra (green box at (A), (B) and (C)) from pyruvate and its conversion to lactate and alanine in the liver for the first dynamic time point.