BOLD MRI Signal Analysis of Activated Human Liver

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Introduction:

BOLD (blood oxygenation level-dependent) contrast has been demonstrated in the liver, following certain challenges, in rats and humans [1,2]. As a metabolic center and highly vascularized organ, the liver actively responds to metabolic challenges with increased inflow blood and blood volume in the hepatic parenchyma. The effect is exacerbated in the liver between fasted and postprandial states [3].

In the present study, fasted human liver was stimulated through ingestion of a controlled meal resulting in dynamic modulation of T2*-weighted images. Analysis of hepatic signal vs. time provides a baseline for healthy liver response to a standardized challenge. The approach is hypothesized to hold potential as a reproducible and feasible way of assessing liver physiological status and, in turn, possibly serve in screening of human liver disorders.

Methods:

Healthy human subjects (n=3) were asked to fast for 12 hours after which MR examination was done using a GE Signa 3T (GE Healthcare, Waukasha WI) system and 8-channel torso phased array coil. The images were acquired with free-breathing in the sagittal plane. With this plane cranio-caudal and anterior-posterior motions remain in-plane, minimizing through-plane motion as would be observed if axial acquisition were chosen. A T2*-weighted GRE EPI sequence was used (α=90°, 1 NEX, TE=35ms, TR=250ms, 24cm FOV, and matrix 64×64). Scanning was done for 5.4 minutes with 1300 evenly sampled images during which ingestion of a controlled meal (1 can of Ensure Plus, Ross Prod. Div., Abbott Labs, Saint-Laurent, Que., Canada) was performed by subjects with aid of a straw. Ingestion (2 minutes in length) began 30s into scan.

In-plane image motion was corrected using software written in-house based on the correlation coefficient template matching algorithm [4]. Using motion-displacement data, corrected images were extracted using Matlab (Ver. 6.5, The Mathworks, Natick MA). From the motion compensated template region ROIs within liver parenchyma were selected and analyzed using ImageJ (public domain image processing program).

Results and Discussion:

Following a meal, there is increased blood flow from the gut to the liver, and therefore increased blood volume in the liver parenchyma. We hypothesized that the T2*-weighted image intensity would increase. However, in the liver parenchyma, an approximate 70% decline in BOLD signal intensity followed by elevation to a level 20% higher than baseline (i.e. fasted state) was observed (**Fig. 1**).

To demonstrate BOLD signal difference we show subtraction of images (**Fig. 2**) corresponding to time points '**a**' and '**b**' from **Fig. 1** (i.e. one with maximum, the other with minimum average ROI BOLD signal intensity). The controlled meal caused a decrease in image intensity within liver parenchyma region as well as blood vessel region. The initial signal drop may indicate higher rate of liver oxygen consumption relative to blood flow as metabolic machinery become activated. It has been previously shown that O_2 saturation in the superior mesenteric vein (drains into hepatic portal vein) increases following a meal [5]. This would be reflected in increased liver parenchyma BOLD signal. However the signal overshooting over baseline levels implies increased oxygen delivery, probably through hepatic artery delivery. Further experiments are currently underway to further characterize healthy liver tissue.

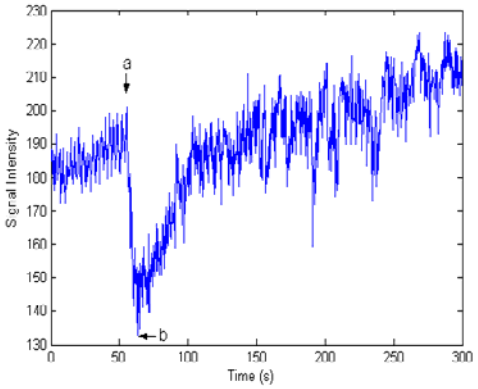

Fig. 1. BOLD signal vs. time

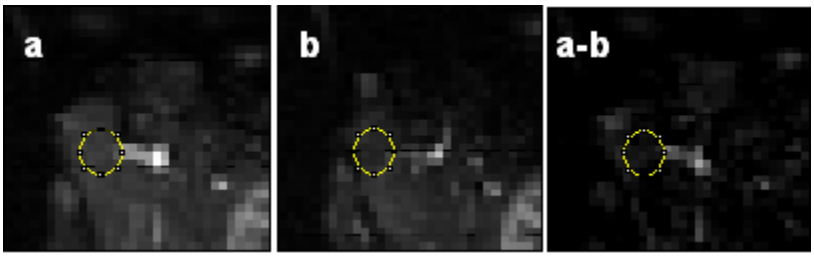

Fig. 2. Sagittal GE- EPI images at times (a) and (b), and subtraction

References:

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[4] Sussman *et al.* (2003) *IEEE Trans Med. Img.* 22:206;
[5] Li *et al.* (1997) *Radiology* 204:71.