A simple approach for improving lipid SNR for hepatic fat measurement with 1H MRS

G. Gambarota[1], M. Tanner[1], J. Berg[2], R. V. Mulkern[3], and R. D. Newbould[1]
[1]GlaxoSmithKline, London, United Kingdom, [2]Radiology, University Hospital of Malmö, Sweden, [3]Radiology, Children's Hospital Boston, Boston, MA, United States

Introduction

Assessing lipid content in liver is of interest for number of pathologies and for observation of metabolic changes during therapy [1]. Magnetic resonance spectroscopy (MRS) is rapidly becoming the method of choice for non-invasive assessment of lipids in liver [2]. To avoid artifacts due to liver motion, MRS is often performed with a breath-hold approach [3, 4]. Given this limited amount of time available to perform the acquisition, it is of interest to maximize the signal-to-noise ratio (SNR) per unit time of the fat resonances, since the fat tissue levels are one to two orders of magnitude lower than water tissue levels. Previous studies [1-4] have used repetition times (TR) of 1.5-2 seconds, which is more optimized for water SNR. We hypothesized that, by a proper choice of a shorter TR, it might be possible to substantially increase the fat SNR in breath-hold MRS of liver, and thereby increase the precision of the calculation of the fat content in the voxel.

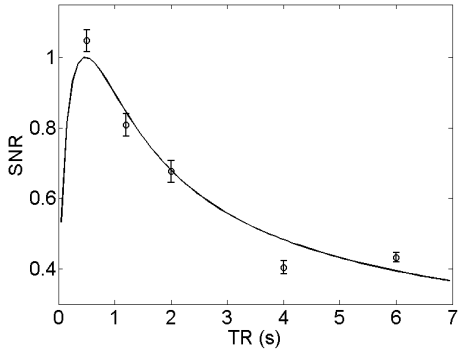

Fig.1. *SNR per unit time of fat in liver at 3 T. Fat SNR is maximum in the 400-600 ms range. Whiskered circles indicate the experimental SNR calculated from in vivo spectra.*

Materials and Methods

The lipid SNR per unit-time [5] was calculated using published values of liver fat T1 at 3T [6]. MRS experiments were performed on a clinical 3 T Tim Trio Siemens scanner (Siemens Healthcare, Erlangen Germany). After first- and second-order shimming, spectra of a 2x2x2 cm^3 VOI (positioned in the right hepatic lobe of the liver) were acquired using PRESS, in healthy volunteers (n = 3). Spectra at various TR (0.5-6.0s) were acquired using 512 readout points over 2.0 kHz bandwidth and the experimental SNR was compared to the theoretical SNR. The scan time of each breath-held spectrum was 12 sec.

Results

The fat SNR per unit-time obtained from the analytical formula showed a maximum approximately at 500ms [**Fig. 1**]. Since the normalized fat SNR at TR=2s is ~0.7 times the SNR at 500ms [**Fig. 1**], the shortening of TR yields an ~40% SNR improvement. Good agreement was observed between simulated and experimental data [**Fig. 1**]. The liver spectra showing the lipid resonances as a function of TR [**Fig. 2**] demonstrates increased SNR as TR approaches 500ms.

Discussion

We propose a **S**hort **TR** **E**nhanced **S**pectroscopic **S**ignal (**STRESS**) method to improve lipid SNR in liver MRS. The limited time available to perform the breath-hold acquisition requires optimal choice of sequence parameters to maximize lipid SNR. Liver MRS studies are typical performed at TRs of 1500ms or greater [1-4]. As the T1 of lipids at 3T is relatively short [5], it is possible to improve lipid SNR by properly shortening the TR. For calculation of water/lipid ratios, a standard T1 correction factor can be used. It should be noted that even at the more commonly used TR's of 1.5-2s water recovery (T1≈800ms [6]) will also be incomplete. Alternatively, the acquisition of a single-shot spectrum (i.e. long TR) will provide the fully relaxed water content.
The increased lipid SNR comes at the penalty of increased water saturation. However the SNR of the water peak is typically very high, such that the decrease will not affect the reproducibility of the experiments. The increase in lipid SNR could also be exploited, for instance, to measure more accurately the lipid T2 [3]. Another approach for liver MRS is to perform data acquisition in free-breathing condition. However, partial volume errors occur, and a motion-correction post-processing is needed in order to take into account variation in phase during measurements. Such post-processing tools are not generally available on clinical scanners.

Conclusions

We conclude that it is possible to substantially improve the SNR of the fat in breath-hold MRS of the liver, by choosing an appropriate TR. This new current approach has the advantage of experimental simplicity and can be applied to routine clinical sequences, such as STEAM and PRESS.

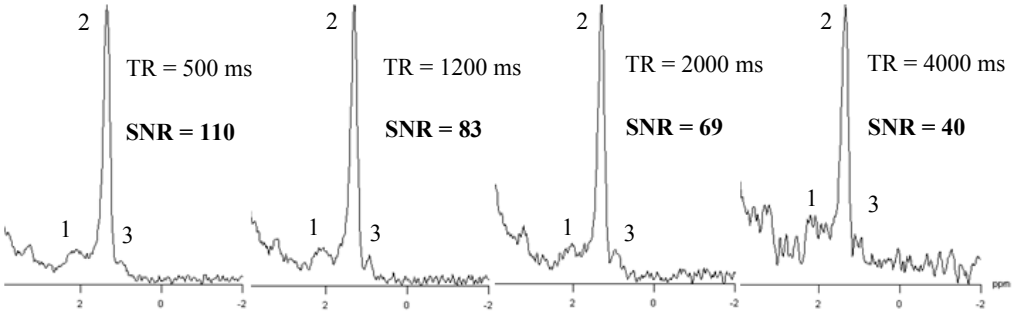

Fig.2. ^{1}H MR PRESS spectra of liver (TR increasing left-to-right). The scan time of each spectrum is 12 s. The lipid SNR per unit time increases with decreasing TR. Peak **1** = CH_2, 2.1ppm. Peak **2** = $(CH_2)n$, 1.3ppm. . Peak **3** = CH_3, 0.9ppm.

References
[1] Szczepaniak, LS et al., Am J Physiol Endocrinol Metab. 2005, 288, E462-8. **[2]** Machann J, Magn Reson Med. 2006;55:913-7. **[3]** Sharma, P et al., J Magn Reson Imaging. 2009;29:629-35. **[4]** Hamilton, G et al., J Magn Reson Imaging. 2009;30:145-152. **[5]** Ernst, RR, Anderson, WA., Rev Sci Instrum. 1966;37:93-102. [6] De Bazelaire, CMJ et al., Radiology. 2004;230:652-9.