Volume selective MRS of the liver for determination of hepatic lipids – is there a need for cardiac and/or respiratory triggering?

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Introduction
Determination of hepatic lipids by means of volume selective ^{1}H-MRS has become of increasing importance in the last years [1] as this ectopic lipid compartment has been shown to be involved in the pathogenesis of insulin resistance and Type 2 Diabetes [2]. Commonly, spectra are acquired during normal breathing [3], a single breathhold [4] or volunteers are asked to be in expiration during data acquisition and to breathe flatly during the TR interval (voluntary breath triggering, VBT) [5]. However, liver is a moving organ and examinations of the liver may be affected by breathing and the beating heart. Line-broadening or even two signals for each resonance are possible due to susceptibility effects when spectra are recorded during free breathing. Aim of this study was to examine differences in hepatic lipid quantification for cardiac triggering, respiratory triggering, combination of both, VBT and free breathing.

Material and Methods
Spectroscopic examinations were performed in 5 healthy volunteers on a 3 T whole-body-imager (Magnetom Tim Trio, Siemens Healthcare, Erlangen, Germany). After morphologic imaging, a volume of interest (3x3x2 cm³) was placed in posterior part of segment 7 of the liver avoiding inclusion of major vessels. A single voxel PRESS technique with a TE of 30 ms was chosen. Thirty-two acquisitions were recorded without water suppression (bandwidth: 2 kHz). Minimum TR was 4 s in order to reveal comparable longitudinal relaxation characteristics. Triggering was performed as following: ECG-triggering in the late diastole, respiratory triggering by 2D Prospective Acquisition Correction (PACE) on the diaphragm (gradient echo imaging with a temporal resolution of approx. 100 ms, acceptance window: ±2mm, acceptance position: 25%). Six spectra were recorded for each volunteer: 1. combined ECG+PACE-triggering, 2. PACE-triggering alone, 3. ECG+VBT, 4. ECG and free breathing, 5. VBT alone and 6. free breathing. Post-processing of the spectra was performed by manual integration of water signal and methylene/methyl-signals of lipids. The ratio of lipids and water was calculated and HL are expressed as percentage of water signal. Additionally, FWHM was determined.

Results
Volunteers were characterized by different amounts of HL, ranging from 1.9% to 8.5%. Figure 1b shows exemplary spectra of a male volunteer with low HL recorded with the mentioned triggering modalities. Spectra are of acceptable quality for ECG+PACE, PACE, ECG+VBT and VBT, however, there is an obvious line-broadening in the ECG+VBT-spectrum. Spectra recorded with free breathing and ECG+free breathing depict the mentioned line-splitting due to susceptibility effects caused by different breathing cycles, aggravating quantification of HL. Coefficient of variance for intraindividual HL with the different triggering modalities was very low for all volunteers (CV between 0.01 and 0.05), thus leading to very similar results. Linewidth of spectra showed clear differences with the lowest linewidths for PACE and VBT (25.8 Hz and 25.9 Hz), a slightly broader line for ECG+PACE and ECG+VBT (27.9 Hz and 30.7 Hz) and the broadest lines for ECG+free breathing and free breathing (32.4 Hz and 36.0 Hz). Individual linewidhts are shown in Fig. 1c. Acquisition time amounted to 5:38 min for ECG+PACE, 5:15 min. for PACE, 2:53 min. for ECG+VBT, 2:55 min. for ECG+free breathing, and 2:08 min. for VBT and free breathing, respectively.

Discussion
Quantification of hepatic lipids by ^{1}H-MRS has become a reliable non-invasive alternative to liver biopsy. However, for acquisition of spectra with good quality, some rules have to be considered. The present study shows that one should refrain from data recording during free breathing. ECG-triggering alone seems not to influence spectral quality whereas the combination of PACE and ECG or PACE alone leads to spectra of high quality with the drawback of clearly longer preparation and examination times. However, in cooperative subjects, voluntary breath triggering (VBT) – where the subject complies with the scanner after a short learning phase – seems to be the most beneficial and time-saving technique. Finally, it has to be mentioned that HL can be correctly determined by all of the mentioned strategies.

References
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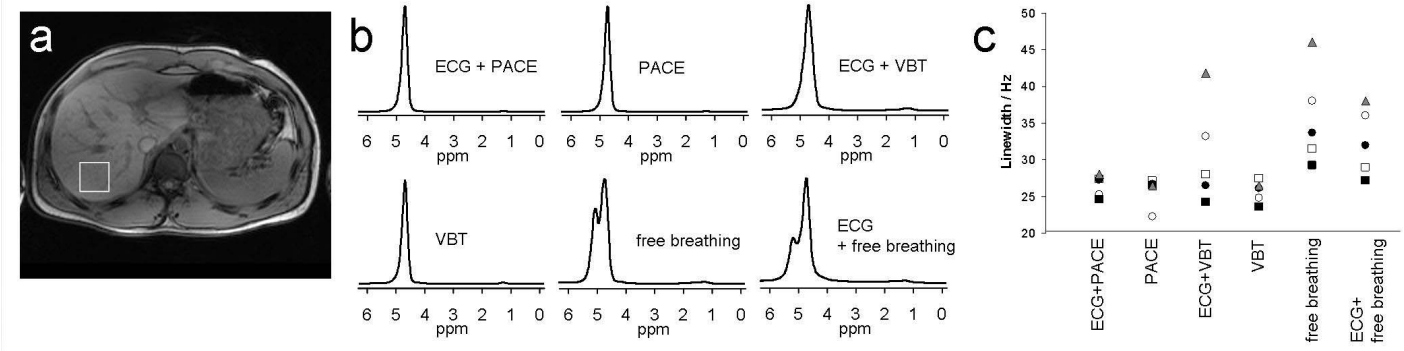

Figure 1: *(a) axial T1-weighted image of the liver with indicated VOI for spectroscopic examinations. (b) spectra recorded with different triggering modalities as indicated. (c) full width at half maximum (FWHH) of the water signal*