Real-time navigator gating in proton liver spectroscopy at 3T

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Introduction:
Proton MR spectroscopy was shown to be suitable for quantification of different lipids and TMA in the human liver but has not yet been recognized as a tool for liver disease diagnostics in the clinical routine. Most severe reasons are B_0 fluctuation and voxel displacement due to breathing and patient movement, which make free breathing measurements[1] difficult. Breath hold acquisitions[2] are able to decrease the influence of these artifacts, but require patient compliance. But this does not provide guarantee that the measurement position is stable. The use of real-time navigator gating (NG) during the data acquisition was shown to be a promising step to minimize the influence of breathing artifacts for MR spectroscopy in the heart[3] and it was also applied in an early study in the human liver[4]. However, the liver study suffered from a very high artifact content, poor water and additional lipid suppression by DANTE suppression bands, a limited spectral resolution (1.5 T, shim problems) and focused mainly on TMA detection. **Therefore, in this work**, the quality improvement of ^{1}H liver spectra due to real-time NG acquisition for simultaneous lipid and TMA quantification is demonstrated using inner-volume saturated PRESS at 3T, 1st order FASTERMAP shimming, water suppression and no fat suppression.

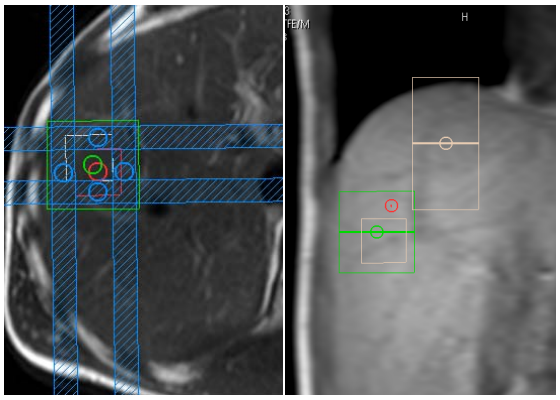

Fig. 1: Transversal and coronal image of the liver including the navigator position (brown) and the shim box (green). Due to the chemical shift artifact, by applying the PRESS localization the position of the lipids (red) and water (white) voxel is shifted. Applying IVS bands (blue) minimizes the chemical shift artifact.

Materials and Methods:
After the approval from the local ethics committee, five volunteers (3 female, 2 male) were consecutively measured at a 3T whole-body MR scanner (Achieva, Philips Medical Systems, Best, Netherlands) with a standard 6-element phased array cardiac coil. After applying a survey, a navigator[3] was placed through the right hemi-diaphragm. For accurate localization of the spectroscopy voxel at the end-expiration position, transversal and coronal navigator gated T_2 weighted TSE images were acquired (Fig.1). Standard PRESS (20x20x20mm^3, TR=3000ms, TE=30ms, spectral bandwidth=2kHz, 64 averages plus 16 averages of unsuppressed water spectra for phase and eddy-current correction, 1st order FASTERMAP[5] shimming), with CHESS based two-pulse water suppression (200Hz window, frequency selective excitation and dephasing followed by quasi-adiabatic frequency selective refocusing and dephasing) was used for localization. Voxel placement is indicated in Fig. 1; major blood vessels were avoided. Inner volume saturation (IVS) was used to minimize the chemical shift displacement between lipids and water (Fig.1). For comparison, the measurement was done with and without real-time NG (Fig. 2). Unfiltered MRS data were quantified using the 'liver-6' setting in LCModel[6].

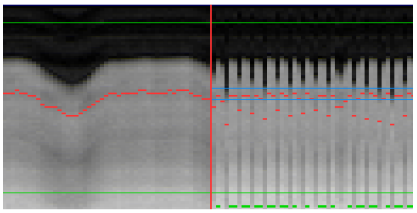

Fig. 2: Navigator display: the vertical line separates the preparation from the spectral acquisition. Two blue lines represent the gating window. Only acquisitions done in the window are added to the average.

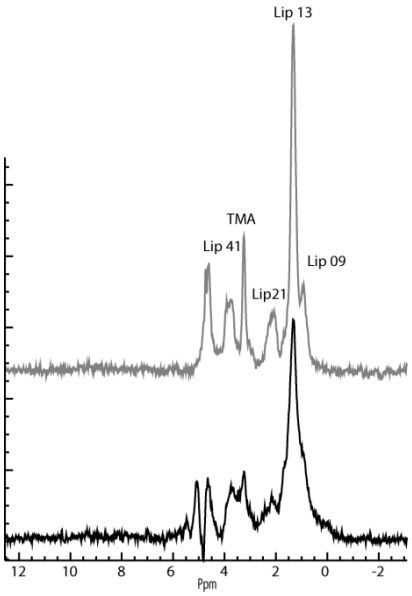

Fig. 3: Single voxel liver spectra of vol. 3. with (above) and without (below) NG. Spectra are zero-order phased and Gaussian filtered by 2Hz.

Results and Discussion:
Fig. 3 depicts the spectra measured in one volunteer during free breathing (below) and NG (above). The spectra contain contributions from TMA (tri-methyl amine group) and various lipid molecules. The spectrum measured with the NG technique shows a clear separation of different lipid (Lip) substances at 0.9, 1.3, 2.1/2.3 and 4.1ppm along with the TMA resonance at 3.2ppm. The level of residual water is in the order of magnitude of the metabolite peaks and no artifact could be identified in the spectrums while NG was used. The decrease in the FWHM of the water peak, using NG is (mean ± SD) 35.3% ± 13.8% (to 22 ± 4Hz) and the increase of SNR is 51.8% ± 36.9% (to 17 ± 6). Metabolite to Lip 13 (most prominent resonance line) ratios clearly show the reduced variation when NG is used (Fig. 4).Our study clearly showed that using real-time NG improves the SNR of the data and also the FWHM of the metabolite peaks. This leads to a more precise quantification. The improvement depends on the depth of the breathing of the subject, but is distinguishable also in very flat breathing (seen in vol. 4). The motion influence is diminished and the spectral quality measured with the NG technique is comparable to breath hold acquisition[2]. In addition, by using NG the measurement position is much more accurate, since the measurement is done in the same phase of the breathing cycle and does not depend on subject cooperation. The use of real-time NG technique may help to validate this method as a non invasive diagnostic tool, and thus improve early diagnosis of liver disease. The method is more time demanding than non-gated free breathing with scan times depending on the gating efficiency, but it is also applicable in non-compliant patients and children.

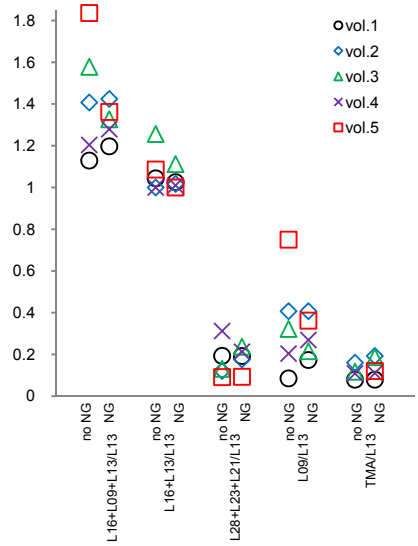

Fig. 4: Comparison of molecule ratios between NG and not gated data acquisition.

References:
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