In vivo 1H Liver Spectroscopy with Free Breathing 2D PACE

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Introduction

The use of breathhold scanning techniques has significantly improved the quality of clinical abdominal imaging. However, conventional MR spectroscopic examinations of abdominal organs such as liver or kidney do not lend themselves to breathhold techniques, and are hampered by respiratory motion, which leads to voxel displacement during the scan. For single voxel spectroscopy (SVS) examinations, the use of multiple averages together with voxel displacement can cause inhomogeneous spectral broadening and other artifacts resulting in sub-optimal spectra. For chemical shift imaging (CSI) examinations, the periodic respiratory motion can modify the point spread function (PSF) and hence cause voxel bleeding. Spatial misregistration of the spectra relative to the reference images can occur.

In imaging patients who cannot suspend respiration, motion compensation techniques such as 2D prospective acquisition correction (PACE) have proven successful [1]. During respiration, abdominal organs typically move over a range of 5 mm or less, but some of them exhibit larger excursions; the diaphragm and fatty tissues in the gut typically move ~15 – 20 mm [2]. Ghosting or blurring of lipid signals into voxels located in the organ or tumor of interest is likely to provide the most severe spectral degradation. For spectroscopy studies, where the voxel dimensions are typically 20 – 30 mm in each direction, tumor or organ excursions will be less than half the voxel dimension. The primary signals will be significantly affected; thus, motion correction techniques could be beneficial in these studies. Tyszka, et al reported that 1D-navigated single-voxel ^{1}H spectroscopy in the liver can improve spectral quality [3]. We describe in this paper the incorporation of 2D PACE into a single-voxel spin echo sequence to evaluate lipids and choline in liver and kidney.

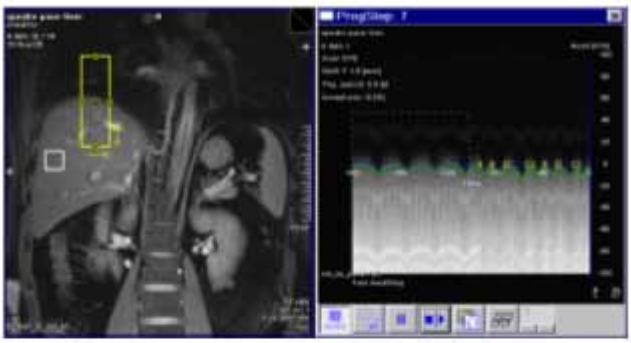

Figure 1: Selection of the 2D area (yellow box) used for detection of the diaphragm position when using 2D-PACE (left) and the respiratory curve of the trigger option (right). Half the rectangle covers the lungs, the other half covers the liver. The spectral voxel is represented by the square. The height of the small yellow boxes on the right shows the accepted motion tolerance.

Materials and Methods

2D PACE allows for imaging while the patient is breathing freely. Figure 1 shows the selection of the 2D area used for detection of the diaphragm position (rectangle) and the voxel of interest (square). The change in signal intensity of the rectangular region along the axis of the rectangle is used to determine the position of the diaphragm. The time needed to acquire an image for 2D PACE is ~100 ms. After a short "learning phase", the patient's breathing is analyzed and the central position of an "acceptance window" is calculated automatically, which determines the vertical width of the displacement of the diaphragm. With the current PACE implementation, the spectroscopy sequence is triggered to the quiet end expiration phase with either an automatically or manually defined acceptance window. The real time evaluation of the navigator signal allows for immediate start of the spectroscopy sequence part, as soon as the diaphragm position within the acceptance window is reached. Within one breathing cycle, only one spectroscopy average is measured, to minimize tissue displacement during the spectroscopic data acquisition.

All experiments were performed on a MAGNETOM Symphony scanner. Figure 2 shows *in vivo* localized single voxel spin echo MR spectra of the liver of a healthy volunteer with (left) and without (right) 2D PACE motion correction. The acquisition parameters were kept the same for both acquisitions: voxel size = 20 x 20 x 20 mm^3; TE = 30 ms, averages = 64; bandwidth = 1 kHz, total acquisition time = 5:20 – 5:40 min; TR_{eff} with PACE = 5360 ms; TR without PACE = 5000ms. The PACE acceptance window was +/-2 mm.

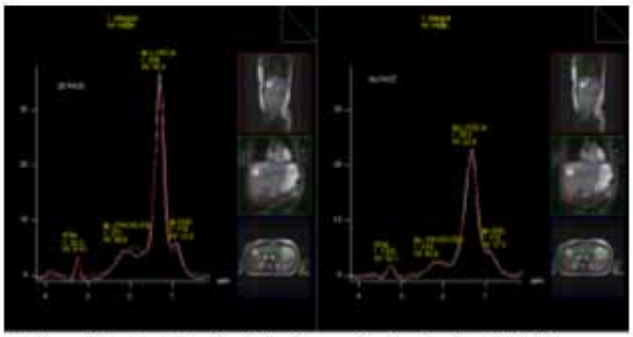

Figure 2: In vivo localized single voxel spin echo liver MRS images with (left) and without (right) 2D PACE.

Results and Conclusion

With 2D PACE, an exact triggering to the relatively motion free end expiration breathing phase could be realized. This prevents misregistration of spectroscopic signals and improves spectral quality, as shown in Figure 2: The triggered spectra (left) show clearly better definition of the total choline at 3.22 ppm and of lipid peaks. The better spectral resolution achieved with 2D PACE triggering is in addition indicated by the decreased line width (W) and increased amplitude of the fitted single peaks.

For abdominal MRS, the real-time prospective 2D PACE trigger technique provides a more comfortable examination of patients and ensures reproducible high quality spectra. Research on 2D/3D CSI with free breathing 2D PACE is ongoing.

Reference

1. Klessen C. et al. JMRI 2005, 21:576-582
2. A J Schwarz, et al. Phys. Med. Biol. 2000; 45: 2105-2116.
3. Tyszka JM, et al. MRM 1998; 39:1-5.