Improved Diagnostic Utility of T2-weighted 3D-TSE Liver Imaging by Suppression of Vascular Signals using a Motion-Sensitive Preparation

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Introduction: Single-slab, three-dimensional turbo/fast spin-echo (3D-TSE) pulse sequences with variable-flip-angle refocusing RF pulses [1,2] (e.g., SPACE [Siemens] or 3D FSE CUBE [GE]), when combined with navigator-based respiratory triggering, provide a sufficiently high sampling efficiency to permit high-resolution, T2-weighted 3D imaging of the liver in a clinically-reasonable acquisition time [3,4]. Although such acquisitions have the advantage of permitting retrospective multiplanar evaluation, the high signal intensity of small vascular structures within the liver makes it difficult to distinguish them from small lesions, particularly in the periphery. The purpose of this work was to evaluate the performance of a motion-sensitive preparation for suppressing the signal from vascular structures in T2-weighted 3D images of the liver.

Methods: In recent years, motion-sensitive preparations have been used widely to suppress the signal from flowing blood for vessel-wall imaging. A common form of such a preparation includes a driven-equilibrium RF pulse train (i.e., the transverse magnetization created by the first RF pulse is returned to the longitudinal axis by the last RF pulse) with interspersed gradient pulses to generate flow-induced dephasing [5]. Since our interest includes applications at both 1.5T and 3T, and since substantial variations in the B_1-transmit field (and hence flip angles) commonly occur for body imaging over the volume of interest at 3T, we implemented an adiabatic version of a motion-sensitive preparation based on a 0-degree BIR-4 pulse [6], as illustrated in Fig. 1. This pulse, composed of sequential adiabatic half-passage, full-passage and (time-reversed) half-passage segments, essentially acts as a 90°, 180°, 90° driven-equilibrium preparation. The motion-sensitive preparation was inserted just before each application of the excitation RF pulse of a SPACE single-slab 3D-TSE pulse sequence. The first moment associated with the motion-sensitization gradients applied on each axis could be selected on the user interface.

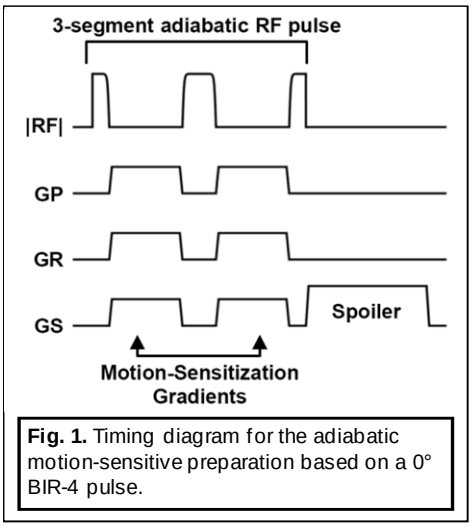

Fig. 1. Timing diagram for the adiabatic motion-sensitive preparation based on a 0° BIR-4 pulse.

A range of motion-sensitization parameters were evaluated in healthy volunteers on a 1.5T whole-body scanner (Avanto, Siemens Medical Solutions) by acquiring T2-weighted 3D image sets of the liver with selected values of the gradient first moments (<1000 mT-ms^2/m) and with the gradients set to zero. Typical pulse-sequence parameters included: TR 4-7 s (depending on respiratory rate); FOV 38 x 29 x 16 cm; matrix 384 x 290 x 30; ETL 157; echo-train duration 500 ms; fat suppression; parallel acceleration factor 2; averages 1.8; acquisition time 4-6 min. Without motion-sensitization, the center of *k* space was sampled at an echo time of 271 ms; considering the effect of the variable flip angles, the contrast was similar to that for a conventional echo-train with a TE of 100 ms. With motion-sensitization the time corresponding to the center of *k* space was shortened to 204 ms to offset the T2 weighting that occurred during the preparation. Informed written consent was obtained from all subjects prior to imaging.

Results: First moments of 300-500 mT-ms^2/m for the phase-encode and readout axes were found to be sufficient to suppress signal from the small vascular structures in the liver. A non-zero moment for the slab-select axis was found to generate ghosting artifacts along the slab-select direction. We believe that these artifacts occurred because, even though the acquisition was triggered to end inspiration, there was nonetheless some movement of high signal-intensity structures (such as the gall bladder) during the acquisition, primarily in the head-foot direction (slab-select direction for an axial acquisition). Thus, the first moment for the slab-select axis was set to zero in subsequent tests. In some cases, signal loss was observed in the vicinity of the vena cava, presumably due to the effect of the pulse wave on surrounding tissue; this signal loss was suppressed by ECG triggering. Further optimization will be aimed at avoiding signal loss in the region of the vena cava without the need for ECG triggering. Figure 2 shows representative axial images from a 3D-TSE acquisition of the liver without (left 2 images) and with (right 2 images) a motion-sensitive preparation. With the preparation, signals from small vascular structures throughout the liver are suppressed, while the signals from the biliary system are largely unaffected.

Conclusions: The addition of a motion-sensitive preparation to single-slab, 3D-TSE imaging is effective for suppressing the signal from small vascular structures in T2-weighted 3D images of the liver, thus eliminating potential ambiguity between vascular structures and small liver lesions. We anticipate that this improvement will enhance the diagnostic utility of single-slab, 3D-TSE imaging of the liver.

References:

1. Mugler JP et al. Proc ISMRM 8 (2000); 687.
2. Busse RF et al. Magn Reson Med 2006; 55:1030-1037.
3. McKenzie CA et al. Proc ISMRM 15 (2007); 725.
4. Lichy MP et al. Invest Radiol 2005; 40:754.
5. Wang J et al. Magn Reson Med 2007; 58:973.
6. Staewen RS et al. Invest Radiol 1990; 25:559–567.

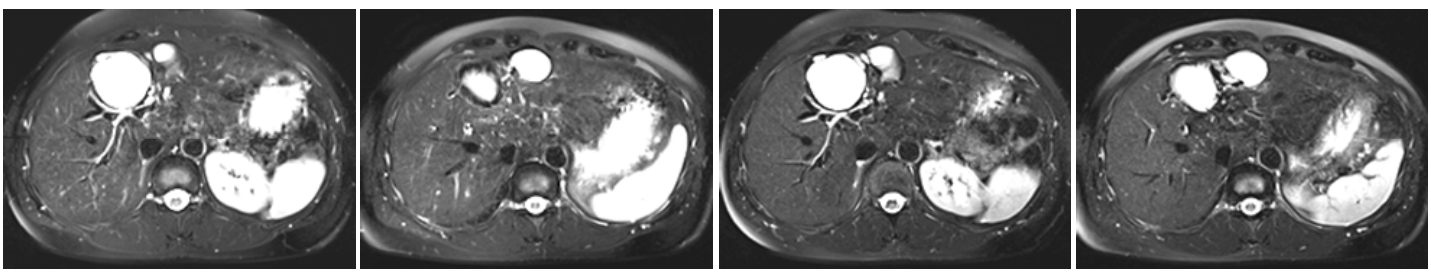

Fig. 2. Axial T2-weighted liver images from a healthy volunteer acquired using a single-slab, 3D-TSE pulse sequence without (left 2 images) and with (right 2 images) a motion-sensitive preparation that preceded each application of the excitation RF pulse. For motion sensitization, the first moments corresponding to the phase-encode and readout axes were 300 and 500 mT-ms^2/m, respectively.