Optimized Dual-Echo T1-Weighted Abdominal MRI at 3.0 Tesla

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Introduction

T1-weighted, dual-echo gradient echo sequences (GRE) are an integral component of liver MR examinations to observe fatty infiltration and assess fat content in lesions [1]. T1-weighting is achieved using a long TR (150-200 ms) combined with a large flip angle (50^o-80^o). The two required TEs are such that fat/water peaks are opposed- and in-phase, respectively. Also, blood flow should be suppressed to avoid flow-related ghosting artifact in the phase-encode direction [2].

Ideally, the acquisition covers the entire liver (18-20 cm) in a single breath-hold (20-25 seconds). At 3.0 Tesla, though, multi-slice, large flip angle acquisitions with spatial saturation (SpSat) deposit commensurately greater energy (SAR) than at 1.5 Tesla [3]; this can either compromise spatial coverage and/or resolution, or necessitate smaller flip angles which reduce SNR and CNR. And, the preferred opposed- and in-phase TE times at 3.0 Tesla are 1.14 and 2.27 ms, which place stringent demands on the hardware.

We have designed a 3.0 Tesla optimized, single breath-hold, asymmetric dual-echo GRE sequence that allows increased spatial coverage/resolution and large flip angle acquisitions. Moreover, it allows variable-rate application of SpSat and uses a SAR-efficient slice-to-slice time minimization procedure that satisfies all the governing-body SAR deposition requirements [4].

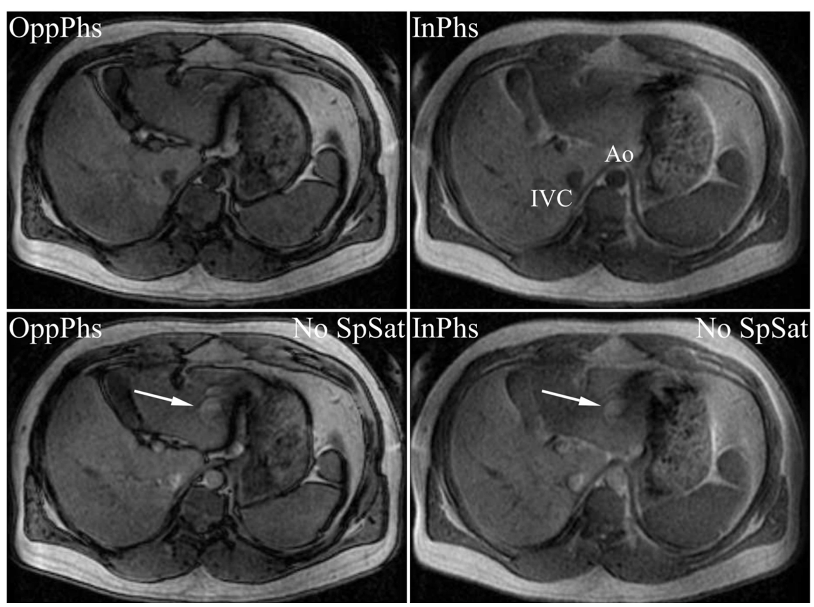
Methods

For body imaging, the allowed SAR deposition is ≤2.0 W/kg within 6 minutes but ≤6-8 W/kg within 10 seconds [4]. Consequently, we modified the vendor-provided 2D fast GRE pulse sequence (General Electric Medical Systems, Waukesha, WI; software release 8.5M38) as follows: (a) implemented two-echo fractional/asymmetric echo sampling (the default is single-echo), (b) allowed variable-rate application of SpSats within TR, (c) calculated the minimum slice-to-slice time based on gradient timings (T_{GRD}) and 10 second average SAR deposition (T_{10S}), (d) set the slice-to-slice time to the greater of T_{GRD} and T_{10S}, (e) modified the advisory panel to display breath-hold and total scan times, (f) added "cool down" time (hereafter T_{WAIT}) after the breath-hold to satisfy 6 minute average SAR requirements, and (g) adjusted the reported SAR deposition values to account for the T_{WAIT} time.

We scanned the abdomen in ten volunteers with the enhanced dual-echo GRE sequence using the following parameters: body coil, axial orientation, fractional echoes with TEs of 1.1 and 2.3 ms, 150 ms TR, 75^o flip angle, 7.5/2.5 mm slice thickness/gap, 19-21 slices, 40x30 cm^2 FOV, 160x160 matrix, ±125 kHz receive bandwidth, 1.0 NEX, either with or without superior/inferior SpSat bands. The breath-hold time was 19 seconds for all patients, and depending on patient weight, T_{WAIT} varied from 15-35 seconds.

Results

None of the volunteers experienced a feeling of warmth or discomfort. The liver-spleen contrast was qualitatively acceptable, but inferior to comparable acquisitions at 1.5 Tesla. The opposed-phase (OppPhs) images show the characteristic signal loss at fat/tissue interfaces compared to the in-phase (InPhs) images. Since both echoes are acquired simultaneously, they are inherently co-registered; this avoids any possibility of slice mis-registration. The aortic flow produced significant ghosting artifact (arrows) in the acquisitions without saturation (No SpSat); by comparison, the inferior vena cava (IVC), whose flow rate is much slower, produced negligible flow-related effects in this volunteer. In other volunteers, though, we sometimes observed IVC-related ghosting artifacts.



Conclusions

Asymmetric dual-echo GRE coupled with minimizing the slice-to-slice time with respect to T_{GRD} and T_{10S} permits efficient breath-hold abdominal T1-weighted, fat/water opposed- and in-phase acquisitions. This approach, followed by cool down time, allows us to scan rapidly while fully exploiting coverage/resolution benefits and chemical shift effects at 3.0 Tesla, eliminating slice mis-registration, and suppressing flow-related ghosting artifacts.

References

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