Ultra high spatio-temporal resolution hepatic MRI using a novel 2-point Dixon time resolved 3D SPGR sequence at 3T

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Introduction: Dynamic contrast enhanced MRI (DCEMRI) is commonly used in abdominal-pelvic imaging for detection and characterization of primary and metastatic lesions. Current methods have adequate spatial resolution but the temporal resolution is often insufficient for visualization of hypervascular tumors. Optimal timing of the contrast arrival and robust fat suppression are the two critical pieces in capturing the arterial phase and in improving lesion conspicuity. Recently, a novel DCEMRI technique called META (Multi-Echo Tricks Acquisition) [1] was introduced that combined a dual echo TRICKS [2] scan with a two-point Dixon fat-water reconstruction algorithm [3] to generate fat-only and water-only time resolved images at very high spatio-temporal resolution. This work reports initial clinical results of META on 23 patients referred for hepatic MRI evaluated against routinely used 3D Spoiled Gradient Recalled Echo (SPGR) imaging.

Methods: A dual-echo bipolar readout 3D SPGR pulse sequence with an elliptical centric TRICKS *k*-space interpolation scheme [1] was followed by an online two-point Dixon image reconstruction with a phase correction algorithm as described in [3]. Imaging parameters for META were as follows- 15° flip, $\pm$167 kHz bandwidth, TR/TE_1/TE_2 4-6/1.2/2.4 ms, (256-320)x192 matrix, 26-35 cm FOV, 48-60 slices, 3-4 mm thick, effective temporal resolution per phase was 4-5s. An auto-calibrating hybrid space parallel imaging [4] method (R=2.5-3) in the phase-encoding direction was used. For comparison, a conventional fat suppressed 3D SPGR sequence with 1D SENSE parallel imaging (R=2) was acquired with the similar acquisition parameters except BW was $\pm$83 kHz and TR/TE 3.5-4/1.2 ms. Timing bolus derived fat suppressed 3D SPGR images from previous clinical examinations were also available in some patients (n=7) and were used to compare the success of arterial phase capture. All breath-holds including scout scans were at end-expiration to maintain *k*-space consistency for the TRICKS scheme. Twenty three patients, referred for MRI of hepatic metastases or renal masses were imaged on a GE 3T Excite system (GE Healthcare, Waukesha, WI) under an IRB approved protocol with an 8-channel torso array coil using both pulse sequences. All images were qualitatively evaluated for quality of fat suppression (degree and uniformity), overall image quality, degree of artifacts, and efficiency of arterial-phase capture. The images were randomized and graded on a scale of 0-4 (0-worst, 4- best) through consensus review by two board certified radiologists. A non-parametric Wilcoxon signed rank test was used to compare qualitative ordinal image scores. An overall pulse sequence preference was also recorded.

Results: Figure 1 shows six phases- one pre-contrast (a) and five post-contrast (b-f) obtained using the META sequence with a temporal resolution of 4.5s on a patient with neuro-endocrine metastases. As a comparison, three post-contrast phases (g-i) from a previous exam obtained using a conventional fat suppressed 3d SPGR sequence with 18s temporal resolution, are also shown. Note the multiple hyper-vascular masses best depicted in phase 3 (1d) of the META sequence and visualization of the rapid enhancement and washout of the smaller lesions that occur as early as phase 2 (1c). Table 1 summarizes the image quality scores of the META sequence compared to the conventional 3D SPGR sequence. For three of the five qualitative metrics considered- degree of fat suppression, uniformity of fat suppression, and efficiency of arterial phase capture, the META scans scored significantly better than conventional 3D SPGR scans ($p < 0.05$). The arterial phase was adequately captured in all 23 patients for META. There were no significant differences in overall image quality and degree of artifacts between META and 3D SPGR images. Both the readers preferred the META sequence in 5 cases and had no specific imaging sequence preference in the remaining 18 cases.

Conclusion: The proposed META sequence provides excellent fat suppression at 3T and generates high temporal resolution multi-phasic images to allow visualization of structures with rapid contrast enhancement and washout. The use of elliptical centric TRICKS obviates the need for a timing bolus and offers modest immunity to motion artifacts that may occur due to respiratory motion near the end of the breath-hold period.

References: [1] Saranathan et al. Proc ISMRM p 651 (2008). [2] Korosec et al. MRM. 36:345-51 (1996). [3] Ma et al. MRM. 52:415-419 (2004) [4] Beatty et al. Proc ISMRM p1749 (2007)

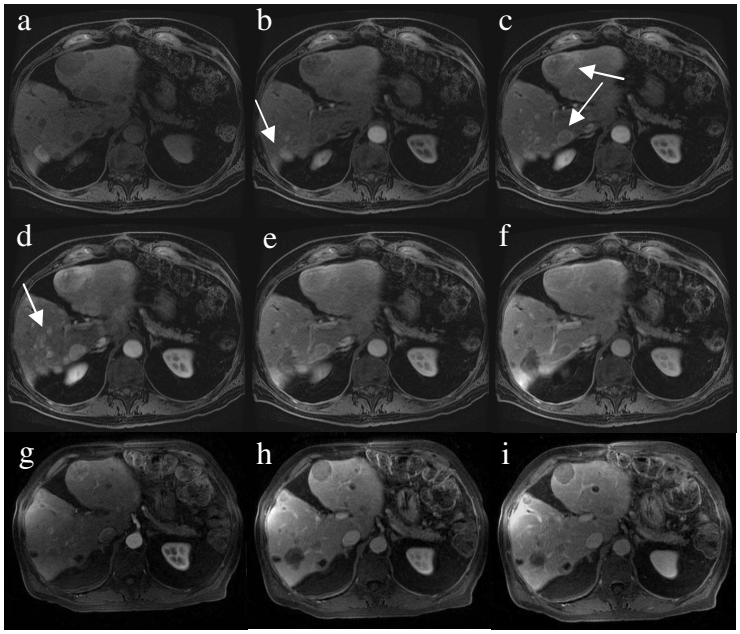

Figure 1. Six phases- one pre-contrast (a) and five post-contrast (b-f) phases obtained using the META sequence with 4.5s temporal resolution on a patient with neuro-endocrine metastases; three post-contrast phases from a previous study obtained using a conventional 3D SPGR acquisition with 18s temporal resolution (g-i) are shown for comparison

Table 1. Comparison of META and fat suppressed 3D SPGR imaging sequences (scoring scale 0-4, 0-worst, 4-best)

	META	3D SPGR	*p*-value
Arterial phase capture	3.96$\pm$0.21	3$\pm$0	<0.05
Degree of fat suppression	3.70$\pm$0.47	3$\pm$0.6	<0.05
Uniformity of fat suppression	3.70$\pm$0.47	2.87$\pm$0.69	<0.05
Artifacts	2.78$\pm$0.52	2.61$\pm$0.5	0.28
Overall image quality	3.0$\pm$0.52	2.74$\pm$0.54	0.11