Improvement of Gadoxetate Arterial Phase Capture With a High Spatio-Temporal Resolution Multiphase 3D SPGR-Dixon Sequence

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Introduction: Arterial phase imaging with gadoxetate disodium (Eovist, Bayer Healthcare) is challenging due to its small injected size, resulting in a brief temporal window of peak aortic enhancement. In this study, we sought to determine whether a high spatiotemporal resolution (STR) imaging method that uses a combination of parallel imaging and view sharing (DISCO) improves capture of the gadoxetate arterial phase.

Materials and Methods: In short, the DIfferential Sub-sampling with Cartesian Ordering (DISCO) sequence is based on a three dimensional (3D) fast SPGR-Dixon sequence with an elliptically ordered ky-kz that is segmented into four regions: the first representing the center of k-space (labeled A) and the remaining three representing equally distributed pseudo-random sub-samples of the periphery of k-space (labeled B1, B2 and B3) (Figure 1) (1). Fat water separation was performed using a two point Dixon reconstruction. All imaging was performed on a 3T MR750 system (GE, Waukesha, WI) using a 32-channel torso phased array coil. 0.025 mmol/kg of gadoxetate was administered at a rate of 2.5 mL per second with a standard 15 second delay. The first group of patients (conventional), included 37 patients imaged using a routine clinical 3D SPGR-Dixon (LAVA-FLEX) sequence using similar parameters to the high STR multiphase group. The high STR multiphase group included 48 patients imaged using the DISCO sequence with the following parameters: 320 x 224 matrix, ±167 kHz bandwidth, 15° flip angle, 3.0-4.4 mm section thickness reconstructed to 1.5-2.2 mm sections, TR/TE1/TE2 4.1/1.2/2.4, typical number of slices acquired per volume 60, 2 x 2 outer acceleration. The percent of studies with adequate arterial phase capture was calculated for each patient group. Image quality was graded by a board-certified radiologist on a five point scale for overall quality and the quality of fat saturation. Regions of interests (ROIs) were placed over the hepatic artery (HA) and adjacent hepatic parenchyma. The ratio of peak HA intensity to precontrast intensity within the HA as well as to adjacent hepatic parenchyma was determined for both average and maximum intensities within the ROIs. Within the conventional group, there were 14 hypervascular lesions, including 9 FNHs. In the high STR multiphase group, there were 28 hypervascular lesions, including 25 FNHs. Maximum lesion enhancements relative to precontrast images (pre_{max}) and relative to adjacent parenchyma ($adjacent_{max}$) were calculated. A chi-squared, Mann-Whitney U, Student t-test, and Wilcoxon signed rank test were used to determine differences between the two groups.

Results: The use of the high STR multiphase acquisition resulted in a higher rate of arterial phase capture. Overall 31/37 in the conventional group, or 84% (95% CI: 72-96%), had an early or late arterial phase image, and 47/48 in the high STR multiphase group, or 98% (95% CI: 94-100%) had an early or late arterial phase (Figure 2 and 3: p < 0.001). Image quality and quality of fat saturation was not significantly different between the conventional and high STR multiphase groups (average image quality score of 3.72 ± 0.59 for high STR multiphase vs 3.59 ± 0.72 for conventional, Z = -1.00 and p = 0.32; average score of quality of fat saturation of 3.84 ± 0.41 for high STR multiphase vs 3.76 ± 0.43 for conventional, Z = -1.55 and p = 0.12). The ratio of hepatic artery intensity to precontrast hepatic artery intensity was greater with high STR multiphase compared to conventional acquisitions (Figure 4: average intensity ratio: 4.22 ± 1.54 for high STR multiphase vs 2.94 ± 1.04 for conventional, p < 0.001; maximum intensity: 6.18 ± 2.44 for high STR multiphase vs 4.03 ± 1.64 for conventional, p < 0.001). The maximum relative enhancement of lesions with respect to adjacent parenchyma was greater in lesions imaged with high STR multiphase compared to conventional acquisitions ($adjacent_{max}$ of 2.16 ± 0.67 for high STR multiphase vs 1.62 ± 0.46 for conventional, p = 0.01).

Discussion: The incorporation of temporal view sharing and parallel imaging to allow the acquisition of multiple arterial phases within one breathhold resulted in more reliable gadoxetate arterial phase capture compared to a conventional acquisition while preserving image quality with robust fat saturation. Additionally, relative hepatic artery enhancement and lesion enhancement improved significantly. With the high STR multiphase acquisition, the center of k-space is sampled roughly every 5 seconds, increasing the probability that the center of k-space is acquired during peak arterial enhancement.

Conclusion: The high spatiotemporal resolution multiphase DISCO acquisition provides clinically acceptable arterial phase capture without the use of bolus timing techniques or compromising spatial resolution or coverage.
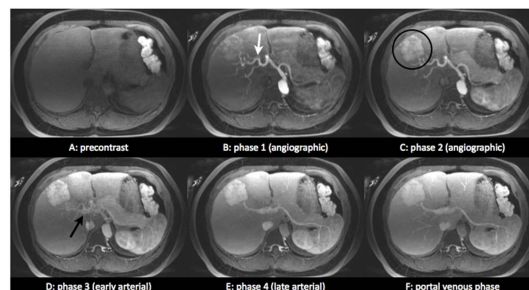
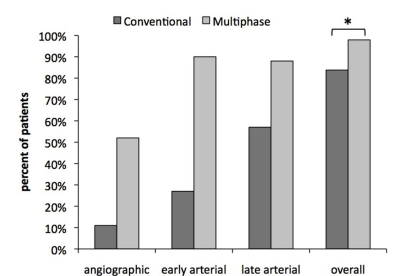**References**: (1) Saranathan et al. JMRI 2012.
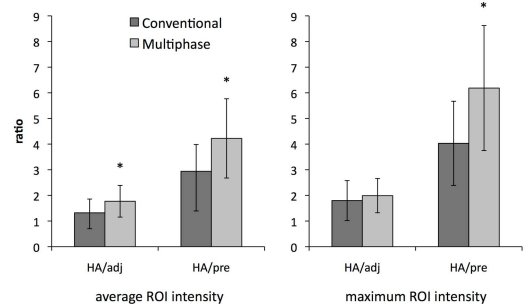
Figure 4: relative hepatic artery enhancement is greater in the high STR multiphase group
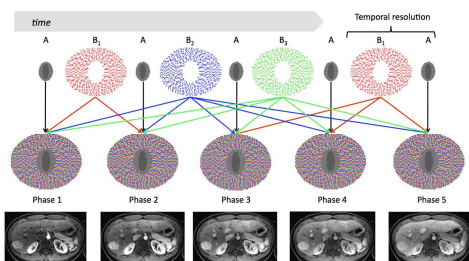
Figure 1: k-space acquisition strategy used in the high STR multiphase acquisition (DISCO)

Figure 2: example multiphase acquisition

Figure 3: arterial phase capture is more reliable in the high STR multiphase group