High spatio-temporal resolution contrast-enhanced MRI with view sharing improves detection of small hepatocellular carcinomas

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Purpose: Effective capture of the late arterial phase is essential for detection of small foci of hepatocellular carcinoma (HCC) in high-risk patients undergoing surveillance for this disease. In clinical practice, a fixed scan delay post contrast injection of 12-20 seconds is used with sequential k-space data acquisition to obtain a single arterial phase with the center of k-space being acquired approximately 30 seconds post-injection. Alternatively, lower spatial resolution with multiple phases can be used to increase the probability of capturing the late arterial phase (1). A new high spatio-temporal resolution DCEMRI technique called DISCO (DIfferential Sub-sampling with Cartesian Ordering) combines a dual-echo SPGR sequence with pseudo-random variable density k-space segmentation and a view sharing reconstruction in order to provide high spatial resolution images with a temporal resolution of ~4 seconds without sacrificing spatial resolution (2). The purpose of this study was to assess the added value of high spatio-temporal resolution acquisition on the detection of small HCCs.

Methods: Retrospective review of images from 20 consecutive patients referred for HCC screening on a 3T GE MR750 system (GE Healthcare, Waukesha, WI) using a 32-channel torso array coil was performed. After administration of a gadolinium-based contrast agent, 7 post-contrast phases were acquired with a temporal resolution of 4s in a ~28s breath-hold. Imaging parameters were as follows: 12° flip, +/-167 kHz bandwidth, TR/TE1/TE2 4.1/1.2/2.4 ms, 320x224 matrix, 30-35 cm FOV, 3 mm thick, 60 slices, ARC parallel imaging with 2x2 acceleration.

Analysis: The fourth and sixth phases were considered to be approximately equivalent to conventional scanning with an 18 and 26 second post-injection scan delay with sequential k-space acquisition, respectively. Each patient's scan was interpreted three times, once using the data from phase 4 in isolation, a second time using phase 6 in isolation, and finally utilizing the information from all 7 phases. Using all seven phases of the DISCO acquisition was said to change the diagnosis if, on the single phase (either phase 4 or 6), the arterial enhancement of the lesion was missed (either too late or too early) in a lesion that arterially enhanced on other phases and was noted to washout out on subsequent imaging, thereby making it concerning for HCC. In addition, the estimated contrast-to-noise ratio (CNR) of largest suspicious arterially enhancing lesion was calculated on phase 4, phase 6, and on the phase where it was most visible. CNR was defined as (SI lesion – SI background liver)/SD background liver, where SI = signal intensity and SD = standard deviation.

Results: Compared with phase 4, having all 7 phases provided by DISCO resulted in a change in diagnosis in 7 cases (35%) compared to interpretations based on phase 4 in isolation. In 3 cases, phase 4 was too late and missed the arterial enhancement of the lesion(s); in 2 cases, arterial enhancement indicating recurrence near a site of prior transarterial chemoembolization (TACE) was missed; and in 2 cases, phase 4 was too early and multiple foci of arterial enhancement seen on subsequent phases were undetectable. Compared with phase 6, information from all 7 phases of the DISCO acquisition resulted in a diagnosis change in 4 cases (20%). In three cases, phase 6 was late and the lesion(s) were already iso-intense to liver parenchyma; in one case, enhancement in a lesion that had previously undergone TACE was missed. The use of the entire DISCO data set with 7 phases significantly improved the CNR of the hepatic lesions compared to phase 4 (10.2 $\pm$ 6.0 vs. 5.1 $\pm$ 3.7, p<0.05) and compared to phase 6 (10.2 $\pm$ 6.0 vs. 8.2 $\pm$ 7.0, p<0.05).
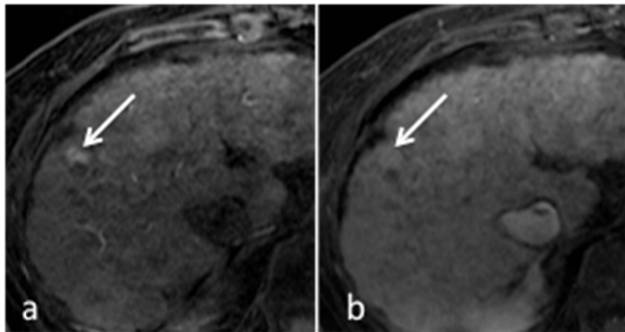

Figure 1: Phase 2 (a) demonstrates nodular arterial enhancement (arrow) suspicious for HCC in this patient with cirrhosis; on phase 6 (b), the nodule has become isointense to the surrounding liver parenchyma (arrow).
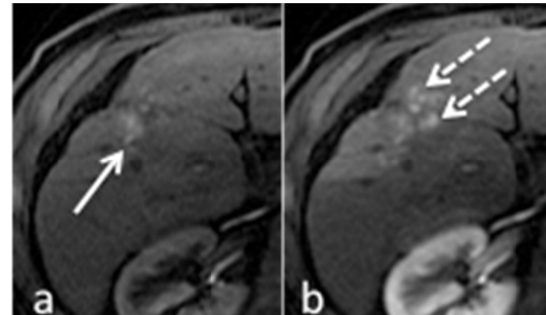

Figure 2: a) Phase 4 demonstrates an area of intrinsic T1 brightness (arrow) that was present on precontrast images (not shown); on phase 6 (b), multiple foci of arterial enhancement (dashed arrows) were seen in this patient with recurrent multifocal HCC that were not clearly evident just 8 seconds earlier (phase 4).

Conclusion: High temporal resolution (~4sec) dynamic contrast-enhanced images of the liver can be obtained in a single breath-hold without sacrificing spatial resolution. This type of acquisition has the potential to alter patient management by improving detection of small arterially enhancing lesions concerning for HCC in high risk patients undergoing surveillance imaging.

References: 1. Ringe et al. AJR. 2010 Jul;195(1):13-28; 2. Saranathan et al. Proc ISMRM, p2941 (2011).