Dynamic Contrast Enhanced MR Liver Imaging using IVD HYCR: Initial Experience

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INTRODUCTION

Dynamic contrast-enhanced (DCE) liver MRI is a powerful tool for the detection of hepatocellular carcinoma (HCC) [1]. HCC lesions demonstrate specific enhancement characteristics during the first pass of contrast agents with brisk arterial phase enhancement and washout during the portal venous phase [2]. Dynamic imaging of the contrast bolus with whole liver coverage and high spatial-temporal resolution is therefore important both for visualization of these characteristics as well as for potential kinetic modeling. Recently, a method of MRI liver perfusion entitled "IVD HYCR" has been developed [3], which combines Cartesian interleaved variable density (IVD) sampling [4], parallel imaging [5] and Cartesian HYPR (HYCR) [6,7] reconstruction to enable whole-liver perfusion imaging with isotropic 2 mm spatial resolution and 4 sec temporal resolution [3]. In this work, we present our initial experience using this method in both healthy and HCC patient volunteers.

	Healthy	HCC
0.1mmol/kg gadobenate	2	3
0.05mmol/kg gadoxetic acid	5	0

MATERIALS AND METHODS

Ten (10) liver perfusion exams (see table) were performed in this IRB-approved, HIPPA-compliant study using the IVD HYCR technique. All exams were performed on a 3.0T clinical scanner (GE Discovery MR750, Waukesha, WI, USA) with a 32-channel torso array. All exams were acquired with whole liver coverage, 2.0 mm isotropic resolution and a 4.0 sec/frame temporal resolution. After a 12-sec breath-hold pre-contrast baseline image acquisition, a single dose of contrast agent was injected (~15-20mL at 2mL/sec, with 25mL saline flush) and followed by three separate breath-hold acquisitions, each of 20-second duration. The sequence was paused between breath-holds. Other imaging parameters included: parallel imaging factor R = 2 × 2, IVD undersampling of 3, yielding a total acceleration factor of 12; flip angle = 12º; 75% fractional echo readout; TE/TR=0.9/2.6 ms; BW = ±83.33 kHz; FOV = 40×32×20 cm^3.

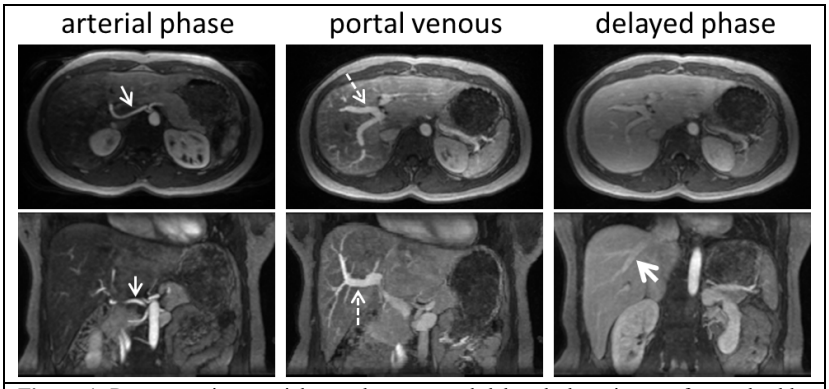

Figure 1. Representative arterial, portal venous and delayed phase images from a healthy volunteer after gadoxetic acid injection. Axial (top row) and coronal (bottom row) images are shown for the three phases with 2.0 mm isotropic resolution. The hepatic artery (thin solid arrows, left), portal vein (thin dashed arrows, middle) and hepatic vein (thick solid arrow, right) are well visualized in the three phases of enhancement. Respiratory motion artifacts are minimal.

RESULTS

Representative images from a healthy volunteer (0.05 mmol/kg gadoxetic acid) and two HCC patient volunteers (0.01mmol/kg gadobenate dimeglumine) are shown in Fig. 1 – Fig. 3. In Fig. 1, the hepatic artery, portal vein and hepatic vein are well visualized, and enhancement of the liver parenchyma can be seen in the delayed phase. In Fig. 2, a very large and heterogeneous HCC can be seen in the late arterial phase. In Fig. 3(a), many small HCCs are seen enhancing in the arterial phase, with contrast agent washout from these lesions seen in Fig. 3(b) (portal venous phase). This phenomenon is also depicted in Fig. 3d, which shows representative temporal waveforms for HCC and normal liver ROIs with size of 4 × 4 pixels. See figure captions for additional details.

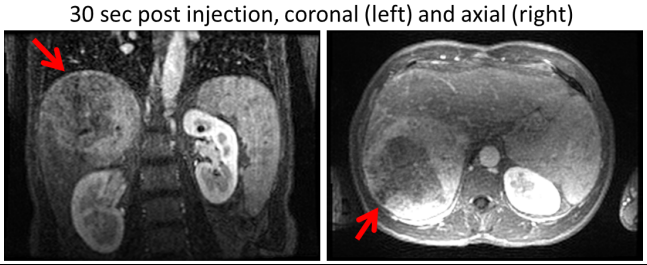

Figure 2. Late arterial phase images of an HCC patient volunteer after injection of Multi-hance. Coronal (left) and axial (right) images are shown, with the red arrow pointing to a very large and heterogeneous HCC in the liver. Resolution was 2.0 mm isotropic.

DISCUSSION

DCE-MR liver imaging is challenging not only due to its demand for rapid data acquisition, but also because of the protocol optimizations required to coordinate sequential breath-holds during the three phases of contrast enhancement, as well as the recovery periods in between the breath-holds. In Fig. 3(d), the gray boxes represent these recovery durations during which data acquisition was paused in this work, and a linear temporal interpolation was assumed for these periods.

CONCLUSIONS

In this work, we have demonstrated the clinical feasibility of the IVD HYCR technique for DCE liver MRI, particularly for the detection of HCC lesions. With near 12-fold acceleration, whole liver coverage with 2.0 mm isotropic spatial resolution and 4.0 sec/frame temporal resolution has been achieved and specific enhancement characteristics of HCC have been observed in patient volunteer exams.

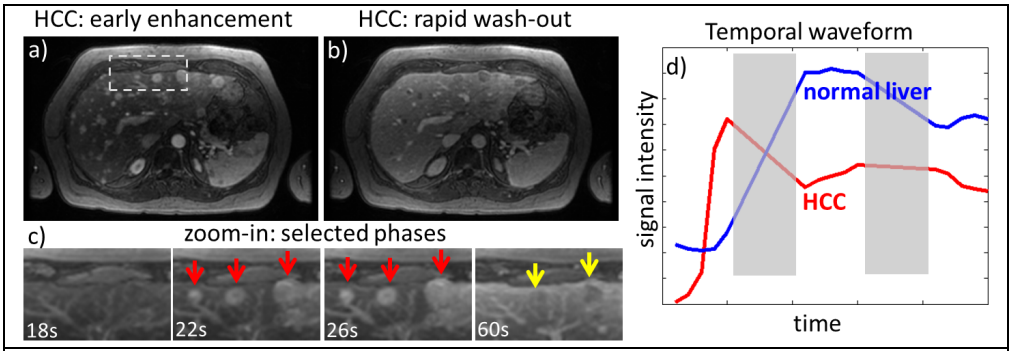

Figure 3. Representative images from a second patient with multi-focal HCC after injection of 0.1mmol/kg of gadobenate dimeglumine. The early enhancement and rapid wash-out of the tumors can be well seen in (a) and (b), respectively. Zoomed-in images of four selected 4-sec phases shown in (c) also demonstrate the same phenomenon, with red arrows pointing to arterial phase enhancement and yellow arrow denoting contrast washout. Temporal waveforms of the HCC and surrounding normal liver are shown in (d). Note that the gray box areas represent free-breathing periods where the MR sequence was paused.

ACKNOWLEDGMENTS: We acknowledge support from the NIH (R01 DK083380, R01 DK088925 and RC1 EB010384) and departmental R&D funding.

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