High Resolution Renal and Hepatic DCE Perfusion with Continuous Respiratory Monitoring using IVD-HYCR Sampling-Reconstruction

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INTRODUCTION The goal of this project is to develop a 3D Interleaved Variable Density – HighlY-constrained Cartesian Reconstruction (IVD-HYCR) [1] method that can be used to reproducibly and robustly provide high quality Dynamic Contrast Enhanced images of the abdominal cavity including the kidneys and the liver. Diagnosis of hepatocellular and renal carcinomas typically requires acquisition of a pre-contrast mask and three post-contrast phase images [2,3]. Single kidney glomerular filtration rates (SK-GFR) can also be estimated using DCE-MRI [4]. For all these applications, data acquisition must be performed during a breath hold interval to cease motion of the organs. These goals are achieved using continuous acquisition, a flexible breath-holding scheme, and retrospective detection of end expiration breath-hold periods and constructing separate HYCR composite images for each of these periods.

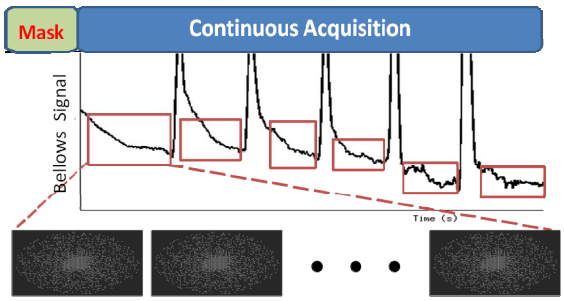

Figure 1: Continuous acquisition scheme with retrospective detection of breath-holding periods. Each frame is sampled using an undersampled IVD pattern.

METHODS Volunteers were scanned using a 3T MRI system (Discovery MR750, GE Healthcare, Waukesha, WI) with a 32 channel phased array body coil (Neocoil, Pewaukee, WI) after IRB approval and obtaining informed consent. Subjects were instructed to hold their breath for a pre-contrast mask acquisition. After the mask, 0.05mmol/kg of gadobenate dimeglumine was injected (Multihance, Bracco, Princeton, NJ) and the volunteers were instructed to hold their breath as long as they could and IVD time-resolved imaging with data-driven parallel imaging [5] was performed with the respiratory waveform being recorded for retrospective determination of breath-holding periods. After the initial breath-hold, while scanning was still ongoing, the subjects recovered with a few breaths and continued to hold their breath at their convenience. This holding and breathing pattern was continued until the end of the two-minute time-resolved scan [6]. During reconstruction, data were binned into separate breath-holding periods and HYCR reconstruction was performed on each of the images in these periods. HYCR processing relies on weighting a high resolution composite image with a weighting image that comes from individual time-frames data. The window to create composite images was retrospectively limited only to the data coming from each breath-holding period to minimze respiratory artifacts.

RESULTS HYCR processed perfusion images of the kidneys from a healthy volunteer are shown in Figure 2 [a-h]. Images have $1.2 \times 1.2 \times 2.1$ mm^3 spatial resolution and 4s temporal resolution. The uptake of contrast in the renal cortex and medulla, liver and spleen as well as hepatic blood vessels are visible in the images. There is contrast present in renal pelvis from an earlier injection.

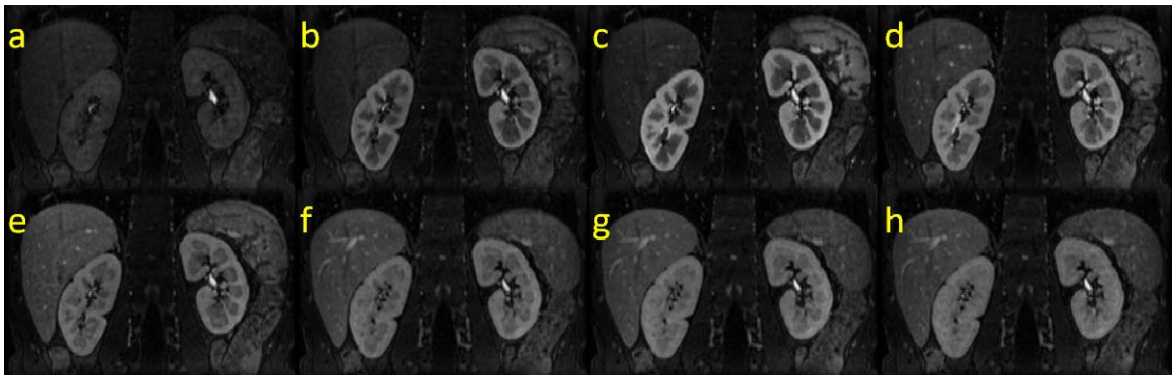

Figure 2 (a-h): Reformatted DCE images of abdominal cavity of a healthy volunteer. Contrast uptake in the liver, kidneys and spleen is visible. Time-resolved images are obtained every 4 seconds.

Figure 3 shows the signal curves obtained by placing a region of interest (ROI) over different areas of the 3D volume time-resolved image set. To avoid respiration artifacts, images were not reconstructed for the periods when the subject was recovering from the breath-holds (grey boxes in figure).

DISCUSSION & CONCLUSION We demonstrated high resolution renal and hepatic DCE images using the IVD-HYCR technique with full volumetric coverage of liver and kidneys. The flexible breath-holding approach can result in higher patient comfort and data acquisition through much of the contrast agent passage. Near isotropic spatial resolution also provides the opportunity to generate angiograms from the same dataset [7]. High resolution may also enable isolation of SK-GFR estimates to the renal cortex only, improving the accuracy of cortical perfusion results. It may be possible to use these results to calculate quantitative or semi-quantitative perfusion parameters for further assessment of liver and kidney function.

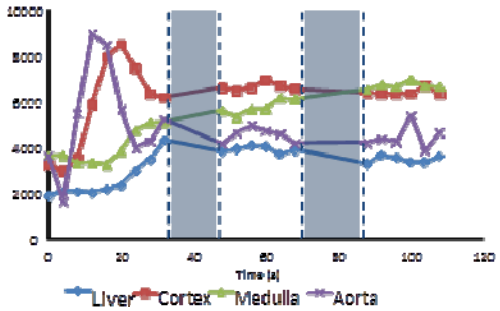

Figure 3: Signal curves from ROIs showing contrast agent uptake in the liver parenchyma, renal cortex and renal medulla. An arterial input function is also plotted for reference. Data in the gray areas is discarded to avoid motion artifacts caused by respiration .

REFERENCES [1] Wang et al., ISMRM 2011; 3459 [2] Materne et al., MRM 2002:135 [3] Nikken et. al. EuroRadiology 2007:2780 [4] Buckley et al. JMRI 2006:1117 [5] Brau et al. MRM, 2008:382.[6] Rahimi et al. ISMRM 2012: 4006 [7] Holmes et al. ISMRM 2012: 3867