Comparison of under-sampled Cartesian pulmonary perfusion MRI reconstructed with either view sharing or HYCR

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INTRODUCTION: Pulmonary perfusion MRI is emerging as a useful clinical tool[1] in assessing lung function in a wide range of diseases, including pulmonary embolism[2,3], pulmonary hypertension[4], and cystic fibrosis[5]. However, truly quantitative pulmonary perfusion MRI has been limited by the need for both high temporal-spatial resolution and full-lung coverage. The purpose of this work was to compare the performance of 3 different Cartesian under-sampling methods in combination with 2 alternative reconstruction methods for both *qualitative* pulmonary perfusion imaging and *quantitative* assessment of contrast dynamics.

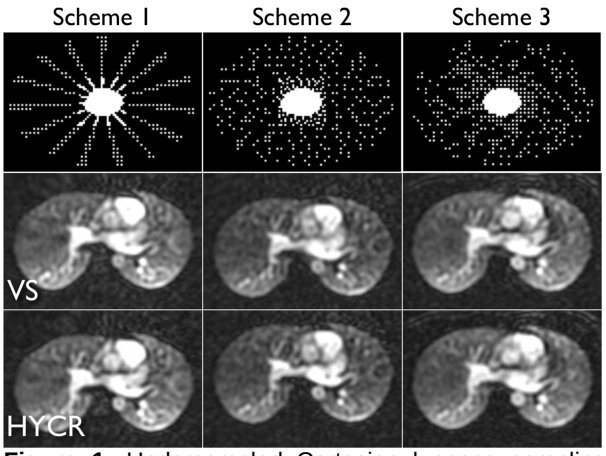

Figure 1: Undersampled Cartesian k-space sampling schemes (top row). All 6 reconstructions showed comparable quality. VS = view sharing. HYCR = HighlY Constrained Cartesian Reconstruction.

METHODS: Twenty-two (22) healthy subjects (10M, 13F, age 22-61yrs) were scanned in this IRB-approved study on a 1.5T scanner (MR450w, GE Healthcare, Waukesha, WI) using an 8-channel cardiac coil. Pulmonary perfusion MRI was performed using a 3D spoiled gradient echo pulse sequence with each of 3 *k*-space sampling schemes (top row, Fig. 1): 1) similar to the Cartesian Acquisition with Projection Reconstruction-like (CAPR)[6] method, 2) Differential Subsampling with Cartesian Ordering (DISCO)[7], and 3) Interleaved Variable Density (IVD)[8]. Gadobenate dimeglumine (0.05 mmol/kg) was injected at 4 mL/s followed by 35 mL saline administered at the same rate. Scans were performed in a randomized order at least 20 min apart. Scan parameters included: 22s breath-hold, whole-lung 4mm isotropic resolution, FOV=40(SI) × 28(AP) × 40(LR) cm^3, TE/TR=0.6/1.7ms, FA=12°, BW=±125kHz, parallel acceleration 2×2, 1.0s reconstructed temporal resolution for the first 8 subjects and 0.5s for the remaining 14 subjects. Data from each acquisition were reconstructed using two methods: view-sharing (VS) and HighlYConstrained Cartesian Reconstruction (HYCR)[8]. *Qualitative Analysis:* Three cardiothoracic radiologists independently ranked the 6 reconstructions for each subject in order of overall image quality in a blinded fashion. Kruskal-Wallis tests were used to assess for differences in the image quality. *Quantitative Analysis:* From a region of interest (ROI) placed in the main pulmonary artery, the mean signal intensity for each time frame was used to fit a gamma variate function for each of the 6 reconstructions. After normalization to its initial (baseline) value, its maximum value, maximum slope, and rise time (20%-80%) were determined. A linear mixed effects model was used to compare the effects of 1) injection order, 2) sampling scheme, and 3) reconstruction method on these quantitative measures of contrast dynamics.

Quantitative Metric	View-Share	HYCR	p-value
Maximum (AU)	26.3 ± 11.5	29.6 ± 11.0	0.005
Max Slope (AU)	8.5 ± 4.4	10.0 ± 4.4	< 0.001
Rise-Time (s)	1.3 ± 0.3	1.2 ± 0.2	< 0.001

Table 1: Comparison of time-resolved lung perfusion kinetics using view-sharing vs HYCR reconstruction

RESULTS: All reconstructions generated good quality peak lung enhancement images. There were no significant differences in image quality between the acquisition-reconstruction methods (bottom rows, Fig. 1). The only factor that demonstrated a statistically significant effect on image quality was the injection order (p=0.04, 0.12, 0.01 for the 3 readers). The principal factors affecting the *quantitative* measures were injection order (higher maximum and slope on earlier injections, p<0.001) and reconstruction method. Pair-wise comparison of VS and HYCR reconstructions from the same data showed 23% higher maxima, 5% steeper maximum slopes, and 6% shorter rise times with HYCR than with VS reconstructions, with total population mean ± SD values shown in Table 1. These differences were greater at 0.5s temporal resolution than at 1s, although only rise time showed a statistically significance difference with temporal resolution (p=0.036). The rise time observed with Scheme 3 sampling was shorter than with Scheme 1 (p=0.003), although there was no significant difference between the acquisition methods using the other metrics.

CONCLUSION: All 6 acquisition-reconstruction methods evaluated in this study produced images of similar quality. The shorter rise times, greater maximum intensities, and steeper slopes of contrast enhancement curves based on HYCR suggest a higher true temporal resolution and may yield higher accuracy than view-sharing for whole-lung quantitative perfusion MRI.

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