Peripheral MRA using an interleaved variable density Cartesian acquisition with HYPR reconstruction

J. H. Holmes[1], K. Wang[2], R. F. Busse[1], C. J. Francois[3], P. J. Beatty[4], L. A. Keith[2], Y. Wu[2], S. B. Reeder[3], J. H. Brittain[1], and F. R. Korosec[3]
[1]Applied Science Laboratory, GE Healthcare, Madison, WI, United States, [2]Medical Physics, University of Wisconsin-Madison, Madison, WI, United States,
[3]Radiology, University of Wisconsin-Madison, Madison, WI, United States, [4]Applied Science Laboratory, GE Healthcare, Menlo Park, CA

Introduction: Accurate depiction of arterial and venous structures is critical for the diagnosis and management of a variety of vascular conditions including peripheral vascular disease (PVD) and arterial venous malformations (AVM). While view sharing techniques provide time-resolved imaging that accurately capture the arterial-phase of contrast passage [1], improvements in temporal and spatial resolution would be attractive to provide more detailed hemodynamic information and higher spatial resolution closer to X-ray digital subtraction angiography (DSA). An interleaved variable density (IVD) acquisition with Cartesian HYPR reconstruction has previously been demonstrated in simulations for improving contrast-enhanced time-resolved imaging [2-4]. Here we demonstrate the application of these techniques for imaging of peripheral vascular disease.

Methods: Peripheral run-off studies with both IVD-HYPR and conventional view sharing were performed in seven normal volunteers on a 3 T MRI system and three clinical volunteers on a 1.5 T system (MR750 and Signa HDx, GE Healthcare, Waukesha, WI), both using 8 channel phased array coils. IVD-HYPR acquisition parameters included 48 (S/I) × 33.6 (R/L) × 12.9 (A/P) cm^3 FOV, 512 (freq) × 360 (phase) × 68 (slice) acquired matrix for an acquired resolution of 0.94 × 0.94 × 1.9 mm^3, update time 7.5 s with the center of k-space sampled during each frame, and a 75% fractional echo. Parallel imaging acceleration of 4× (2× in both the y and z directions) was performed in the volunteers at 3 T and 2× acceleration in the left-right direction was performed in the volunteers at 1.5T. Externally calibrated ARC reconstruction [5] was integrated into the HYPR reconstruction. Conventional view-sharing acquisition parameters included 48 (S/I) × 34 (R/L) × 13.2 (A/P) cm^3 FOV, 384 (freq) × 256 × 66 (slice) acquired matrix for an acquired resolution of 1.3 × 1.3 × 2.0 mm^3, and 2× parallel imaging. The center of k-space was sampled every 10.8 s and images were reconstructed every 5.4 s using view-sharing.

Figure 1. Comparison of coronal MIPs from IVD-HYPR (a-d) and conventional view-sharing (g-j). Note improved depiction of bolus with IVD-HYPR (a-c, arrows) as compared to view-sharing (g-i, arrows), demonstrating higher temporal fidelity with IVD-HYPR. Enlarged views show improved in-plane resolution with comparable out of plane resolution with IVD-HYPR (e, f) versus view-sharing (k,l).

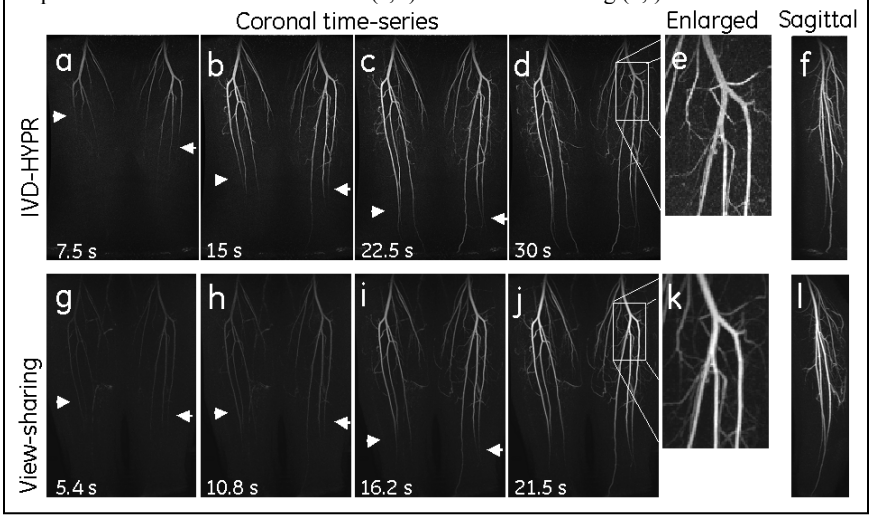


Figure 2. Signal time-curves from the volunteer shown in Fig. 1. Note increased arterial to venous signal separation (blue arrows) and shorter rise time of the IVD-HYPR curves (a) relative to the view-shared method (b).

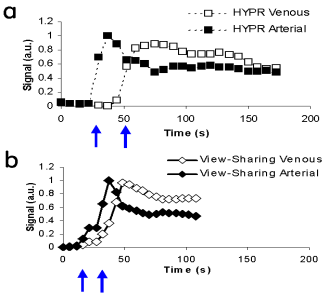
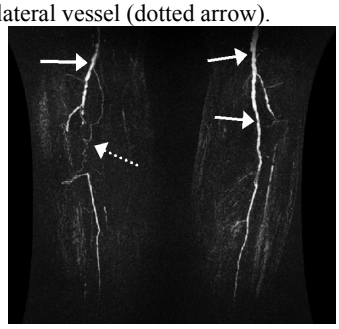


Figure 3. Arterial phase coronal MIP of a patient with peripheral vascular disease including arterial narrowing (solid arrows) and an occlusion of the anterior proximal artery that is reconstituted through a collateral vessel (dotted arrow).



Results: Individual time frames from a normal subject acquired using IVD-HYPR and a view-shared method demonstrate improved temporal resolution of the IVD-HYPR technique (Fig. 1). Specifically, improved depiction of the leading edge of the contrast bolus is evident in the IVD-HYPR images (Fig. 1 a-c arrows) and is not well visualized in the view shared data (g-i, arrows). Enlarged views of the data demonstrate the improved in-plane resolution of the IVD-HYPR method compared to view sharing (Fig. 1e and k) due to the factor of 2 decrease in acquired voxel volume. Sagittal reformats of both datasets show comparable out of plane spatial resolution (Fig 1.f and l). Time curves further demonstrate the improvement in arterial to venous separation using the IVD-HYPR method (Fig 2). A MIP image demonstrating the arterial phase acquired from a patient with severe vascular disease (Fig. 3) provides good depiction of arterial narrowing (solid arrows) and a collateral vessel (dotted arrow) resulting from an occlusion.

Discussion: A method combining IVD Cartesian acquisition with a reconstruction that integrates HYPR and parallel imaging has been applied to peripheral run-off MRA. Comparison of the technique with a conventional view-sharing method in normal volunteers demonstrated improved spatial resolution and temporal fidelity using IVD-HYPR. Clinical assessment of the technique in subjects with peripheral vascular disease shows promising initial results (Fig 3) and is continuing. In the current comparison, the view-sharing method uses temporal interpolation of k-space data to achieve a frame rate of 5.4 s with high spatial resolution. Similar methods could be applied to the reconstruction of the HYPR time-frame data to achieve a further acceleration in the frame rate.

References: [1] Korosec et al. MRM 1996 ;36 :345-351. [2] Busse et al. ISMRM 2009;A4534. [3] Busse et al. ISMRM 2009 ;A2834. [4] Wang et al. ISMRM 2009 ;A3884. [5] Brau et al. MRM 2008 ;59 :382-295.