Time-Resolved Nonenhanced QISS MR Angiography Using a Golden Angle Radial Trajectory and HYPR

Ioannis Koktzoglou[1,2], Charles A Mistretta[3], Shivraman Giri[4], Parag Amin[5], and Robert R Edelman[1,6]

[1]*Radiology, NorthShore University HealthSystem, Evanston, Illinois, United States,* [2]*The University of Chicago Pritzker School of Medicine, Chicago, IL, United States,* [3]*Radiology, University of Wisconsin-Madison, Madison, WI, United States,* [4]*Siemens Healthcare, Chicago, IL, United States,* [5]*Radiology, Northwestern University, Chicago, IL, United States,* [6]*Northwestern University Feinberg School of Medicine, Chicago, IL, United States*

TARGET AUDIENCE: Vascular imaging professionals.

PURPOSE: To present a time-resolved variation of nonenhanced QISS[1] MRA using a golden angle radial trajectory and highly constrained back projection (HYPR) reconstruction[2,3] that displays peripheral arterial anatomy and flow with high spatial and temporal resolution.

METHODS: This study was IRB approved. Imaging of the lower or upper limbs of 6 healthy subjects and 2 patients was performed on a 32-channel 1.5T MRI system (MAGNETOM Avanto, Siemens Healthcare) using a cardiac-gated saturation-recovery radial 2D trueFISP sequence acquiring golden angle (111.25°) incremented views over the majority of the cardiac cycle (**Figure 1**). Sliding window reconstruction was used to create a series of 20 time-resolved MR angiograms; all acquired views were reconstructed to create a static MR angiogram. Typical imaging parameters were: TR/TE/flip of 4.1-4.5 ms/2.0-2.2 ms/90°, slice thickness 2.3-3.0 mm, in-plane spatial resolution 1.0-1.2 mm, 160 (upper limbs) to 432 (lower limbs) slices, 1 heartbeat/slice (i.e., single-shot mode), 20 temporal frames/heartbeat, phase-based fat suppression[4], tracking venous saturation. A multi-shot implementation (2-4 heartbeats/slice) was tested to improve SNR and/or temporal resolution.

Using the static angiogram and the undersampled time-resolved reconstructions, local HYPR reconstruction[3] was performed as shown in **Figure 1**. Comparisons of undersampled and HYPR-enhanced time-resolved reconstructions were made. Static angiograms were compared to Cartesian QISS MR angiograms and/or contrast-enhanced MRA (CE-MRA).

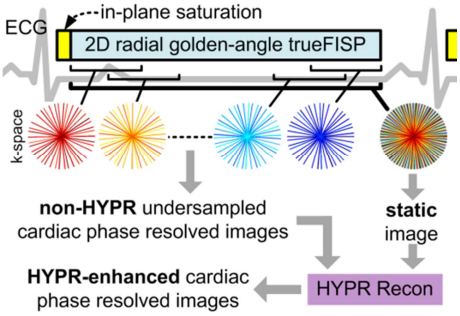

Figure 1. Acquisition sequence and reconstruction methodology. Procedure is repeated for every acquired slice.

RESULTS: The described nonenhanced MRA method depicted the onset and propagation of arterial flow in the peripheral arteries and created static and HYPR-enhanced time-resolved angiograms that provided excellent arterial conspicuity (**Figures 2 and 3**). Multi-shot imaging enabled the use of undersampled constraining images with narrower temporal footprints, and increased the signal-to-noise of the static MR angiogram. HYPR reconstruction enhanced the quality of the time-resolved MR angiograms.

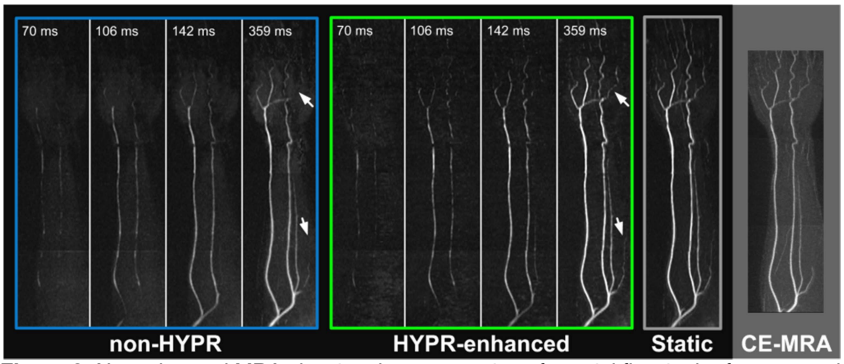

Figure 2. Nonenhanced MRA showing the propagation of arterial flow in the forearm and hand of a volunteer (shots = 4). The static and HYPR-enhanced time-resolved images demonstrate excellent arterial conspicuity and spatial resolution. HYPR reconstruction improved vascular contrast and display of small arterial branch vessels (arrows). Delay times after the ECG R-wave are noted. Excellent correlation with CE-MRA is observed.

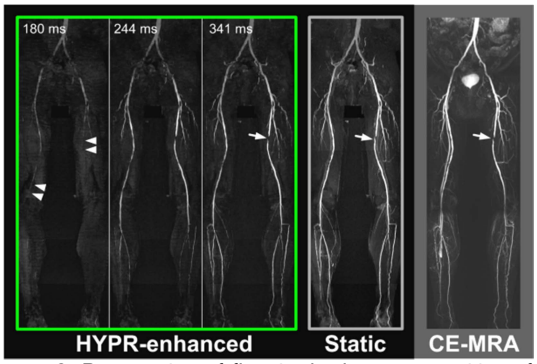

Figure 3. Propagation of flow in the lower extremities of a vascular disease patient. The nonenhanced angiograms show a left SFA stenosis (arrows) and delayed flow enhancement with respect to the opposite leg (arrowheads). Note the excellent agreement with CE-MRA.

DISCUSSION: High quality time-resolved and static nonenhanced MRA of the peripheral arteries is feasible using saturation-recovery 2D radial golden angle trueFISP and HYPR reconstruction. The technique produces 3D angiograms displaying the propagation of blood flow in the peripheral arteries and a static 3D high spatial resolution angiogram that is comparable to CE-MRA in initial studies. A single-shot implementation enables rapid static and time-resolved nonenhanced MRA of a large vascular territory, while a multi-shot configuration affords the user the freedom to improve temporal resolution and/or signal-to-noise. Initial patient studies show the method can depict the impact of arterial stenosis on the pulse wave. Future studies will rigorously test the method for diagnosing and characterizing vascular disease.

CONCLUSION: Time-resolved and static nonenhanced MRA of the peripheral arteries is feasible with a variation of QISS using a 2D golden angle radial trajectory, an extended data acquisition window, and HYPR reconstruction.

REFERENCES: 1. Edelman et al. MRM 2010;63:951-958. **2.** Mistretta et al. MRM 2006;55:30-40. **3.** Johnson et al. MRM 2008; 456-462. **4.** Hargreaves et al. MRM 2003;50:210-213.

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