A Single-Shot Inflow-Based Approach to Simultaneous Non-Contrast-Enhanced MRA and MRV

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TARGET AUDIENCE: This work is intended for scientists and clinicians studying peripheral vascular disease, non-contrast enhanced MRA, and/or steady-state imaging methods.

PURPOSE: MR angiography techniques that rely on inflow for contrast, including time-of-flight (TOF), inflow inversion-recovery (IFIR), and quiescent-inflow single-shot (QISS)[1], generally select for a single direction of vascular flow. Although techniques to perform MR angiography and venography simultaneously have been explored for neurological applications[2,3], the peripheral vasculature presents a different set of imaging challenges, such as pulsatile flow and the need for robust fat suppression. Simultaneous MRA/MRV may allow the detection of additional clinically-relevant features such as venous compression and/or thrombus, as in May-Thurner syndrome of the common iliac vein. The purpose of this work was to demonstrate a non-contrast-enhanced, single-shot, inflow-based approach to the simultaneous acquisition of directionally-opposed arterial and venous signal in the lower extremities, without compromising the MRA acquisition or adding scan time.

METHODS: A Non-Contrast Enhanced simultaneous MR Angiography-Venography (NCE MRAV) sequence was developed by interleaving, within a single TR, the pulses for a standard QISS NCE MRA acquisition[1], and a second QISS-based MRV acquisition. This results in the formation of two independent, two-dimensional images per heartbeat (Fig 1). The additional venous slice was prepared similarly to the previously-reported QISS MRA method, however the tracking saturation band was located superiorly to the second slice to suppress inflowing arterial signal. Slice order progressed sequentially from inferior to superior, and undesirable interactions between the venous and arterial slice acquisitions were avoided by offsetting the venous slice location by half of the full S/I coverage. Five healthy volunteers were scanned on a 1.5T system (HDxt, GE Healthcare, Waukesha, WI), using an 8-channel cardiac coil. Imaging parameters for the simultaneous NCE MRAV acquisition were as follows: axial excitation, TR/TE=4.0/1.7 ms, 90º flip, ±125-kHz receive bandwidth, 40-cm (R/L) x 20-cm (A/P) FOV, 3-mm slice, no overlap, 256x192 matrix, 0.5 NEX, and a parallel imaging (ASSET) acceleration factor of 2.0. Timing variables were consistent with previously reported timing for the arterial phase [1]. Coverage in the S/I direction was 30 cm at and above the knee, and the venous acquisition was offset by 15-cm. For comparison, standard QISS MRA and MRV images were acquired independently and sequentially using the same imaging parameters.

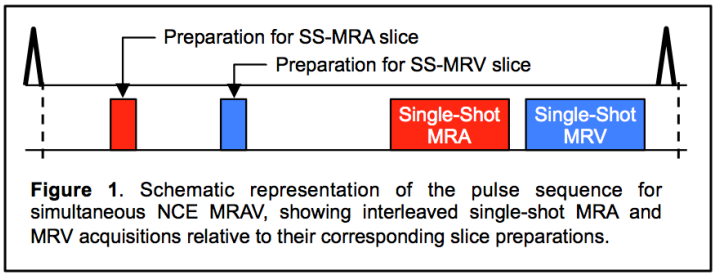

Figure 1. Schematic representation of the pulse sequence for simultaneous NCE MRAV, showing interleaved single-shot MRA and MRV acquisitions relative to their corresponding slice preparations.

RESULTS: Inferiorly-directed (arterial) flow is well-visualized in coronal maximum intensity projections (MIPs) from both the simultaneous and independently-acquired sequences in a representative volunteer (Figures 2a & 2c), and superiorly-directed (venous) flow is well-visualized for both sequences (Figures 2b & 2d). Image quality of the simultaneous NCE MRAV acquisition was observed to be consistent and robust across all five volunteers, and is shown to be comparable with that demonstrated by the standard, independent QISS MRA and MRV acquisitions that required twice the scan time.

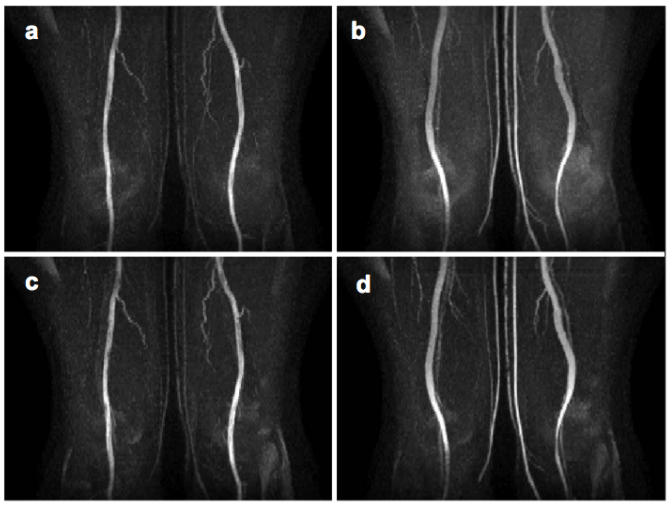

Figure 2. Coronal maximum intensity projections at and above the knees of a healthy volunteer: a) simultaneous NCE MRAV, "arterial" phase, b) simultaneous NCE MRAV, "venous" phase, c) independently-acquired QISS MRA, d) independently-acquired QISS MRV.

DISCUSSION: This work demonstrates the feasibility of simultaneously acquiring signal from directionally-opposed flow within a single QISS-based acquisition, without sacrificing any of the robustness of the original standalone MRA technique. By interleaving the pulses within a single TR, there was also no increase in scan time over the single-direction QISS acquisition. In addition, we believe this simultaneous approach may supplement the standard QISS NCE MRA technique by allowing the simultaneous visualization of venous anatomy and tortuous arterial pathways that may run counter to the standard slice acquisition order.

CONCLUSION: We have demonstrated a non-contrast enhanced imaging technique that allows the simultaneous imaging of arteries and veins in the peripheral vasculature without compromising image quality or adding scan time. Additional efforts to evaluate the performance of this technique in a clinical setting are underway.

REFERENCES: 1) Edelman et al. MRM 63:951-958 (2010); 2) Kim JH, Cho ZH. MRM 14:554-561 (1990); 3) Du YP, Jin Z. MRM 59:954-958 (2008)