Quiescent-Interval Single-Shot Non-Contrast Enhanced MR Angiography using Two-Point Dixon Fat-Water Decomposition

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BACKGROUND: Interest continues in non-contrast enhanced MR angiography as a less-invasive alternative to contrast-enhanced MRA. Quiescent-Interval Single-Shot (QISS) is a recently-developed non-contrast MRA technique that uses a 2D cardiac-gated balanced steady-state free precession (bSSFP) acquisition, preceded by slice-selective saturation and a quiescent interval (QI) to ensure maximal arterial enhancement during the diastolic period of slow flow [1]. QISS was recently shown to exhibit diagnostic performance nearly equal to that of contrast-enhanced MRA and digital subtraction angiography in evaluating patients with symptomatic lower limb ischemia [2]. In addition to slice-selective saturation, the QISS sequence utilizes a signal-saturation-based fat suppression pulse, which is sensitive to B_0 and B_1 inhomogeneities that can lead to non-uniform fat suppression and perturbation of the steady-state. The purpose of this work was to demonstrate the feasibility of a dual-echo bipolar QISS sequence, followed by a two-point Dixon fat-water reconstruction algorithm [3] to synthesize fat-free, water-only images of arterial signal in the lower extremities.

MATERIALS & METHODS: A QISS sequence incorporating a dual-echo bipolar bSSFP acquisition was developed. Following informed consent, images were acquired in the lower extremities of a healthy volunteer on a 1.5T scanner (HDxt, GE Healthcare, Waukesha, WI), using an 8-channel cardiac coil positioned below the knee. Imaging parameters for the standard QISS acquisition were as follows: TR/TE=4.0/1.8 ms, 90º flip, ±62.5-kHz receive bandwidth, 40-cm FOV, 3-mm slice, no overlap, 256x256 matrix, 0.5 phase FOV, and 5/8 partial NEX. Linear catalyzation was used to establish the steady state, and preparation and trigger delay times of 309 and 409 ms, respectively, were chosen to provide consistency with previously-reported QISS acquisition timing (i.e. an initial time delay of 100 ms, and a quiescent interval of 228 ms) [1]. Imaging parameters for the dual-echo bipolar QISS acquisition were nearly identical, with in-phase and out-of-phase TE values of 2.4 and 4.7 ms, respectively, and a resulting TR of 7.5 ms. Coverage in the S/I direction for both acquisitions was approximately double the previously-reported per-station coverage of 14 cm [1].

RESULTS & DISCUSSION: The resolution of both data sets, after zero-padded interpolation, was 1.5x1.5x3 mm. Figure 1a contains the maximum intensity projection (MIP) of the standard QISS coronal reformat. In Figure 1b, the MIP of the synthesized water-only image acquired with the dual-echo bipolar QISS sequence is shown. Note the uniform and complete fat-suppression of the modified QISS sequence in Figure 1b, which reveals a number of vessels otherwise obscured by subcutaneous fat. In addition, the dual-echo nature of the modified QISS sequence provides twice the amount of data, and a corresponding increase in SNR of approximately 41% without an increase in imaging time.

CONCLUSIONS: The proposed dual-echo bipolar QISS acquisition with two-point Dixon-based fat-water separation yields robust and uniform fat suppression with improved contrast and vessel conspicuity, and the added benefit of improved SNR compared to the standard QISS method. Venous suppression may be improved through optimization of the spatial presaturation pulse. This pulse sequence could also be accelerated using parallel imaging methods, and may be compatible with other two-point echo acquisition strategies. In addition to its application in the lower extremities, this dual-echo approach to QISS MRA may prove beneficial for arterial imaging in the pelvis and abdomen, where conventional fat-suppression is especially challenging. The in-phase and out-of-phase images also contain additional registered anatomic information that may prove useful for visualization and surgical planning.

REFERENCES: 1) Edelman et al. MRM 63:951-958 (2010); 2) Hodnett et al. Radiology 260:282-93 (2011); 3) Ma et al. MRM. 52:415-419 (2004)

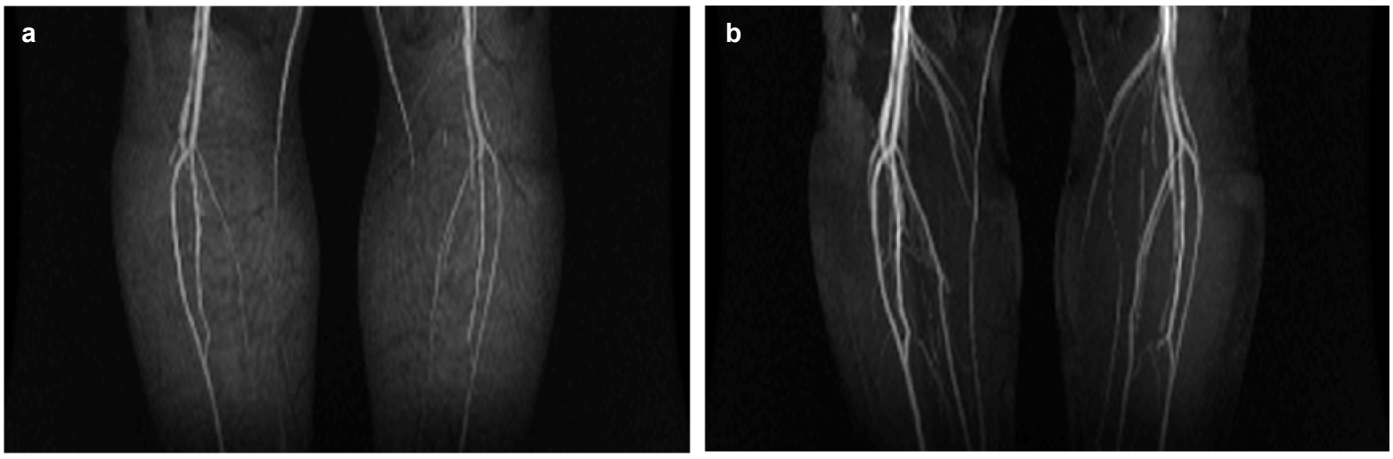

Figure 1a: Standard QISS, coronal reformat maximum intensity projection. Figure 1b: Dual-echo bipolar QISS, coronal reformat maximum intensity projection. Note the uniform and complete fat suppression, improved vessel conspicuity, and increased SNR.