Non-Contrast-Enhanced Magnetic Resonance Venography using DANTE and MSDE preparations

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Introduction: The limitations along with safety concerns regarding gadolinium contrast media have led to the development and application of non-contrast-enhanced magnetic resonance angiography (NC-MRA). Recent work shows that NC-MRA for venography (NC-MRV) can be realized by subtracting an image with all vessels suppressed from an image with only arterial vessel suppressed using motion-sensitized driven equilibrium (MSDE) preparations [1]. However, MSDE is sensitive to the velocity of blood flow. It has difficulty to suppress the venous vessels due to the venous blood flow rather slow. A recent developed dark-blood preparation module, DANTE, has been approved that it has minimum flow sensitive for blood signal suppression. Thus, we hypothesized that better NC-MRV can be realized using MSDE and DANTE than using MSDE only.

Theory: A schematic of the proposed NC-MRV technique using MSDE and DANTE preparations was shown in Figure 1. Two scans are acquired with MSDE and DANTE preparations followed by the same bSSFP readouts, respectively. In the MSDE scan, only the signal from arterial flow is suppressed by the MSDE preparation. While in the DANTE scan, signal from both arterial and venous flows are suppressed by the DANTE preparation. Magnitude subtraction of the two scans allows the visualization of veins with dramatically suppressed background and arterial signals (Fig. 1(c)).

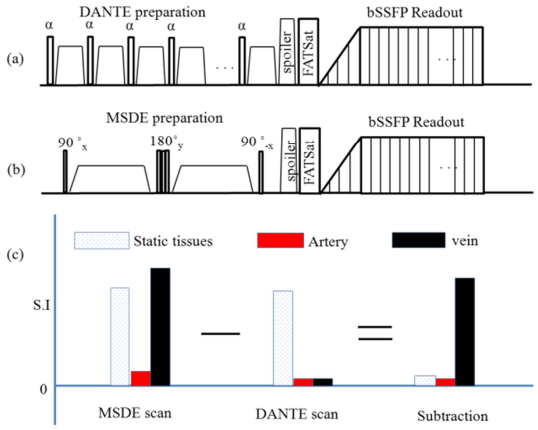

Fig. 1. Schematic of the proposed NC-MRV technique using MSDE and DANTE preparations. NC-MRV is realized by subtracting the data acquired in DANTE scan from the data acquired in MSDE scan.

Experiments: The IRB approved study scanned 4 healthy volunteers (age 25±4) on a 3T MR scanner (MAGNETOM Trio, Siemens, Germany). As the bSSFP is sensitivity to B0 homogeneity, a small FOV (260×130×120 mm^3) which only covered one lower leg was used to avoid banding artifacts. Parameters for the bSSFP included: TE/TR = 2.0/4.0 ms, flip angle = 60°, 3D isotropic resolution = 1.0×1.0×1.0 mm^3, bandwidth = 1149 Hz/pixel, turbo factor = 71, acceleration factor (GRAPPA) = 2. To achieve sufficient signal suppression on both arterial and venous flows, parameters for the DANTE preparation included: gradient amplitude = 20 mT/m, gradient duration = 1ms, flip angle = 20°, pulse trains = 200. To achieve sufficient signal suppression in the arterial flow but little in the venous flow, a small first-order gradient moment (M1, approximately 15–50 $mT \cdot msec^2/m$) of MSDE was individually optimized using a previously proposed method. For comparison, an additional scan using MSDE with a much larger M1 (1206 $mT \cdot msec^2/m$) was performed to get another group of dark arterial and venous images. Subtractions between the group of dark arterial images and the two groups of dark arterial and venous images were carried out to realize NC-MRV.

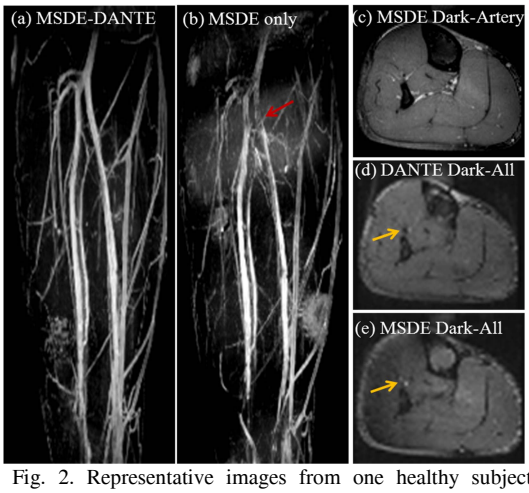

Fig. 2. Representative images from one healthy subject. (a&b) Subtraction MIP images obtained using the proposed technique with MSDE and DANTE, and using the technique with MSDE only; (c) a raw image obtained using MSDE with small M1 to suppress the artery only. (d&e) raw images with matched location to (c), obtained using DANTE and MSDE with larger M1 respectively. Residual signal of venous blood flow can be found in (e) although a large M1 was used in the MSDE preparation.

Results and discussion: All scans were successfully completed. Figure 2 shows the representative images from one healthy subject. Bright veins were visualized with significant background and artery suppressions. Compared to the MSDE preparation, DANTE has better performance on suppressing the slow venous blood flow (yellow arrows in figure 2(d&e)). The proposed technique using DANTE and MSDE together is therefore realizing better venous vessel visualization (figure 2(a)) than using MSDE only (figure 2(b)) as expected. There are some high intensity residual fat signals after subtractions using both techniques, which need to be evaluated and optimized in next step.

Conclusion: A technique for NC-MRV was developed using DANTE and MSDE preparations. Preliminary in vivo studies show that the proposed technique has better performance than the technique using MSDE only. This study warrants further technical improvement and more in vivo studies.

References: [1] Priest A., et al. MRM. 2012. 67:628-637 [2] Li L., et al. MRM, 2012, 68:1423-1438.