STARBURST Peripheral MR Venography

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Introduction: Time-of-flight methods for lower extremity MR venography are slow and image quality is limited. Contrast-enhanced 3D methods require the administration of high doses of contrast agent and depict both arteries and veins. STARBURST (Selectively Targeted Angiographic Rendering using Blood's Unique Relaxation properties and Subtraction Technique) is a newly described method for creating high quality flow-independent MR angiograms that can selectively depict either arteries or veins.

Methods: STARBURST requires the acquisition of two image sets (with one set being tagged by a spatially non-selective radiofrequency (RF) pulse) that are subtracted to render an angiogram (Figure 1). The images are acquired in an interleaved manner followed by complex subtraction. Fat, and to a lesser extent muscle, signals are suppressed based on the interplay of the tissue T1 relaxation characteristics and acquisition technique, while largely preserving vascular signals. The resultant images are processed with a maximum intensity projection technique.

The study was approved by the hospital Institutional Review Board. The leg of a volunteer was imaged on a 32-channel 1.5 T Siemens Avanto system using the body array and peripheral vascular coils. Segmented three-dimensional bSSFP STARBURST imaging was performed with the following parameters: RF tag = 240 degree spatially non-selective adiabatic inversion pulse, RF tagging mode = sequential, field-of-view = 45 cm x 45 cm, matrix = 256 x 256, imaging slab = 144 1.2 mm-thick slices after interpolation, TR = 3000 ms, TI = 1400 ms, bSSFP flip angle = 90 degrees, bSSFP TR = 2.9/1.4 ms, receiver bandwidth = 975 Hz/pixel, linear k-space ordering in the phase-encoding direction, one shot per partition, GRAPPA acceleration factor = 2, slice oversampling = 25%, slice partial Fourier = $6/8^{th}$, acquisition time = 6 min 35 sec. A coronal slab orientation was chosen to maximize the visualized length of the veins. In order to suppress arterial signal, an adiabatic spatially selective pre-inversion pulse was applied to the arterial inflow on the untagged acquisition only.

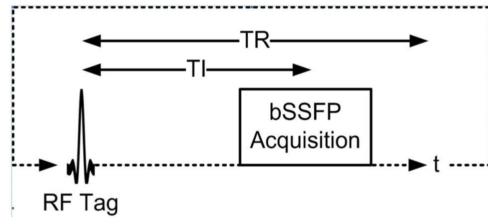

Figure 1. Pulse sequence diagram for STARBURST imaging sequence. A non-selective RF pulse is applied on alternate acquisitions. Inflowing arterial spins are selectively pre-inverted for the untagged acquisition only.

Results: STARBURST effectively suppressed the signal intensity of fat and muscle whereas vessels appear bright (Figure 2). The vein-tissue signal intensity ratios for muscle and fat were respectively 2.1 and 1.2 on the source untagged image compared with 3.9 and 21.3 on the STARBURST image. Banding artifacts due to off-resonance effects with SSFP were visible on the source images. However, these were eliminated by the complex image subtraction and were not visible on the STARBURST images. Arterial SNR in the STARBURST image decreased from 118.6 to 7.8 after application of spatially selective pre-inversion, compared with SNR values of 101.7 and 99.5 for the vein before and after arterial pre-inversion. Extensive lengths of the veins were shown including submillimeter branch vessels; the arteries were almost completely suppressed with the application of spatially selective pre-inversion.

Conclusion: We have demonstrated the feasibility of high resolution MR venography of the lower extremities with suppression of arterial signal and without the need for contrast administration. Potential clinical applications include the detection of deep venous thrombosis and depiction of the venous anatomy to assist with variceal ablation therapy.

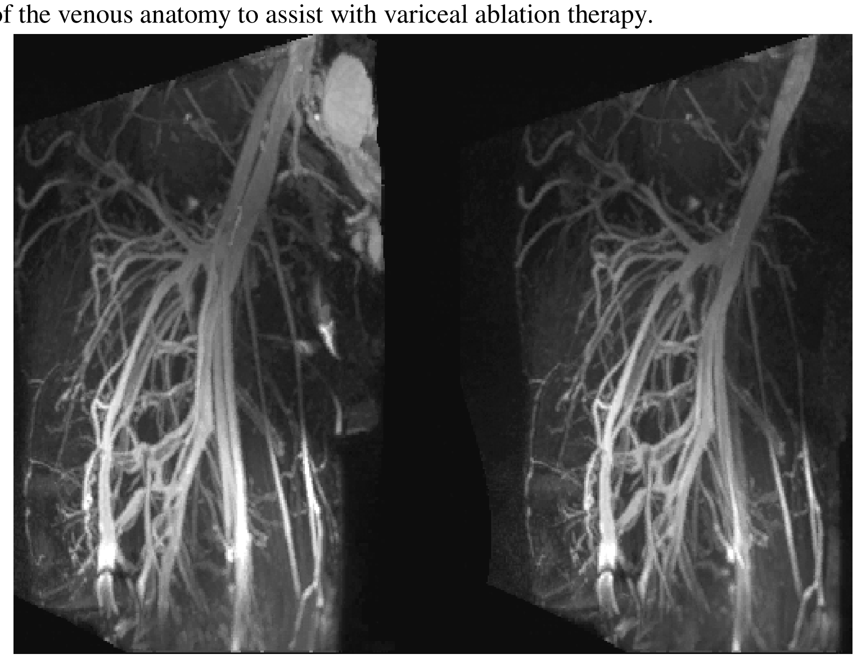

Figure 2. Coronal maximum intensity projection images from STARBURST venograms of the right thigh. Left: both arteries and veins are shown. Right: With use of selective arterial pre-inversion, most of the arteries are suppressed.