STAR and STARBURST for Combined Flow Dependent and Flow Independent Carotid MR Angiography

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Introduction: Clinical evaluation of carotid arterial disease is often performed with MR angiographic methods using contrast media. However, the recent association of gadolinium contrast media with nephrogenic systemic fibrosis has led some to reconsider their use in some patients. Although non-contrast evaluation of the extracranial carotid arteries may be performed, the technique of choice, 3D gradient-echo time-of-flight (TOF), suffers from saturation effects that can degrade diagnostic image quality; moreover, only a limited vessel extent is evaluated [1]. In order for non-contrast MRA techniques to compete with contrast-enhanced MRA, further development of non-contrast methods is needed. Herein we present the unique and complementary techniques of STAR (Signal Targeting with Alternating Radiofrequency [2]) and STARBURST (Selectively Targeted Angiographic Rendering using Blood's Unique Relaxation properties and Subtraction Technique) for high quality angiography of the carotid arteries without contrast media.

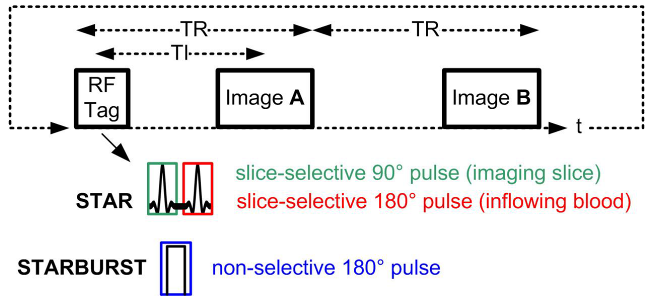

Figure 1. Diagrams of STAR and STARBURST sequences. A tagging RF preparation is applied prior to acquisition of one image set. An angiogram is computed by subtracting image sets. The TI for STARBURST is typically chosen to be greater than three times the T_1 of fat.

Methods: Both the STAR and STARBURST techniques acquire two image sets that are subtracted in the complex domain to reveal an angiogram (Figure 1). The techniques differ in that STAR is a pulsed arterial spin-labeled (i.e. flow-dependent) technique that depends on inflowing blood for angiographic contrast, whereas STARBURST is a flow-independent technique that depends largely on T_1 effects for angiographic contrast and depicts arteries and veins together.

Imaging of 2 volunteers and 1 patient was performed in a 32-channel 1.5 T Siemens Avanto system equipped with a 6-channel head and neck coil. Typical imaging parameters for STAR (STARBURST) were: FOV = 21(24) cm x 21(24) cm, matrix = 256 x 256, imaging slab = 96(64) 0.8(1.0) mm-thick slices, axial slab orientation, 3d trueFISP acquisition, GRAPPA acceleration = 2, TR = 2000(3000) ms, TI = 900(1400) ms, flip angle = 90°, trueFISP TR = 3.8(3.6)/1.9(1.8) ms, imaging bandwidth = 975 Hz/pixel, one partition per segment, slice oversampling = 17(25)%, slice partial Fourier = 6/8th, acquisition time (TA) = 336(366) s. Standard 3D time-of-flight angiography (TA = 300 s) was performed in all subjects, and contrast-enhanced MR angiography was performed in the sole patient study.

The signal ratios of the carotid lumen to the internal jugular vein, muscle, and fat were computed for STAR and STARBUST acquisitions. The lengths of the facial and lingual branches of the external carotid artery were measured for both acquisitions.

Results: Figure 2 shows MR angiograms of a patient with severe carotid stenosis. Note the excellent visibility of the carotid stenosis with STAR (Fig. 2a) and STARBURST (Fig 2b). Signal ratios of the carotid lumen to the jugular vein, muscle, and fat were 9.5, 14.5, and 11.9 for STAR and 2.2, 12.9, and 13.9 for STARBURST. Visible portions of the facial and lingual arteries were on average 29.5 mm and 47.5 mm longer ($P < 0.05$ and $P < 0.01$, respectively) with STARBURST than with STAR.

Conclusion: 3D STAR and STARBURST produce high quality carotid MR angiograms and offer potential benefits compared with 3D TOF for non-contrast carotid angiography. The flow-dependent technique of STAR provides excellent suppression of background signal intensity, whereas the flow-independent technique of STARBURST appears particularly promising for evaluating vessels containing slow blood flow, such that inflow enhancement is inadequate for time-of-flight MRA.

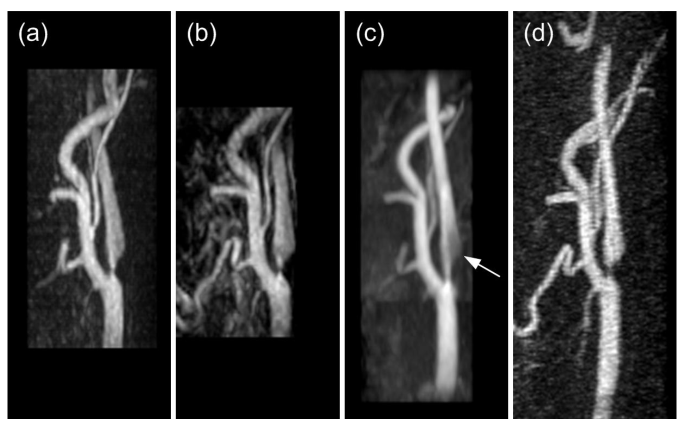

Figure 2. Thin oblique-sagittal maximum intensity projection images in a patient with severe internal carotid stenosis: (a) STAR image; (b) STARBURST image; (c) 3D TOF image; (d) contrast-enhanced angiogram. Note the excellent delineation of the carotid stenosis and patent lumen in the STAR and STARBURST images. Compare with the marked flow artifact in the 3D TOF image (arrow).

References: [1] Masaryk et al. Radiology 1991; 179:797-804
[2] Edelman et al. Magn Reson Med 1994; 31: 233-238