ECG-Triggered Dynamic Time-Resolved Magnetic Resonance Angiography of the Thoracic Aorta

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Introduction: Time-resolved subsecond contrast-enhanced magnetic resonance angiography (SS-MRA)[1], which utilizes acquisition times of 700-800 msec per 3D data set, has been shown to be particularly useful for assessing high-flow abnormalities in the thoracic aorta, such as shunts and dissections. Because of the close proximity to the heart, cardiac motion artifact can frequently obscure subtle findings in the ascending aorta. Acceleration techniques for contrast-enhanced MRA using TREAT (time-resolved, echo-sharing, angiographic technique) and iPAT (intelligent parallel acquisition technique) have recently been developed. When these are used in combination with conventional SS-MRA, it is possible to reduce the acquisition time to less than 300 msec. With frame durations this short, it is possible to use ECG-triggering to gate the acquisition period to diastole, thereby eliminating any cardiac motion artifact. The purpose of this study was to compare conventional SS-MRA to ECG-gated contrast-enhanced MRA using TREAT and iPAT, for the assessment of thoracic aortic disease.

Methods: 58 patients with suspected disease of the thoracic aorta underwent time-resolved contrast-enhanced MRA on Siemens 1.5T Sonata and Avanto scanners. All patients had correlative imaging with echocardiography, CT or conventional axial MRI. 31 patients were imaged using a conventional subsecond 3D FLASH sequence (SS-MRA) with short TR (TR/TE: 1.6/0.7; flip angle 20^0; 256 readout; 6 partitions; 2.6x1.4x15mm voxels). 27 patients were imaged with a newer pulse sequence, which combines SS-MRA with TREAT and iPAT. The TREAT sequence, which is based on the original TRICKS (time-resolved imaging of contrast kinetics)[2] concept, uses a novel k space echo-sharing approach with elliptical centric reordering (fig. 2). When combined with iPAT, the acquisition time was 300 msec per 3D set. ECG-triggering was used to gate the acquisition period to diastole. Scanning parameters were similar to the conventional SS-MRA technique. For both techniques, imaging was carried out in an oblique sagittal orientation and 6cc of Gadolinium were injected at 6cc/sec.

A quantitative analysis of vessel sharpness was performed for both techniques in five different anatomic locations (aortic root, ascending aorta, aortic arch, upper thoracic aorta, lower thoracic aorta). Two different methods were used. The first method involved generating a point-spread function across the vessel wall and calculating the upslope of the resultant curve. The second measure involved calculating the profile and distribution of signal intensities across the vessel lumen. Statistical comparisons were performed using a Students t-test, with significance determined at the 5% level.

A qualitative analysis was also performed by two independent observers. Image quality and sharpness were scored on a scale of 1-5. Image artifact was graded on a 3 point scale. The results were compared using a student's t-test.

The presence of pathology in the thoracic aorta was also noted for both techniques.

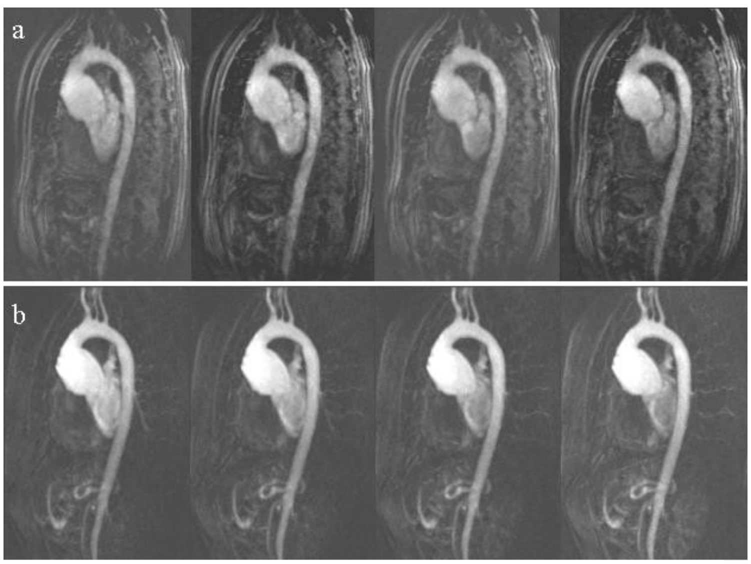

Figure 1. Sequential peak intensity frames of SS-MRA (a) and TREAT (b) sequences in patient with proximal thoracic aortic aneurysm. Note changes in heart dynamics and decreased sharpness of vessel edges in (a).

	"Slope"			"Profile Error"		
n=20	**SS-MRA (n=10)**	**TREAT (n=10)**	**p-value**	**SS-MRA (n=10)**	**TREAT (n=10)**	**p-value**
Root	0.157 (0.065)	0.250 (0.094)	<0.05	0.236 (0.057)	0.192 (0.047)	<0.05
Ascend	0.173 (0.047)	0.197 (0.081)	n.s.	0.252 (0.046)	0.243 (0.053)	n.s.
Arch	0.214 (0.059)	0.205 (0.049)	n.s.	0.288 (0.046)	0.260 (0.056)	n.s.
Upper Thoracic	0.214 (0.066)	0.197 (0.064)	n.s.	0.257 (0.044)	0.256 (0.034)	n.s.
Lower Thoracic	0.220 (0.065)	0.216 (0.095)	n.s.	0.281 (0.040)	0.270 (0.064)	n.s.

Table 1. Results of quantitative image analysis of vessel sharpness, based on the two described measures. Statistically significant differences were found in both analyses at the aortic root.

Results: Quantitative measurements of image sharpness were higher for the ECG-gated technique compared to the conventional SS-MRA (table 1). This was statistically significant in the aortic root ($p<0.05$). Qualitative values of image sharpness and quality were higher for the ECG-gated technique ($p<0.001$). There were fewer artifacts visible on the ECG-gated technique ($p<0.001$) compared to the conventional SS-MRA. Both techniques were equally accurate at detecting aortic pathology (100% sensitivity)

Conclusion: ECG-triggered, time-resolved CE-MRA produced sharper and higher quality images compared to conventional SS-MRA, particularly in the ascending aorta. ECG-triggered, time-resolved CE-MRA with TREAT and iPAT is a superior technique for evaluating the thoracic aorta and may be particularly useful for better demonstrating disease in the ascending portion.

References

1. Finn et al. Radiology. 2002; 224:896-904.
2. Korosec FR et al. Magn Reson Med. 1996; 36:345-51.

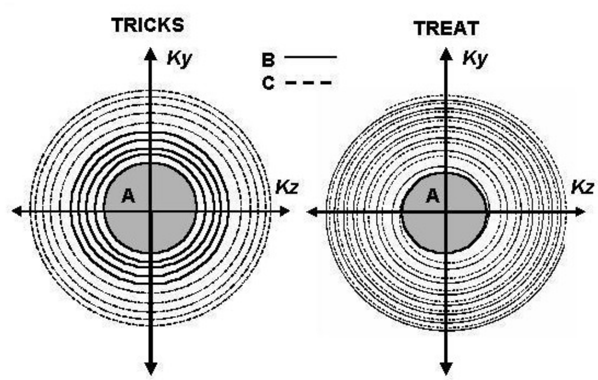

Figure 2. A comparison of the k-space segmentation schemes of hypothetical 3-region (A, B, C) TRICKS and TREAT pulse sequences. (a) An elliptically centric encoded TRICKS acquisition acquires A, B, and C regions concentrically with the A region covering the central 1/3 of k-space (solid gray region), the second 1/3 is the B-region (solid lines) and peripheral 1/3 the C-region (dashed lines). (b) The TREAT sequence defines the A-region the same as TRICKS but interleaves the B- and C-regions.