On Improving Temporal and Spatial Resolution in 3D Contrast-enhanced Body MRA with Parallel Imaging

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Synopsis
This study investigated a parallel imaging technique (ASSET) to improve temporal and spatial resolution of 3D contrast enhanced body MR angiography. Thirty studies were acquired in five groups to compare ASSET with standard MRA. Our results show that the use of ASSET to increase imaging speed by factors of 2 and 4 produced images with SNR and CNR almost equivalent to those obtained with standard MRA. Such preservation of SNR and CNR was likely a result of increased contrast concentration in ASSET-accelerated scans. ASSET can also achieve higher spatial resolution, although with reduced SNR and CNR.

Introduction
Three-dimensional contrast enhanced body magnetic resonance (3D CE-MRA) has become widely accepted as a diagnostic tool in clinical settings. However, the speed and spatial resolution of this technique are determined and limited by the performance of the gradient hardware. In addition, data must be acquired during the first pass of contrast bolus in order to avoid venous enhancement and the peak bolus concentration needs to be coordinated with data collection. Parallel imaging technique [1, 2] is a promising tool that allows rapid data acquisition and/or improved spatial resolution though the use of spatial information contained in the component elements of a coil array to partially replace spatial encoding which would normally be performed using gradients [1,2]. However, issues remain with regard to the reduction in SNR and CNR that are typically associated with parallel imaging. In the current work, we investigated the strengths and weaknesses of a parallel imaging technique (ASSET) to improve temporal and spatial resolution of 3D contrast enhanced body MRA to address these issues.

Methods
In one study, ASSET was used to speed up data acquisition time from 20 s to 10 and 5 s. In the other study, ASSET was used to improve the spatial resolution in the phase encoding direction by double the number of phase-encoding lines. Thirty experiments were performed on 26 healthy subjects (5 females, 21 males, 20-56 years old, mean 33.4 years). Each subject was assigned randomly to a specific study group. For each scan, two data sets were obtained: one with the standard technique and the other using ASSET imaging, in random orders. Data were acquired in five groups to compare ASSET with standard MRA to assess the value of such technique in helping improve imaging speed, by a factor of 2 or 4 (3 groups), or spatial resolution (2 groups). Each group contained 6 subjects. 3D CE-MRA data were obtained using a fast gradient echo sequence after administration of Magnest. In each volunteer, two contrast injections of 0.1-0.15 mmol/kg were used. The duration of the contrast bolus was set the same as the 3D data acquisition time. Specific imaging parameters were TR/TE = 5.1/1.3 ms, field of view = 35-40 cm, bandwidth = 125 kHz, 32 3-mm-thick sections were interpolated to 56 1.5-mm-thick sections.

Results
Maximum intensity projections (MIP) of ASSET scans demonstrated that data can be acquired in half (Figure 1A) or a quarter (Figure 1B) of the scan time without artifacts, while maintaining SNR and CNR (Figure 2). Such preservation of SNR and CNR was likely a result of increased contrast concentration in ASSET-accelerated scans. The use of ASSET to improve spatial resolution by two fold was also demonstrated (Figure 1C), although with a loss in SNR and CNR. ASSET can also achieve higher spatial resolution, although with reduced SNR and CNR.

Discussion
Our results show that ASSET may be used to help improve both temporal and spatial resolution in 3D CE-MRA. The use of ASSET to increase the imaging speed is very promising because of the near identical SNR and CNR as compared to standard 20-s scan. The reduction in scan time helps to reduce breath-holding time and eliminate potential contrast timing problems. The use of ASSET to increase spatial resolution was proven feasible as well, although with reduced SNR and CNR. However, the loss of SNR and CNR in such an approach may not affect 3D CE-MRA because of the intrinsically high SNR and CNR of 3D CE-MRA images. Further study in patients with vascular disease is needed to assess the applicability of these techniques for detection of pathological conditions.

References