Contrast-enhanced MR Angiography of the Circle of Willis at 3.0 Tesla

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Introduction:

In recent years there has been growing interest in the use of 3.0 T imaging systems for clinical MR angiography. The anticipated doubling of the signal to noise ratio (SNR) has the potential to allow for high spatial resolution MRA exams with SNR sufficient to produce diagnostic quality images. Due to the demands of sub-millimeter spatial resolution that is required to depict the intracranial vasculature, and the very short intracranial arterio-venous transit time intracranial MRA has been traditionally been performed using time of flight TOF techniques. TOF exams which are acquired over several minutes have inherently high SNR and spatial resolution, but are subject to inflow effects that causes artifactual signal loss. The purpose of this study is to evaluate CE-MRA at 3T in human subjects. We have compared the signal to noise ratio and vessel conspicuity of 1.5 T and 3.0 T CE-MRA exams of the intracranial vasculature.

Materials and Methods:

Subjects: Five healthy subjects including three women and two men (mean age = 31.4 yrs, range = 22-42 yrs) were scanned at both 1.5 T and 3.0 T. Imaging session were separated in time by 7 to 14 days.
Image acquisition: Images were acquired on a 1.5 T Siemens Sonata and 3.0 T Siemens Trio within 14 days of each other. Images acquisition was coordinated with the arrival of bolus of contrast using a standard dose timing scan (axial, 2D FLASH, one images/sec, 2.0 ml Gd-DTPA injected at 3.0 ml/sec) acquired at the level of the carotid bifurcation. The CE-MRA images were acquired with the clinical intracranial MRA protocol used at our institution, Images were acquired in the coronal plane with a 3D FLASH, sequence (TR/TE/flip = 3.4 ms/1.3 ms/20^o). One pre-contrast and 2 post contrast images were acquired with inline mask-mode subtraction. In all exams, the field of view, imaging matrix, number of partitions, and partition thickness were held fixed (FOV = 169 mm X 300 mm) to yield a fixed voxel size of 0.6 mm X 1.0 mm x 0.8 mm^3. In all exams, 18 ml of contrast were injected at a rate of 3.0 ml/s, independent of body weight.
Image analysis: 1.5 T and 3.0T images were evaluated independently by two board certified radiologist. The SNR of the CE-MRA images was evaluated by placing a region of interest to cover the carotid siphon and internal carotid artery. SNR was calculated and the mean signal/standard deviation of the noise. In addition, images were scored on a four point scale for vessel conspicuity of the Sylvain Fissure branches and the more distal branches of the middle cerebral arteries.

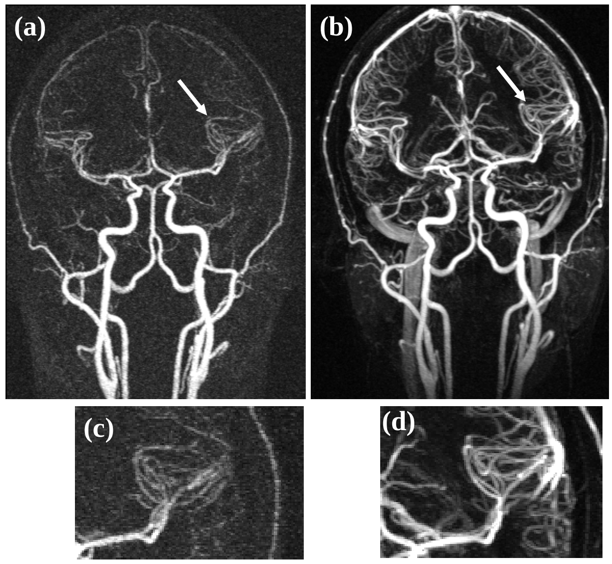

Figure 1: A comparison of intracranial CE-MRA exams at 1.5 T (a,c) and 3.0 T (b,d) in the same subject. The anticipated increase in SNR at high field results in improved of the distal cortical branches (arrows) of the middle cerebral artery, which are blow up for the 1.5 (c) and 3.0T images (d).

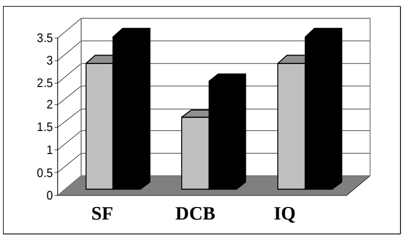

Figure 2: Images acquired at 1.5 T (gray bars) and 3.0T (black bars) were compared. Vessel conspicuity of the Sylvian Fissure (SF) and distal cortical branch (DCB) vessels and overall image quality (Q) were determined.

Results:

Representative images comparing 1.5 T and 3.0 T CE MRA exams appear in Figure 1. Mean scores for SNR in the Carotid siphon were 37.1 (69.0) for the 1.5 T (3.0 T) images. For the ICA, SNR was 31.7 (50.5) for the 1.5 T (3.0 T) images. Subjective scoring results appear in Figure 2. The scores for the SF/DCB/IQ were 2.8/1/6/2.8 for the 1.5 T exams and 3.4/2.4/3.4 for the 3.0T exams.

Conclusion:

Preliminary results suggest that MRA at 3T produces improvements compared to 1.5T. However direct comparison of 1.5 T and 3.0 T images could potentially be a result of improvements in coil design. Signal loss due T_2* dephasing effects have not proven to be a practical concern. SAR is proportional to $(B_0)^2$ in the range 1.5T to 3.0 T however we did not find this to be a practical problem.

References:

Bernstein et al, MRM 2001