Scoutless Abdominal Angiography at 3 Tesla With Two-Dimensional Acceleration

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Introduction:

Recently EZ-STEP, a new method using non-selective RF excitation, was proposed for the scoutless acquisition of peripheral MRA [1]. This method decreases the overall imaging time by using a non-selective RF pulses, but it does not take advantage of the speed benefits that could be obtained by the use of parallel imaging. We propose the use a non-selective, self-calibrating parallel imaging approach that combines the benefits of the two techniques. In this paper we evaluate the performance of our method in the imaging of abdominal arteries at 3 Tesla.

Methods:

A modified version of the EZ-STEP sequence [1] was implemented on a GE 3.0 T Signa Twinspeed system (GE Healthcare Technologies, Waukesha, WI) with a high performance gradient system achieving a maximum gradient strength of 40mT/m and maximum slew rate of 150mT/m/msec. Support for two-dimensional acceleration with self-calibration was added to the sequence. A diamond-sampling pattern [2,3] was used for the acquisition of the self-calibrated mask and angiographic scans. The Generalized Encoding Matrix (GEM) reconstruction approach was used to unalias the accelerated (Y-Z) planes [4,5]. An 8-element torso phased array coil was used for acquisition. An additional set of images was generated by subtracting the mask images from the angiographic images. These images were processed on a Vitrea workstation (ViTAL Images Inc, Minnetonka, MN) to generate 3D renderings of the vessel tree. A set of pre-contrast images with the same parameters was also acquired using the original EZ-STEP sequence with an acceleration factor of 2 in the phase encode direction, using an external calibration. Images obtained with both techniques were compared in terms of acquisition time and image quality.

Following informed consent, healthy volunteers were placed in the scanner. The 3D data set was acquired coronally with the slice FOV prescribed to obtain complete A/P coverage. Typically, 105 to 120 slices were acquired depending on the volunteer's size. The remaining acquisition parameters used were: 25° flip angle, 36-40 cm FOV, 2.2 ms TR, 0.6 ms TE, 2 mm slice thickness, 125 kHz bandwidth and 320 x 192 matrix size, and the phase encoding direction was R/L. A 70% partial Fourier acquisition was used in the slice direction. The reconstruction was done using zero filling for the missing data. For the self-calibrated acquisition, a fully sampled ellipse with major and minor axes of 32 and 30 frames was used for the calibration data. An acceleration factor of 2 was applied in the phase direction and an acceleration factor of 1.6 was applied in the slice direction, in addition to the partial Fourier. For each subject, an initial 2cc test bolus of gadopentetate dimeglumine was administered with a power injector at a rate of 2 cc/s. Using the timing information derived from the test bolus, a 1.5 dose of contrast based on weight was administered at the same rate as that of the test bolus.

Results:

A whole volume MRA of the abdominal vessels obtained using the modified sequence with 2D acceleration is shown in Figure 1. The aorta and renal arteries are clearly depicted. The A/P and lateral views demonstrate the complete volumetric coverage of the acquisition. The complete set of images was acquired in less than 11 seconds, while the conventional EZ-STEP sequence required 17 seconds to complete the same acquisition. In general, the time savings obtained using the EZ-STEP sequence with 2D acceleration with the described parameters was approximately 30%. Figure 2 shows the comparison of conventional EZ-STEP and the modified sequence for the pre-contrast acquisition. As expected, the noise level is higher for the modified sequence due to the higher acceleration used, but the images appear be free of artifacts and g-factor related noise and provide sufficient information to generate clinically useful MIPs or 3D renderings.

Discussion and Conclusion:

As shown in the results, use of the EZ-STEP sequence with 2D acceleration significantly shortens the acquisition time of an abdominal angiographic exam. The shorter acquisition time allows for shorter breath-holds, increased resolution or coverage, or decreased bandwidth. The use of self-calibration eliminates additional sources of artifacts that can arise due to different breath-hold positions between the calibration scan and the angiographic scan. It also simplifies the protocol and makes it especially suitable for use in multi-station applications such as those described for the original EZ-STEP. Finally, the current acceleration factors depend directly on the coil design and the number of channels. As more channels and better coils become available higher acceleration factors will become commonplace, allowing full coverage acquisitions to be performed in under 10 seconds.

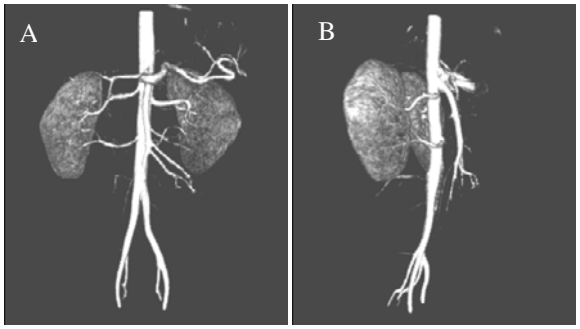

Figure 1. 3D rendering of the (A) A/P and (B) lateral views of the abdominal vessels. The aorta and the renal arteries are clearly depicted. The complete acquisition used an overall acceleration factor of 3.86 and was completed in 11 seconds.

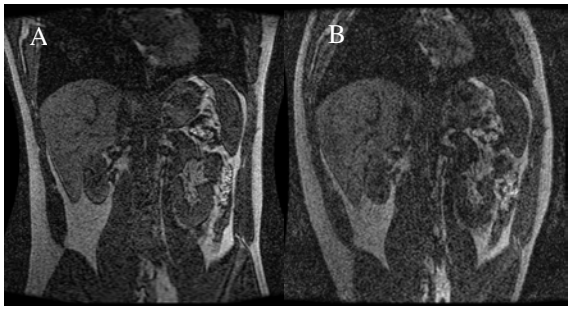

Figure 2. Source images using (A) a non-selective acquisition as described in [1] and (B) our sequence using non-selective acquisition combined with parallel imaging. As expected, the signal to noise level is lower in image (B) due to the higher acceleration but image quality is sufficient to generate a clinically useful MRA. Image (b) was reconstructed offline and gradient non-linearity correction was not applied.

References:

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