Phased Array Imaging in Mouse Hearts using an 8-Channel Phased Array Coil at 9.4 Tesla

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Introduction: Cardiac magnetic resonance imaging (CMR) in surgically or genetically modified mice is typically performed using single dedicated volume or surface coils. The development of coil arrays to speed-up CMR becomes more challenging with increasing magnetic field strength and reduced bore size of the magnet. While the use of coil arrays for cardiac MR exams of the human heart is well established in the clinic, only very few studies have reported on the use of 2-4 element arrays for MR on the mouse heart (1,2). This work presents first results for CMR in mice *in vivo* at 9.4T using a volume-coil-transmit/8-channel-volume-receive-array combination, and performs signal-to-noise-ratio (SNR) comparisons for different regions of heart as a function of selected coil-elements.

Methods: The coil-array consists of 8 elements (id 35 mm, length 32.5 mm) arranged cylindrically inside a linear-driven volume coil (id 67 mm, length 82 mm/od 115 mm). Imaging was performed on a horizontal 9.4T MR system comprising a VNMRS DirectDrive console with eight receivers (Varian Inc., USA) and a 600 mT/m gradient system. Mice were positioned prone and off-centered in a home-built mouse cradle, with the chest resting as close as possible on the lower coil-elements. Double-gated *in vivo* MR images of the three main axes of the heart were acquired using a segmented gradient echo (GE) sequence (TE/TR=1.2/3 ms, 8 segments per cardiac cycle, FOV 30x30 mm, 128x128), and a fast multi-frame GE sequence (TE/TR=1.79/4.6ms, NAE=1, α=15°, FOV 25.6x25.6 mm, 256x256) on a mid-ventricular short-axis slice in three normal mice (28 ± 3 g). Sum-of-square reconstruction (SOS) and SNR-measurements (using the BOOTLEG method (3,4)) as a function of coil-elements (arranged descending according to their signal contribution) were performed in an end-diastolic frame of the cine train for anterior, lateral, posterior, septal left-ventricular and for blood, respectively.

Results: Single coil elements showed high isolation under *in vivo* conditions (max. noise correlation 28%, mean 12%). Overall decoupling of each pair of coil elements was better than 16 dB on the bench, excluding preamplifier decoupling (typically an additional 20 dB). In Fig. 1, the SOS of all eight coil-elements for (A) the long-axis two-chamber and (B) long-axis four-chamber of the heart are shown. Figure 2 depicts (A-H) individual coil images, and (I) SOS of an end-diastolic frame (in plane resolution 50 µm, slice thickness 1 mm) out of the cine train. The scale bars in both Figures correspond to 5 mm. Figure 3 shows the results for the SNR measurements as a function of the number of contributing coils averaged over all voxels in the respective compartment of the three mice (mean ± SD). The optimum coil number was 8 for all compartments with the main contribution from the 3 anterior coil elements.

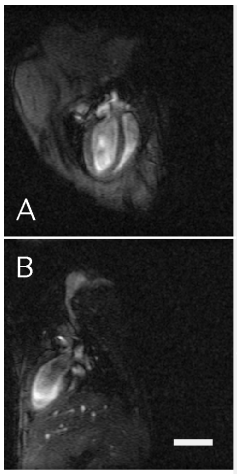

Figure 1

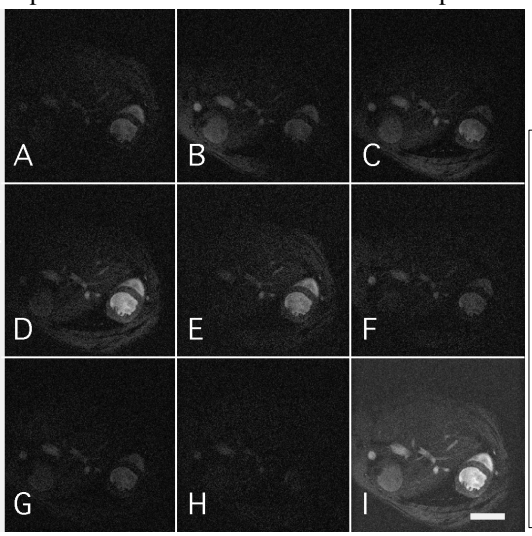

Figure 2

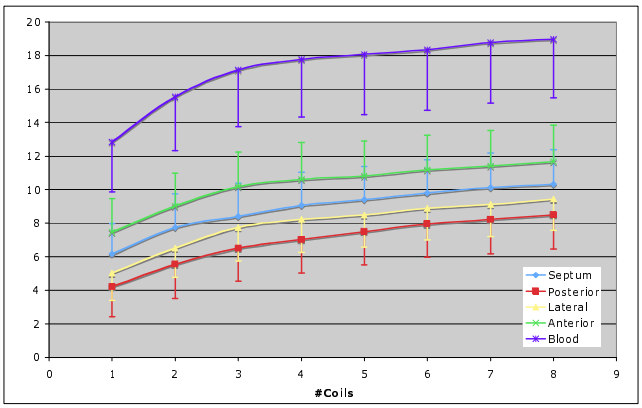

Figure 3

Discussion & Conclusion: This is the first report on the usage of an 8-channel array at ultra-high fields for CMR in mice. Although the main contribution to the image arises from the anterior coil elements as expected (the mice were positioned off-centred), the posterior elements still add constructively. Hence, the optimal number of receive coils was equal to the number of elements in the array. Furthermore, initial experiments indicate that the array provides superior SNR performance for the heart compared to a matching quadrature birdcage coil. Importantly, this coil-array now allows for parallel imaging (PA) and work is in progress to assess the PA characteristics.

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References:

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