Optimized Two-Element Coil-Array for Cardiac Imaging in Mice at 9.4 T

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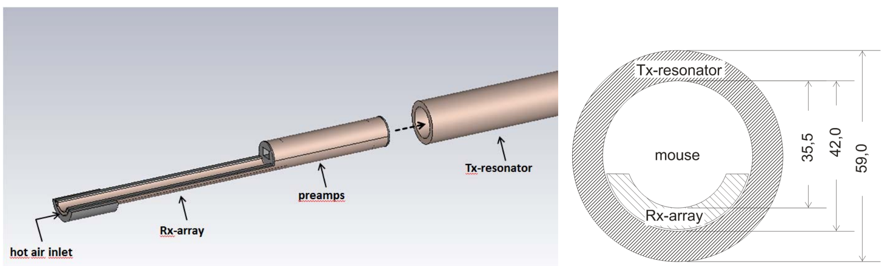
Target audience: This work targets the preclinical cardiac MR community who will benefit from novel and improved receive-coil array designs described in this abstract.

Purpose: Cardiac imaging on mice needs both high performance gradient systems and optimized RF coils. The limited available space leads to either optimized gradient performance with a birdcage as Tx/Rx coil, which is the most commonly used design. Alternatively, larger gradient diameters allow for operating (large) Tx resonators and receive arrays[1]. The aim of this work is to develop a Tx resonator and an Rx coil array, optimized for murine cardiac MRI and to be combined with a high-performance microscopy gradient system, while, still providing all necessary means for maintaining animal physiology and monitoring in the magnet.

Methods: The mouse heart array is, as a first step, designed as a two-channel array for anterior use in prone position. An individual coil element is 20 x 17.4 mm^2, resulting in an overall array size of 20 x 31 mm^2 with overlapping elements. Each coil element is receive-only with active decoupling and preamplifier decoupling at the working frequency of 400 MHz. Since the available space is extremely restricted by the small Tx resonator, the array housing is as thin as possible (thickness 6 mm) and serves as mouse cradle at the same time. Preamplifiers are too large to be located inside the array housing, and are therefore positioned in a preamplifier housing attached to the mouse cradle (distance 20 cm). The mouse holder is heated with warm air flowing through the array housing. All MR experiments were carried out on an Agilent 9.4 T DDR2 MR system (Agilent, Santa Clara, US), equipped with a microscopy gradient system (1 T/m, id 6 cm) and a Tx birdcage (id 42 mm, Rapid Biomedical, Germany). Assessment of coil array performance and comparative experiments with a quadrature driven birdcage (id 33 mm, Rapid Biomedical) were conducted on an agarose phantom (1% agarose made up of 50 mM NaCl + 1 mM Gd, outer diameter (od) 25 mm), and on four mice *in vivo* (C57Bl6, 17 - 30 g), using a spin echo sequence (TE = 8 ms; $TR_{phantom}$ = 1 s; $TR_{in\ vivo}$ = 1.7 - 1.9 s depending on respiratory rate; slice thickness 1 mm; 30 x 30 mm^2, 128 x 128). An additional noise data set was acquired. SNR maps were generated using a bootstrapping approach[2].



Results: Fig. 1 illustrates the design of the coil array. RF workbench measurements yielded unloaded to loaded Q-factors for the individual elements of Q_U / Q_L = 200 / 123 = 1.6. Elements were tuned and matched to 50 Ω (input reflection factors Γ < -20 dB). Coupling between coil elements was T = -20 dB. MR measurements comprised SNR maps of the agarose phantom and of a 28 g mouse shown in Fig. 2 and 3, respectively. In the phantom, the SNR of the coil array was more than 2x higher close to the edge, and ~75% in the center of the phantom compared to the birdcage. For the example mouse shown in Fig. 3, the SNR was 184 ± 18 (anterior wall) / 123 ± 15 (posterior wall) with the coil array (birdcage: 106 ± 10 anterior and posterior wall). The noise correlation between the two channels was 23% in the phantom and 26% in the mouse.

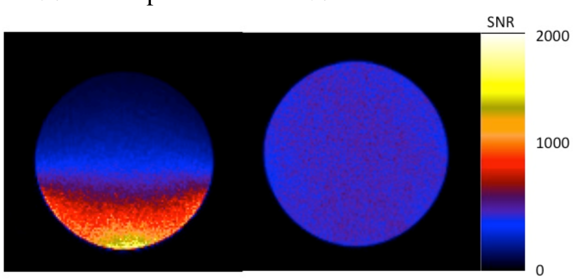


Fig. 2: Axial SNR-maps obtained with the coil array (left) and the birdcage (right).

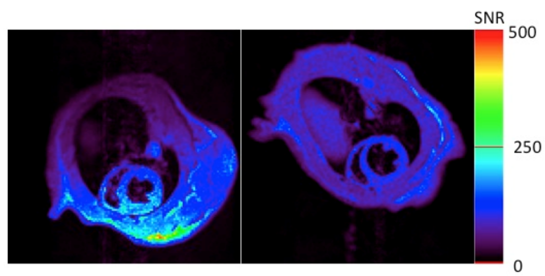


Fig. 3: SNR maps across the thorax of a mouse (in short axis orientation) obtained with the coil array (left) and the birdcage (right).

Discussion & Conclusion: We have successfully developed a two-element coil-array that can be combined with a 42 / 59 mm (id / od) transmit resonator, and demonstrated superior performance for cardiac imaging compared to a commonly used quadrature birdcage coil. Integrating the heating in the animal holder together with the receive coils provides essentially as much free space for the animal as dedicated mouse cradles routinely used for the birdcage – despite the smaller inner diameter of the array. The setup is upgradable with two posterior coil elements to form a four-channel phased array. Work is in progress to investigate whether or not further SNR improvements can be achieved by this approach.

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References: 1. Lanz T, M. Müller, Barnes H, Neubauer S, Schneider J. A High-Throughput Eight-Channel Probe Head for Murine MRI at 9.4 T. Magn Reson Med. 2010;64: 80-87. 2. Riffe M, Blaimer M, Barkauskas K, Duerk J, Griswold M. SNR estimation in fast dynamic imaging using bootstrapped statistics. Proc ISMRM. 2007;15:1879.