Analysis of Geometrical Arrangement for a 64-Channel Cardiac Phased-Array Coil for 3T

Mark Schuppert[1], Boris Keil[2], Bastien Guerin[2], Stefan Fischer[1], Laura M. Schreiber[1], and Lawrence L. Wald[2,3]

[1]*Section of Medical Physics, Department of Diagnostic and Interventional Radiology, Johannes Gutenberg University Medical Center, Mainz, Germany,* [2]*Department of Radiology, A.A. Martinos Center for Biomedical Imaging, Massachusetts General Hospital, Charlestown, MA, United States,* [3]*Harvard-MIT Division of Health Sciences and Technology, Cambridge, MA, United States*

Target Audience: RF engineers

Purpose: Phased-array coils[1] with up to 128 channels are used for various applications[2-7] such as cardiac imaging. Receive phased-arrays with increased number of channels have been shown to yield improved image quality in parallel acquisition strategies. However, even with high numbers of channels, SNR improvement in the center of the body is difficult to achieve due to the limited sensitivity of small coil elements. This is a drawback in cardiac applications. We analyze several different geometrical arrangements of coil elements in a 64 channel phased-array cardiac coil for optimized SNR and g-factor values in the heart.

Methods: Initially the optimum-density arrangement of coil elements over the heart region on chest and back (with 24 channels each) was identified. By means of using static magnetic field simulations applying Biot-Savart law (assuming the principle of reciprocity) coil configurations with element diameters of 65, 75, and 85mm were simulated. Scaling the simulated signal values with the square root of the resistance R ($R=\omega L/Q_{loaded}$) of three built single coils (AWG 16 copper wire) provides relative SNR values in arbitrary units (a.u.). An anatomically shaped human body model including the heart was used to calculate relative SNR values in the heart. The simulated B1 distributions are equivalent to sensitivity maps and used to calculate the geometry factors (g-factor[8]) to evaluate the parallel imaging performance of each coil configuration. Additional 32 channels were added to this initial configuration for improved coverage on the left and right side of the chest. Coil elements with highest SNR contribution while maintaining low g-factor values in the heart were chosen for the final coil pattern.

Results: The posterior wall of the heart represents the critical area containing lowest relative SNR values in our simulations. The final coil pattern (Fig.1) comprises 40 coil elements on the chest and 24 coil elements on the back each exhibiting a diameter of 75mm. A diamond-shaped pattern consisting of 24 channels in five rows centered over the heart (chest and back) is used as a start pattern to arrange further 16 channels on the chest part. Coil elements distant from the center line do not contribute substantially to relative SNR gain in the heart thus the final layout consists of five parallel rows of coil elements. Lateral arrangement of coil elements wrapping around the body is important and results in a homogeneous SNR distribution (Fig.2) and low g-factor values in the heart (Fig.3) simultaneously. The final 64-channel coil configuration with provides 25% higher SNR in the heart compared to the initial 48-channel coil configuration (24 each on chest and back).

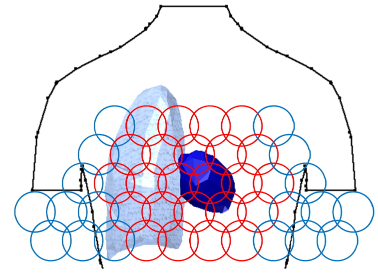

Fig.1: Final unwrapped coil configuration on the chest with diamond-shaped start pattern (red) and added coil elements on right/left side (blue) over the heart (dark blue)

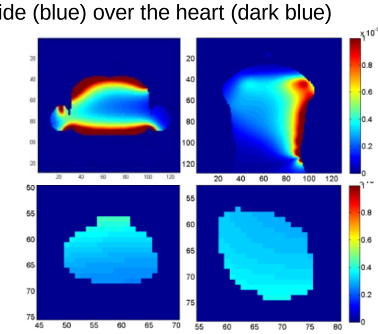

Fig.2: Relative SNR distribution in the body (top) and the heart (bottom) in a transversal (left) and a coronal plane (right)

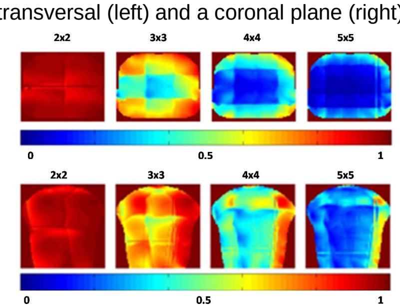

Fig.3: Simulated transversal (top row) and coronal (bottom row) 1/g-maps for various acceleration factors

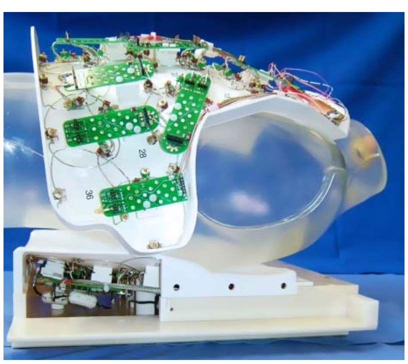

Fig.4: Implementation of the simulated 64-channel cardiac phased-array on chest and back

Conclusion: The simulations of the magnetic field distribution performed during this study are considered a valuable approximation of the realistic field distribution at 3T. By experience, wavelength issues are not heavily corrupting the results at 3T. The simulated SNR and g-factor performance of the final coil configuration seems promising for cardiac imaging applications and is actually being implemented into a 64-channel cardiac phased-array coil (Fig.4).

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References: [1] Roemer PB et al., MRM (1990) 16(2):192-225; [2] Schmitt M et al., MRM (2008) 59(6):1431-9; [3] Hardy J et al., JMRI (2008) 28(5):1219-25; [4] Wintersperger BJ et al., JMRI (2006) 23(2):222-7; [5] Keil B et al., MRM (2012) (Epub ahead of print); [6] Wiggins GC et al., MRM (2009) 62(3):1332-5; [7] Meise FM et al., MRM (2010) 63(2):456-64; [8] Pruessmann KP et al., MRM (1999) 42(5):952-62