Lung-cardiac specific ^{1}H RF array coil at 1.5 T

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Target audience: Lung and cardiac imaging. RF array coil community.

Purpose: ^{1}H MRI is emerging as a viable modality for lung parenchyma imaging. Advancement has been achieved by pulse-sequences with short echo times to study structural and functional information of the lung[1]. However, ^{1}H lung-MR methods have inherently low signal-to-noise ratio (SNR) in the parenchyma due to the lower ^{1}H density (<0.2g/cc) and short T_2^*. Thus there are obvious gains to be made through anatomically customized radio-frequency (RF) receiver coil designs. In this work we propose a receiver RF coil array topology designed for high SNR imaging of the lung-cardiac anatomy at 1.5T and illustrate the ^{1}H SNR improvement over a conventional 8 channel ladder-like topology used routinely for cardio-thoracic MRI.

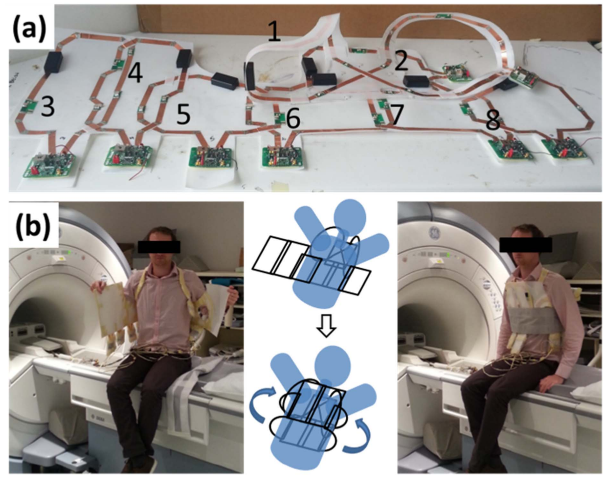

Figure 1: (a) Photograph of novel 8 element RF array coil design for lung and cardiac imaging. (b) Illustration of RF coil array (topology) applied on the subject, arms pass through figure of 8, then the array is wrapped.

Methods: The proposed ^{1}H receiver RF coil array is an 8 channel design as illustrated in Fig 1(a). Element 1 is a volume figure of 8 topology and structured in such a way that, arms of subject pass-through and conforms and couples well to the upper chest as shown in Fig 1(b). Element 1 along with elements 2-4 combine in quadrature for enhanced sensitivity coverage of the upper/superior left and right lobes of the lungs. Elements 3-8 cover the lower/inferior left and right lobes. Element 1 is geometrically decoupled from elements 2,3,4,6,7 as the B_1^- polarization is mutually orthogonal. Element 1 is decoupled from elements 5,8 by critical overlap. Element 2-8 are critically overlapped and a low input impedance LNA fitted to all of the 8 elements[2]. Each of the elements are decoupled from the ^{1}H transmit body coil with one active and one passive detuning circuit. Lung MRI was performed on a GE 1.5T Signa HDx system. For in-vivo studies, the imaging parameters for ^{1}H were flip angle=50^0, TE=0.9ms, TR=2.9ms, slice thickness=10mm, FOV=38cm and matrix size = $384_{\text{frequency}}$ x 256_{phase} with a 2D coronal slice with a bSSFP pulse sequence. The SNR was measured from sum of squares images as the ratio of mean of signal to $\sqrt{2}$ times the standard deviation of noise. To illustrate SNR improvement over the conventional 8 channel cardio-thoracic receiver array a SNR comparison (%) was performed on a NiCl phantom with a GRE pulse sequence with identical imaging parameters.

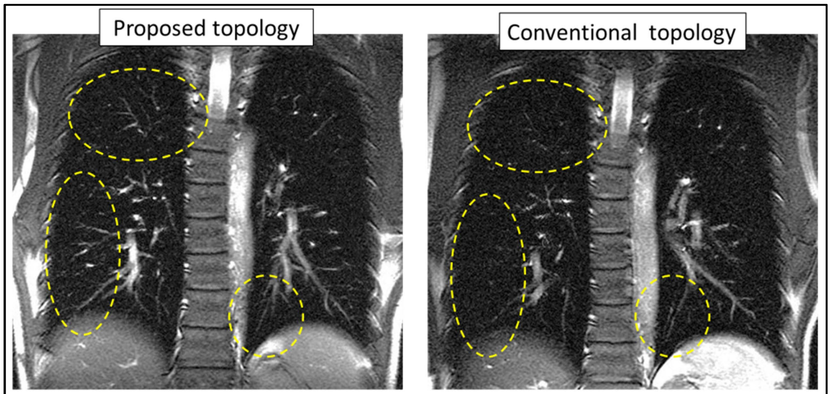

Figure 2: Illustration of SNR improvement of proposed novel 8 element RF array coil over the conventional ladder-like topology. (a) Proposed lung-specific topology and (b) conventional ladder-like topology. As seen more structural information from the small blood vessels discernible is available in proposed topology

Results: All the elements were matched below -20dB. The isolation between any two elements was less than -18dB, decoupling from the LNA further improves isolation. The Q_{unloaded} to Q_{loaded} ratio was more than 8. The ^{1}H SNR (Avg) from the lung-specific topology was >30% higher than the conventional topology. As illustrated in Fig 2, the image acquired with the lung-specific topology enables the resolution of finer more anatomical details than the conventional 8 channel topology.

Discussion: This prototype illustrates SNR improvement, the cable assembly did not have baluns fitted, with baluns we would expect further improvement in SNR. The volume figure-of-8 elements provide sensitivity through-out the right-left direction providing improved ^{1}H SNR over conventional topology but it makes the coil less suited for parallel imaging. Preliminary investigations with the coil indicate, it also provides improved SNR for cardiac MRI and oxygen enhanced lung MRI. The array former is thin (6mm) and easily be inserted within other coils for multi-nuclear applications[4]. Next step in this design is to fit traps for ^{3}He/^{129}Xe for synchronous acquisition of the lungs[3-4]. In addition, though the topology is demonstrated for ^{1}H, it can be readily tuned to ^{3}He, ^{129}Xe and ^{19}F imaging of the Lung.

References: **1.** Wild, J.M., et al., MRI of the lung (1/3): Methods. Insights into Imaging, 2012. 3(4): p. 345-353. **2.** Roemer, P.B., et al., The NMR phased array. Magnetic Resonance in Medicine, 1990. 16(2): p. 192-225. **3.** Wild, J.M., et al., NMR in Biomedicine, 2011. 24(2): p. 130-134. **4.** Rao, M., et al, Magnetic Resonance in Medicine, 2014: 10.1002/mrm.25384.