DEDICATED RECEIVER ARRAY COIL FOR ^{1}H LUNG IMAGING WITH SYNCHRONOUS ACQUISITION OF HYPERPOLARIZED ^{3}He AND ^{129}Xe GAS

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Target Audience: Multi-nuclear imaging; RF coil engineering; hyperpolarized media.

Purpose: Synchronous acquisition of proton (^{1}H) and hyperpolarized (HP) gases in the lungs provide complementary structure-function information with inherent spatial-temporal registration[3, 4]. To date ^{1}H images have been acquired using the MR system's body coil, which has low SNR compared to dedicated receive only coils, this poses limitations when considering ^{1}H lung MR, as it is already a low SNR regime due to low tissue density and short T_2*. The presence of TR coils at HP gas frequencies can further degrade the SNR obtained from the ^{1}H body coil. This study demonstrates the design and application of a dedicated ^{1}H surface array to improve the proton lung SNR in synchronous acquisition with HP gas ^{3}He and ^{129}Xe at 1.5T.

Methods: A 4 loop dedicated receiver array was developed in-house for ^{1}H lung MRI (63.83 MHz) to work in compatibility with a commercially available ^{3}He/^{129}Xe TR vest coil (CMRS, WI -without modifications) and an in-house ^{129}Xe asymmetric-birdcage transmitter[1] combined with ^{129}Xe receiver array as shown in Fig 1c&1d. The resonant loops of the ^{1}H array were critically overlapped and it had a low input-impedance low noise amplifier (≈2Ω). Loops were decoupled from the ^{1}H body coil transmit with one active and one passive detuning circuit. Each of the loops were fitted with passive traps for both ^{3}He (48.62 MHz) and ^{129}Xe (17.65 MHz). Lung MRI was performed on a GE 1.5T Signa HDx system with ^{3}He and ^{129}Xe gas polarized with spin exchange optical pumping[2]. HP gas ventilation MRI and ^{1}H lung imaging were acquired back-back in the same breath. For ^{3}He ventilation MRI a spoiled gradient echo sequence was used with flip angle=8^0, TE=1.1ms, TR=3.6ms, matrix size = $104_{phase}X80_{frequency}$ slice thickness=10mm, FOV=38.4cm. For ^{129}Xe; flip angle =8^0, TE =3.6ms, TR=18.9ms, matrix size = $78_{phase}X64_{frequency}$ slice thickness=15mm, FOV=38cm. For ^{1}H structural imaging a bSSFP sequence was used with flip angle=50^0, TE=0.9ms, TR=2.9ms, matrix size = $192_{phase}X256_{frequency}$. SNR was measured from *sum of squares* images as a ratio of mean of signal to standard deviation of noise.

Results: The SNR from the ^{1}H array was ≈90% more than the SNR from the ^{1}H body coil for synchronous acquisition with ^{3}He TR coil in-situ (Fig 1b). The images from ^{3}He and ^{129}Xe were well co-registered with the images from ^{1}H (Fig 1c&d), consistent with their same-breath acquisition.

Discussion: Even though the ^{1}H array was tuned to 63.83MHz, which is well away from ^{3}He and ^{129}Xe frequencies, it was necessary to add traps to avoid coupling and protect the LNA. For the first case with the ^{3}He TR vest coil, ^{3}He traps were fitted to the ^{1}H array across a loop capacitor of 36pF and no reduction in ^{1}H or ^{3}He SNR was observed. For the second case with ^{129}Xe TR vest coil, additional traps were added across another loop capacitor of 200pF to reduce the footprint of the traps, and residual coupling was observed. ^{1}H SNR from the ^{1}H array with ^{129}Xe TR coil in-situ was ≈40% less when compared to ^{1}H SNR in the first case with the ^{3}He coil, nevertheless SNR was still 50% more than the system ^{1}H body coil. Also, there was a 30% reduction in ^{129}Xe SNR from ^{129}Xe TR coil with ^{1}H array in-situ. In the third case with two birdcage-transmitters/array-receivers for both ^{1}H and ^{129}Xe, the ^{129}Xe birdcage was not shielded to enable ^{1}H transmit.

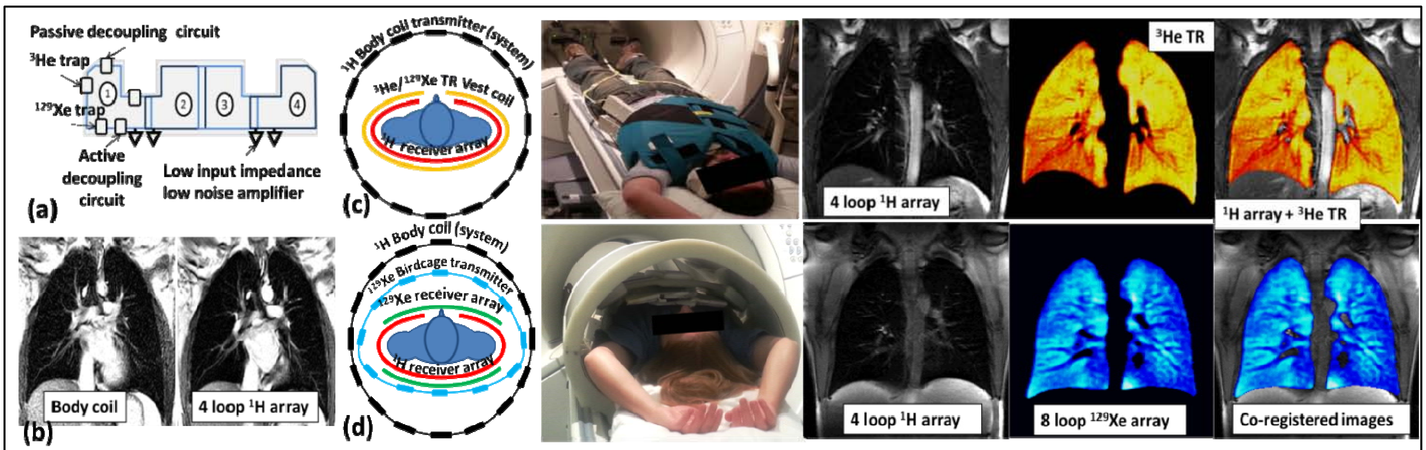

Figure 1: (a) ^{1}H receiver array design, (b) ^{1}H SNR comparison between body coil and receiver array (c) ^{1}H receiver array with ^{3}He/^{129}Xe TR vest coil and (d) two birdcage transmitter and two dedicated receiver array for ^{1}H and ^{129}Xe

Conclusion: The SNR improvement of the ^{1}H images provided by a nested ^{1}H receive array coil in the synchronous acquisition of HP gas MRI has been demonstrated. This is the first time ^{1}H array images have been acquired in synchronous acquisition with HP gas lung MRI and it is also the first time multi-nuclear imaging has been performed with two individual birdcage transmitters and two receiver arrays. Both represent novel developments in the field of multi nuclear MRI RF engineering and open up opportunities for the fusion of high quality images of structure (^{1}H lung MR) and function (HP gas MR) with obvious applications in other areas like ^{13}C metabolic imaging.

References:

1 N. De Zanche, *et al.*, *Magnetic Resonance in Medicine,* 60 (2008), 431-38. 2 G. Norquay, *et al.*, *Journal of Applied Physics,* 113 (2013).

3 J. M. Wild, *et al.*, *NMR in Biomedicine,* 24 (2011), 130-34. 4 J. M. Wild, *et al.*, *Radiology,* 267 (2013), 251-55.