DEDICATED RECEIVER ARRAY COIL FOR ¹H LUNG IMAGING WITH SYNCHRONOUS ACQUISITION OF HYPERPOLARIZED ³He AND ¹²⁹Xe GAS
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Target Audience: Multi-nuclear imaging; RF coil engineering; hyperpolarized media.

Purpose: Synchronous acquisition of proton (¹H) and hyperpolarized (HP) gases in the lungs provide complementary structure-function information with inherent spatial-temporal registration. To date ¹H 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 ¹H lung MR, as it is already a low SNR regime due to low tissue density and short T₂*. The presence of TR coils at HP gas frequencies can further degrade the SNR obtained from the ¹H body coil. This study demonstrates the design and application of a dedicated ¹H surface array to improve the proton lung SNR in synchronous acquisition with HP gas ³He and ¹²⁹Xe at 1.5T.

Methods: A 4 loop dedicated receiver array was developed in-house for ¹H lung MRI (63.83 MHz) to work in compatibility with a commercially available ³He/¹²⁹Xe TR vest coil (CMRS, WI -without modifications) and an in-house ¹²⁹Xe asymmetric-birdcage transmitter combined with ¹²⁹Xe receiver array as shown in Fig 1c&1d. The resonant loops of the ¹H array were critically overlapped and it had a low input-impedance low noise amplifier (≈2Ω). Loops were decoupled from the ¹H body coil transmit with one active and one passive detuning circuit. Each of the loops were fitted with passive traps for both ³He (48.62 MHz) and ¹²⁹Xe (17.65 MHz). Lung MRI was performed on a GE 1.5T Signa HDx system with ³He and ¹²⁹Xe gas polarized with spin exchange optical pumping. HP gas ventilation MRI and ¹H lung imaging were acquired back-back in the same breath. For ³He ventilation MRI a spoiled gradient echo sequence was used with flip angle=8°, TE=1.1ms, TR=3.6ms, matrix size = 104 phaseX80 frequency slice thickness=10mm, FOV=38.4cm. For ¹²⁹Xe; flip angle =8°, TE =3.6ms, TR=18.9ms, matrix size = 78 phaseX64 frequency slice thickness=15mm, FOV=38cm. For ¹H structural imaging a bSSFP sequence was used with flip angle=50°, TE=0.9ms, TR=2.9ms, matrix size = 192 phaseX256 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 ¹H array was ≈90% more than the SNR from the ¹H body coil for synchronous acquisition with ³He TR coil in-situ (Fig 1b). The images from ³He and ¹²⁹Xe were well co-registered with the images from ¹H (Fig 1c&d), consistent with their same-breath acquisition.

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

Conclusion: The SNR improvement of the ¹H images provided by a nested ¹H receive array coil in the synchronous acquisition of HP gas MRI has been demonstrated. This is the first time ¹H 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 (¹H lung MR) and function (HP gas MR) with obvious applications in other areas like ¹³C metabolic imaging.

References: