A flexible 32-channel array for ^{3}He human lung imaging at 1.5T

M. H. Deppe[1], J. Parra-Robles[1], T. Lanz[2], and J. M. Wild[1]
[1]Academic Radiology, University of Sheffield, Sheffield, Yorkshire, United Kingdom, [2]Rapid Biomedical GmbH, Rimpar, Germany

Introduction: Imaging of hyperpolarized (HP) nuclei, such as ^{3}He, ^{13}C and ^{129}Xe, is an application for which parallel imaging methods are particularly beneficial [1], as the typical SNR penalty of $1/\sqrt{N}$ resulting from a lower total number N of acquired k-space lines can be countered by a higher flip angle [2]. Additionally, the attainable shortened total imaging times are desirable, because of the necessity for breath-hold imaging with gases in the lungs and/or the rapid T_1 relaxation of hyperpolarization in-vivo. Hence, several coil arrays for in-vivo imaging of HP noble gas imaging have recently been presented [3,4]. For human lung imaging, a transmit coil with homogeneous B_1 over the large FOV required is advantageous, as HP imaging is very sensitive to flip angle. This work presents a flexible 32-channel receive array for HP ^{3}He human lung imaging at 1.5T, intended for use inside an existing ^{3}He birdcage transmit coil of excellent B_1 homogeneity [5].

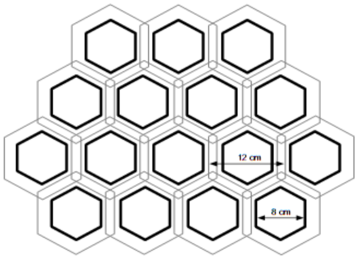

Fig. 1: Layout of each array half, showing coil elements (black), and concentric shields (gray)

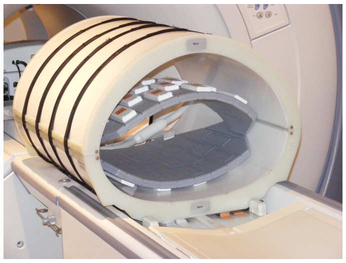

Fig. 2: The finished array halves inside of the transmit coil described in [5].

Methods: The coil was constructed on two flexible circuit boards containing 16 hexagonal coil elements each. The layout of the elements is shown in Fig. 1. Each element is tuned to 48.63 MHz, the ^{3}He resonant frequency at 1.5T. Concentric shields [6], grey in Fig. 1, and preamplifier decoupling [7] are used to decouple all element couples. During the transmission phase each element is actively detuned. Both array halves are enclosed in foam casing for patient comfort and safety. Currently, no detuning modifications have been made to the transmit coil as described in [5]. Figure 2 shows the complete array inside the transmit coil. To test the performance of the coils, ^{3}He lung images were acquired on a GE 1.5T HDx scanner (GE, Milwaukee, USA) from a healthy volunteer, using 300 ml ^{3}He mixed with 700 ml N_2. ^{3}He was polarized to ~20% using a Helispin polarizer (GE, Milwaukee, USA). A 2D spoiled gradient-echo sequence, modified in-house to enable generalized auto-calibrated parallel imaging (GRAPPA) [8], was used for imaging. Parameters were TE = 1.9 ms, TR = 4.5 ms, FOV 48 cm, 128×128 matrix, bandwidth ± 31.25 kHz and slice thickness 10 mm. Two auto-calibrated sets of data were acquired, with acceleration factors $R = 2$ and $R = 4$. Flip angles were derived from the expression in [9] as 9° and 11° respectively.

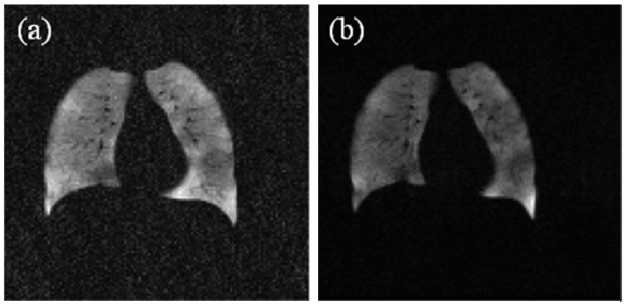

Fig. 3: Images acquired with acceleration factors of R = 2 (a) and R = 4 (b)

Results and Discussion: Figure 3 shows the same slice acquired with the $R = 2$ (3a) and $R = 4$ (3b). The under-sampled k-space was reconstructed in Matlab using the 'opengrappa' implementation of GRAPPA. Comparable image quality is achieved with both sequences; particularly, no deterioration in SNR is observed for the sequence with $R = 4$, as a higher flip angle could be used. Visually, SNR appears even higher in 3(b), but possible confounding factors should be considered: the actual flip angle in 3(a) might be lower than intended, and the slightly lower lung inflation compared to 3(a) might result in the ^{3}He being less diluted. The noise correlation matrix for loading with a human volunteer is shown in Fig. 4. A few coefficients are rather high (the highest three being 0.61, 0.58 and 0.54), which is believed to be due to the fact that the transmit coil is currently not detuned during reception. As some elements come physically quite close to the transmit coil, coupling between elements via the birdcage will occur, resulting in the strong correlations observed. Thus, the next step will be modification of the transmit coil, enabling detuning of the birdcage during transmission.

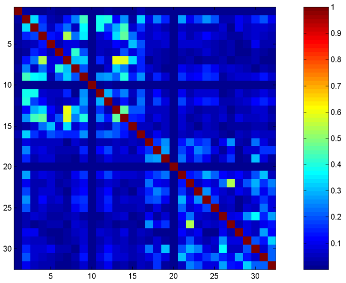

Fig. 4: Noise correlation matrix

In conclusion, this work presents preliminary results from a flexible 32-channel array designed for human lung imaging using HP ^{3}He at 1.5T. The array is designed to be integrated with an existing birdcage transmit coil [5], which is currently not detuned during transmission, limiting the performance of the combined system. Nevertheless, these initial results are encouraging, as they demonstrate accelerated acquisitions without loss in SNR as expected for imaging of HP nuclei.

References: [1] Lee et al., MRM 55, 1132-1141 (2006); [2] Mugler and Brookeman, Proc. ISMRM 13, Miami, 485 (2005); [3] Meise et al., Proc. ISMRM 17, Honolulu, 2993 (2009); [4] Dregely et al., Proc. ISMRM 17, Honolulu, 2203 (2009); [5] de Zanche et al., MRM 60, 431-438 (2008); [6] Lanz and Griswold, Proc. ISMRM 14, Seattle, 217 (2006); [7] Roemer et al., MRM 16, 192-225 (1990); [8] Griswold et al., MRM 47, 1202-1210 (2002); [9] Wild et al., MRM 47, 687-695 (2002)

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