A dedicated coil configuration for hyperpolarized 129Xe imaging at 1.5 T

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Introduction: Hyperpolarised lung MRI research has been concentrated on hyperpolarised ^{3}He due to inherently higher signal as compared to ^{129}Xe. However this trend is changing due to current supply limit of ^{3}He and the interesting solubility and chemical-shift characteristics of ^{129}Xe. Lower ^{129}Xe signal can be mitigated by use of parallel imaging. It has been shown that hyperpolarised gas MRI does not suffer the usual loss in SNR when higher flip angles are used compared to equilibrium MRI[1]. Using an accelerated technique (R>1) by covering less k-space lines will also allow for shorter patient breath–holds (typically<20s). In this work initial images were acquired with a non-circular birdcage for transmission and an 8-ch array coil for reception.

Methods: The transmit coil (Tx) was constructed as a linear birdcage volume coil shaped half-circular half-elliptical to adapt to the available magnet bore space as demonstrated by de Zanche et al. [2] see Fig.1. The available space inside the volume coil is 33.7 cm in the P-A direction and 47 cm in the L-R direction. The coil is also detachable to allow for easy patient access. The Tx birdcage coil is shielded and proton traps are incorporated for proton images with the body coil of the MR scanner. The receive array in Fig.2 consists of a lower and an upper part which can be used individually. Housing of the lower half is rigid and shaped to match the shape of the lower half of the volume coil. The upper half of the coil is flexible to adapt to different patient geometries and hence optimising the filling factor and the signal to noise ratio. Each half of the receivers houses four array elements that are aligned along the lateral direction. Overlap decoupling was used to improve the isolation between neighbouring array elements. The two banks of 4 arrays could also be used separately as a lone 4-ch or in tandem as an 8-ch array. All coils are tuned to 17.66 MHz, the ^{129}Xe Larmor frequency at 1.5T. Proton traps were used in all receive array elements to allow for proton co-registration imaging. All imaging was carried out on a 1.5T GE HDx system. Images were acquired from a xenon sealed cell (25cm^3 cylindrical cell) containing natural abundance xenon (26%) filled to 3atm along with 3atm of N_2 buffer gas. The estimated Xe polarisation was 2-3%.

Fig.1: Volume transmit coil with upper array and lower half positioned in place

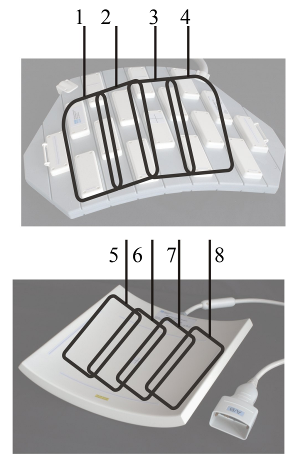

Fig.2: Receive array element layout


Fig.3:Axial image of the cell

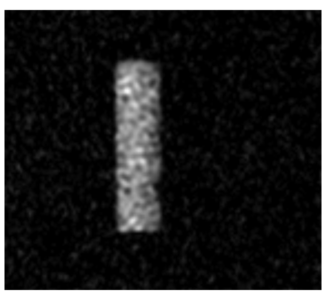
Fig.4: Sagittal image of the cell

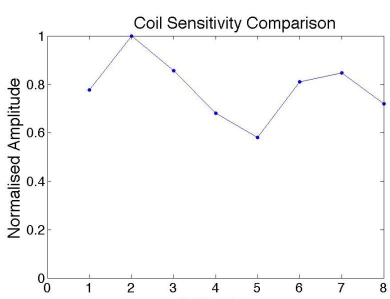

Fig.5: Rx array element 1-8 sensitivity comparison

Results: The transmit coil has an unloaded quality factor (Q) of 125 and a loaded Q of 60 (75kg volunteer) resulting in a $Q_{unloaded}/Q_{loaded}$ ratio >2. The field homogeneity variation inside the transmit coil in the central transverse plane is within 1 dB when measuring S_{21} with a pick-up coil on the workbench. Each receive array element has an unloaded Q of 150 and a loaded Q of 57 (human chest). The mutual decoupling between elements is -15 dB or better. Initial SPGR images were acquired as shown (Fig.3 and Fig.4). Fig.3 shows an axial image with a field of view (FOV) of (32cm)² and a slice thickness of 20cm and was acquired using a minimum TE of 3.5ms with a TR of 10ms with a matrix size of 128x128. In Fig.3 notice the stem of the cell. Fig.4 shows a coronal image with (25cm)² FOV, thickness of 20cm acquired using TE of 3.7ms and a matrix size of 128x128. Fig.5 shows a plot of arbitrary signal amplitude received by each of the array elements 1-8 as depicted in Fig.2. This comparison is done with the sealed cell placed in the middle of the coil and with the top and bottom array housings approximately equi-distanced to the sealed cell.

Discussion: A novel hyperpolarised ^{129}Xe imaging configuration using a non-circular birdcage for transmission and two banks of 4-ch arrays has been demonstrated. This configuration fully utilises the available magnet bore space. Also by having the flexibility of only using one half of the 8-ch array patients in need for more space can be accommodated with multiple receive imaging still feasible. The first ^{129}Xe image obtained using these coil configurations are shown. Future work as a prelude to in-vivo studies will involve better characterisation of the coil by using a flood phantom. Acceleration factors of R>1 will also be explored further to cut the scan time and we anticipate that the enhanced signal gain from the receivers will further improve the sensitivity of XTC experiments [3]. Rapid imaging techniques are potentially useful for ^{129}Xe imaging as this species is less susceptible to signal attenuation due to imaging gradients [4] and when used in conjunction with parallel imaging methods will enhance patient comfort and reduce scan time.

References: [1] Lee et al MRM (2006);[2] De Zanche et al MRM (2008);[3] Ruppert MRM (2004); [4] Holmes et al MRM (2008)
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