

Simultaneous acquisition of ^3He ventilation images, ADC, T_2^* and B_1 maps in a single scan with Compressed Sensing

S. Ajraoui¹, J. Parra-Robles¹, H. Marshall¹, M. H. Deppe¹, S. R. Parnell¹, and J. M. Wild¹
¹University of Sheffield, Sheffield, United Kingdom

Introduction In previous work anatomical correlation between the ^3He ADC and T_2^* in lungs was observed at 1.5T [1]. However, the study was limited by the fact that images were acquired from two separate scans and breath-holds, which did not allow a perfect registration of the parameter maps. The use of a single-scan for combining ventilation information with simultaneous measurement of other functional parameters has been previously reported [2-4]. This work we present a sequence that allows acquisition of ventilation images, T_2^* , ADC and B_1 maps in a single breath-hold scan and in a very short time (~7 s) with Compressed Sensing (CS) [5].

Methods A four interleave sequence was implemented on a 3T system (Philips, Achieva) tuned to ^3He at 97 MHz, with a Transmit/Receive linear Helmholtz coil (Pulseteq, UK). ^3He gas was polarised to 25% with rubidium spin-exchange apparatus (GE). Three healthy volunteers inhaled 300 ml of ^3He mixed with 700 ml N_2 , imaging was performed with ethics and regulatory approval. The first interleave with the shortest echo time ($TE_1 = 1.6\text{ms}$) was used for the ventilation image. The second was acquired with a longer echo time ($TE_2 = 6.6\text{ms}$), to derive T_2^* maps, while the third interleave included diffusion weighting gradients ($b = 2.86 \text{ s.cm}^{-2}$) at TE_2 with interleave 2 used as a reference scan ($b=0$), for the ADC maps. The first three scans acquire the same phase-encoding lines with a centre-out encoding order. Whereas, the fourth interleave, (otherwise identical to the first interleave) was acquired in a reverse centric order to compute the flip angle map as described in [6], using a 2D SPGR sequence. Imaging parameters applicable to all four interleaves were: $384 \times 384 \text{ mm}^2$ FOV, 64×64 matrix, 20 mm slice thickness, $TR = 12\text{ms}$, $BW/\text{pixel} = 500 \text{ Hz}$. Two sets of images were acquired, one set with full phase encoding, and one set with two-fold under-sampling in the phase direction using Compressed Sensing (CS) as described in [7]. Five axial slices were acquired, with 10 mm gap with a flip angle of 5° for the fully sampled data and 7° for the two fold under-sampled CS data to obtain the same k-space filter due to RF depletion.

Results & Discussion Good agreement was obtained between the fully sampled and under-sampled data as shown in fig. 1 and 2. Note also, the improvement of ventilation images after correction with B_1 flip angle maps fig.1. The computed ADC values are in agreement with those previously reported with the same diffusion times, as shown in table 1. The mean T_2^* obtained in a previous study at 3T was $14.4 \pm 2.6 \text{ ms}$ for ~4 mm pixel size [10]. Here, lower values were found (mean 7.59 ms), with a pixel size of 6 mm. One explanation may be that T_2^* increases when voxel size decreases due to length scale dependent intra-pixel dephasing from background gradients [11]. Simultaneous measurements of ADC and T_2^* allows a precise anatomical comparison of the parameters as the data are inherently spatially and temporally registered. The proposed method conserves gas, which is advantageous due to the increasing price and limited supply of ^3He . Combination of the sequence with CS reduces the scanning time by two, or allows an increase in image resolution of the ventilation, T_2^* and ADC maps.

Fig 1. From left to right: non-corrected ventilation images, B_1 corrected images and B_1 flip angle maps for a) full and b) 2 x under-sampled CS images

Fig 2. ADC (A) and T_2^* (B) maps and corresponding histograms, for both fully sampled (top) and 2x under-sampled data (bottom)

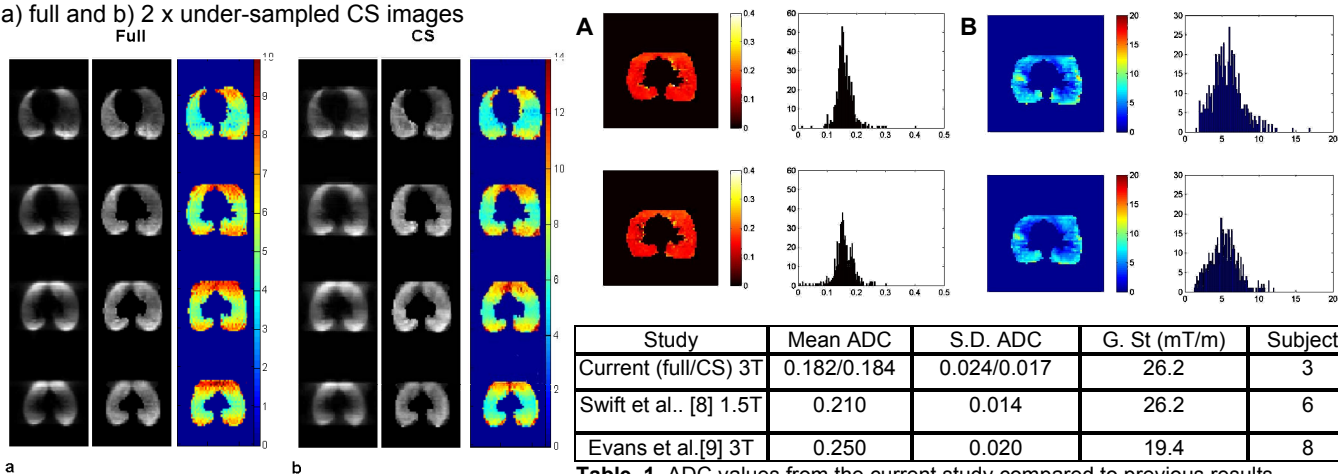


Table .1 ADC values from the current study compared to previous results

Conclusion A novel sequence is presented that allows acquisition of ^3He ventilation, ADC, T_2^* and B_1 maps simultaneously in-vivo. The sequence was tested in three healthy volunteers and the values of parameters obtained are in accordance with those published previously.

References [1] ProcISMRM, #2652, 2008 [2] MRM; 57:1185-1189, 2007 [3] MRM; 61:1015-21, 2009 [4] MRM; 38:890-895, 1997 [5] MRM; 58:1182-95, 2007 [6] MAGMA; 16:218-26, 2004 [7] ProcISMRM, #2175, 2009 [8] Eur. J. Radio, 54(3), p:352-58, 2005 [9] JMRI, 26, p:1537-47, 2007 [10] JMRI, 30(2), p:418-23, 2009; [11] Proc. ESMRMB, #420, 2002

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