Accelerated ^{19}F-MR Imaging of Inhaled Perfluoropropane for Assessment of Pulmonary Ventilation

Mary Neal, Ben Pippard, Kieren G. Hollingsworth, John Simpson, Jim Wild, Pete Thelwall
Newcastle Magnetic Resonance Centre, Newcastle University, Newcastle upon Tyne

Introduction: ^{19}F-MRI of inhaled thermally polarised perfluoropropane (PFP, C_3F_8) exploits its short longitudinal relaxation time to permit a high degree of signal averaging to image pulmonary ventilation using a gas phase (low spin density) tracer.[1,2] The inherently low signal-to-noise ratio (SNR) of the thermally polarised PFP, in combination with its short transverse relaxation time in vivo (2.2 ms)[3] result in scarce signal when restricted to breath-hold length or multiple dynamic acquisitions. Maximising SNR whilst minimising acquisition time is required to improve capabilities of this technique. Here, we improve acquisition speed while maintaining SNR by applying compressed sensing (CS) techniques[4] to image inhaled PFP in healthy volunteers.

Methods: A 3D SPGR acquisition sequence (TE = 1.7 ms, TR = 7.5 ms, flip angle = 50°, FOV = 400 x 320 x 250 mm^3, resolution = 10 x 10 x 10 mm^3, bandwidth = 500 Hz/pixel, B_1 = 4 uT, averages = 4), resulting in an 18 s acquisition time, was used in conjunction with a 50 cm long quadrature birdcage coil (Rapid Biomedical) interfaced to a Philips Achieva 3.0 T system. Images were acquired on five healthy volunteers during a breath hold following three deep wash-in inhalations of a 79% PFP/21% O_2 gas mixture, and retrospectively undersampled with a CS pattern providing an acceleration factor of 1.8x. The same inhalation and breath-hold protocol was then repeated on one participant using prospective 1.8x undersampling, reducing the duration of the 3D gradient echo acquisition to 10 s. In each of the images, SNR was calculated from a 50 x 50 mm^2 ROI in the apex of the right lung.

Results: Figure 1 displays fully sampled ^{19}F-MR image of inhaled perfluoropropane overlaid on a proton anatomical image. A mean SNR of 14.3±5.9:1 was achieved using the fully sampled 3D SPGR ^{19}F acquisition in 18s, and SNR was 7.1:1 in a single 4.5 s average. No loss of image detail was visible in the retrospectively sampled 1.8x acceleration images (Figure 2). Figure 3 shows a comparison of a fully sampled and prospectively collected 1.8x CS dataset acquired from one healthy volunteer, demonstrating comparable data quality and conserved SNR.

Fig. 1.

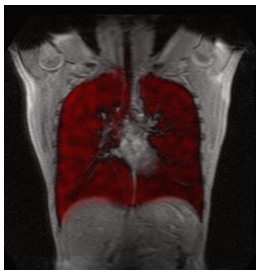
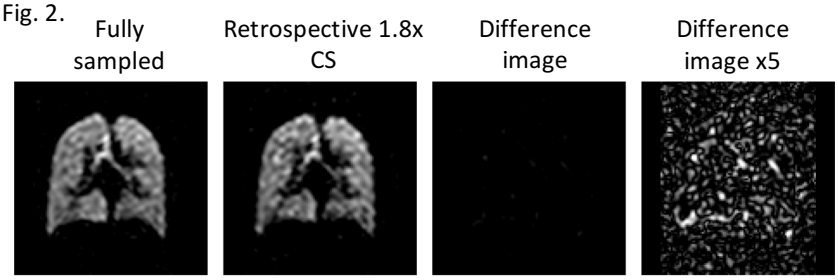
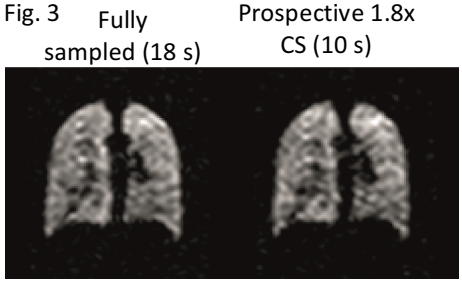


Fig. 2.



Conclusions: We have demonstrated that 3D full lung images with an average SNR of 14.3:1 can be acquired in a 10 s acquisition time on our scanner hardware with a SPGR imaging protocol and compressed sensing techniques. The time saved could be used to acquire data at a finer resolution during breath hold acquisition, or to collect more signal averages to improve the SNR, thus broadening the potential utility of this imaging technique.

Fig. 3



References: 1. Wild, J., et al., 2015, *European Respiratory Journal*, 46(59). **2.** Halaweish, A.F., et al., 2013, *Chest*, 144(4), p.1300-1310. **3.** Couch, M.J., et al., 2013, *Radiology*, 269(3), p. 903-909. **4.** Mann LW, et al., 2015, *Radiology*, 278(1) p.247-256.