Fluorinated gas MR imaging at ultra short echo time: Initial results on a 1.5 T clinical system

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Purpose

Magnetic resonance imaging of hyperpolarized noble gases, like xenon-129 or helium-3, have been widely used to explore animal and human airways. Despite unmatched polarizations, up to 90%, and very high signal-to-noise ratios, its complex procedure and cost have limited its use to a few groups worldwide. The feasibility of alternative approaches using inert, thermally-polarized, fluorinated gas like sulfur hexafluoride, SF_6, was demonstrated [1]. On the one hand, the short T_1 of the gas, a few ms, allows high repetition rate of MR sequences, thus large signal averaging. On the other hand, its short T_2^*, ~ 1 ms, significantly limits the available time to acquire the MR signal after the RF excitation pulse. To overcome this constraint, ultra-short echo time (UTE) sequences were implemented [1-3]. Here, we report preliminary UTE experiments using SF_6 on a clinical 1.5 T scanner and we evaluate the significant gain over standard gradient-echo acquisition.

Materials and Methods

Acquisitions were performed on a Philips 1.5 T (Achieva, Philips, The Netherlands) equipped with a multi-nuclei option. Dedicated transmit-receive RF switch and preamplifier were designed at the frequency of fluorine-19. A dedicated Helmholtz double bracelet coil, tuned at $f_0 = 60.125$ MHz and with quality factor Q = 33, was developed to fit the fluorinated gas phantom. The phantom was made of a (15×27) cm² L-shape box filled with pure SF_6 at atmospheric pressure. After RF power calibration, a 3D multi-slice gradient echo sequence combined with radial UTE with ramp sampling was set up to reach TE/TR = 0.09/5 ms. FOV = (384×384×120) mm^3, matrix = 128×128×12, voxel = (3×3×10) mm^3. Twenty acquisitions were averaged to improve the SNR. For reference, a standard Cartesian gradient echo sequence with the shortest possible TE allowed by the system was also implemented with TE/TR = 1.61/15 ms, matrix = 128×76×12, and the same voxel size. Ninety degree flip angle and a BW = 5000 Hz/pixel were used in both cases. Images were compared quantitatively by computing SNRs in the same regions of interest (ROI) as the ratio of the signal mean to the noise standard deviation estimated in the background (Figure 1). The influence of the repetition time on the signal was also evaluated by varying TR from shortest to 15 ms.

Results

Resulting MR images for Cartesian (left) and UTE radial (right) acquisitions are shown in Figure 1 with the same absolute grey scale. The UTE image displays a much higher signal as underlined in the signal profile shown in Figure 2. Noise standard deviations were $\sigma_{TE=1.61\ ms} = 1.75$ and $\sigma_{UTE=0.09\ ms} = 2.12$ for standard and UTE acquisitions respectively, such that the SNR ratio was
$SNR_{UTE=0.09} / SNR_{TE=1.61} = 2.61$.

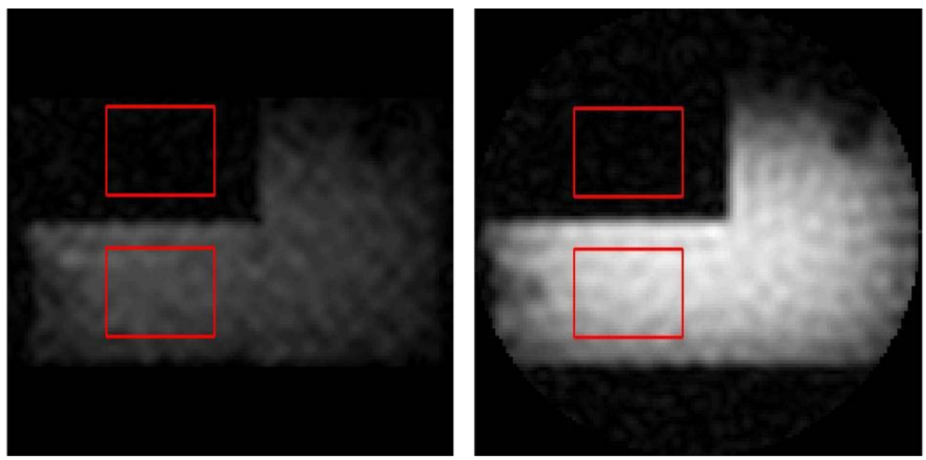

Figure 1: SF_6 gas MRI acquisition on a clinical system. (Left) Cartesian acquisition with TE/TR=1.61/15 ms. (Right) Radial acquisition combined with UTE thus TE/TR=0.09/5 ms. The two ROIs were selected to extract SNRs.

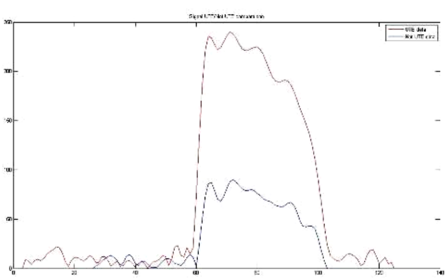

Figure 2: Signal profile comparison in arbitrary units along the dimension of the phantom between Cartesian (blue) and UTE radial (red) acquisitions.

Discussion and conclusion

Only the central slice is shown in this abstract. A three-fold SNR improvement was recorded with a UTE radial acquisition on a 1.5 T clinical system. This preliminary study sets the grounds for more realistic rigid and compliant geometries of the upper airways, from the mouth down to the trachea, which will be eventually enclosed in the L-shape box with controlled outer pressure. Fluorinated gas flow could then be tracked with respect to potential fluid/structure coupling.

Acknowlegements

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References

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