Fluorine-19 MRI of the lung during high frequency oscillatory ventilation (HFOV): visualization of the wash-Out of C4F8

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Purpose:

During the last two decades fluorine-19 MRI of the lung has emerged as a robust research tool to visualize physiologic phenomena such as wash-in, intrapulmonary distribution and wash-out of inhaled fluorinated gases in the context of conventional ventilation in anesthetized animals [1-4] As conventional ventilation bears the risk of lung injury in the ARDS patient, high frequency oscillatory ventilation looked upon as a protective ventilation strategy is of considerable interest in the intensive care unit. To date, the underlying processes of HFOV are poorly understood. The aim of this study was twofold: (i) to find out if MRI of C_4F_8 during HFOV is feasible despite the 5-10 Hz motion, (ii) to measure the wash-out of the contrast gas during HFOV.

Materials and Methods

All experiments were performed on a 1.5 T MRI scanner (Siemens Magnetom Vision Experimental) using FLASH pulse sequences (TR/TE/FA=11.19ms/3.68ms/40°). 5 healthy pigs (24-26kg) were first mechanically ventilated using gas mixtures of 80% fluorinated gas and 20% O_2. After equilibration of the lung with the inhaled gas mixture, a series of 50 transversal images (scan time: 5s) during HFOV was obtained. The signal decay time constant was estimated by a nonlinear fit procedure. Each animal was tested twice at both the frequency of 5 and 10Hz, respectively.

Results

Despite a drop in SNR after the onset of HFOV for each pig the four experiments could be evaluated by the fitting procedure. A mean wash-out time (tau) at 5Hz of 50.9 ± 17.6 s and a mean tau of 123.7± 30.9 s, respectively at 10Hz were found for regions of interest (ROI) including the whole lung. This is in agreement with the clinical findings that wash-out of respiratory gases is significantly prolonged for increased HFOV frequencies.

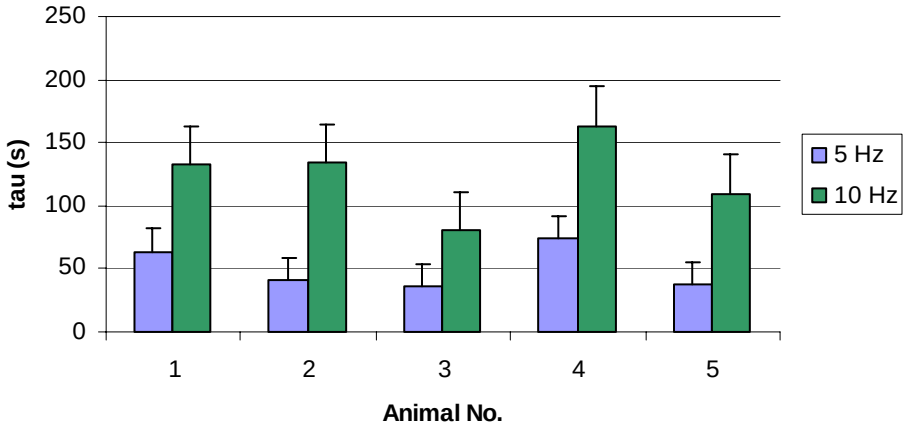

Fig 1: Mean wash-out time constants tau for each of the five pigs investigated at 5Hz and 10Hz, respectively

Conclusion

For the first time, fluorine-19 was successfully applied during HFOV. As we provided evidence that inhaled gases can be visualized during HFOV, this offers the possibility to benefit from this MRI technology to obtain a better understanding of the effective mechanisms of HFOV in the future. Despite the difference between the physical properties of C_4F_8 and of respiratory gases, the MRI signal decay dependence on HFOV frequency shows the expected trend. Therefore, ^{19}F-MRI of fluorinated gases appears to be an interesting imaging modality to assess transport mechanisms during artificial ventilation, e.g. HFOV.

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