

Oxygen-enhanced MRI of the lung at 3 Tesla: Feasibility and T_1 relaxation times

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Introduction: Oxygen-enhanced MRI (O_2 -MRI) of the lung allows spatially resolved visualization of oxygen diffusion from the alveoli into the capillaries of the lung [1–4]. The purpose of this study was to demonstrate the feasibility of O_2 -MRI of the lung at a field strength of 3 Tesla and to determine the T_1 relaxation times of lung tissue at 3 Tesla during inhalation of room air and oxygen.

Subjects & Methods: 3 healthy volunteers were examined with a non-selective saturation-recovery (SR) half-Fourier-acquisition single-shot turbo-spin-echo (HASTE) sequence (TE: 15 ms, minimum TR depending on delay T_{SR} between saturation pulses and readout, slice thickness 10 mm, 128×128 matrix, field of view $40 \times 40 \text{ cm}^2$) implemented on a 3-T whole-body scanner (Magnetom Tim Trio, Siemens Medical Solutions, Germany). Multiple 90° pulses were applied to obtain a homogeneous saturation of tissue. Parallel imaging (acceleration factor $R = 2$) with the GRAPPA algorithm was used to reduce the TE and the minimum TR. Coronal SR images with $T_{SR} = 10, 100, 250, 500, 750, 1000, 1500,$ and 2000 ms were acquired within a single breath hold in end-expiration. These measurements were repeated 5 times during inhalation of room air and 5 times during inhalation of pure oxygen.

T_1 relaxation times were calculated by an exponential fit (Fig. 1) using the mean intensity of lateral lung regions excluding signal from large vessels; in addition, T_1 was determined in the liver and in the spleen. Difference images of acquisitions with room air and oxygen were calculated for all values of T_{SR} .

Results: Saturation-recovery images acquired at different T_{SR} are shown in Fig. 2. The mean T_1 values of lung tissue found for the volunteers were $(1281 \pm 124) \text{ ms}$ during inhalation of room air and $(1102 \pm 135) \text{ ms}$ during inhalation of oxygen, i.e. oxygen breathing reduced T_1 by 14 %, as presented in Table 1. Maps of the relative signal difference of acquisitions during inhalation of oxygen and room air at different SR times are shown in Fig. 3. Note a certain level of motion artifacts in these images due to slightly varying diaphragm positions in end-expiration.

Conclusions: Although lung MRI at 3 Tesla is complicated by increased susceptibility effects in the lung tissue and by reduced T_2^* relaxation times, our results demonstrate that O_2 -MRI of the lung using a saturation-prepared HASTE sequence is feasible. The determined T_1 relaxation times are comparable to those described for 1.5 Tesla [4, 5], i.e., increased T_1 values as reported for many other tissues [6] were not observed. Further measurements on more volunteers are required to validate these first results.

References:

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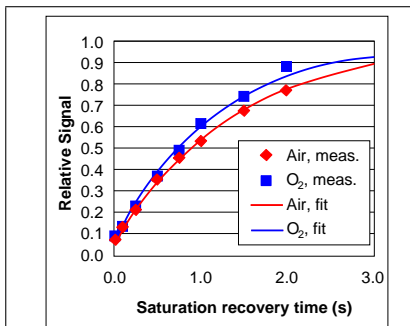


Figure 1: T_1 relaxation after saturation; measurement data and exponential fit (volunteer #1).

Tissue	T_1 relaxation time (ms)			Mean (St.dv.)	Relative T_1 difference
	Vol. #1 33 y	Vol. #2 37 y	Vol. #3 34 y		
Lung, air	1420	1181	1242	1281 (124)	
Lung, O ₂	1144	951	1212	1102 (135)	–14.0%
Liver, air	869	881	989	916 (71)	
Liver, O ₂	866	869	1019	918 (87)	0.2%
Spleen, air	1189	1095	1195	1159 (56)	
Spleen, O ₂	1067	1010	1122	1066 (56)	–8.0%

Table 1: T_1 relaxation times of different tissues (lung, liver, spleen) during inhalation of air and oxygen.

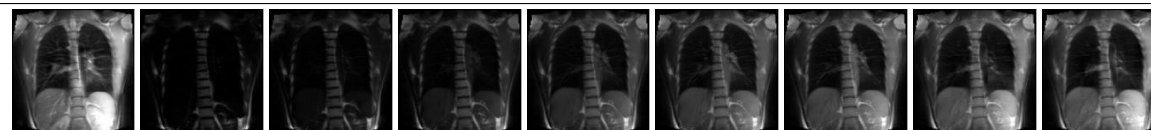


Figure 2: Saturation-recovery image data with $T_{SR} = \infty, 10, 100, 250, 500, 750, 1000, 1500,$ and 2000 ms from left to right (volunteer #3). ($T_{SR} = \infty$ denotes first acquisition without saturation pulses and long TR > 10s.)

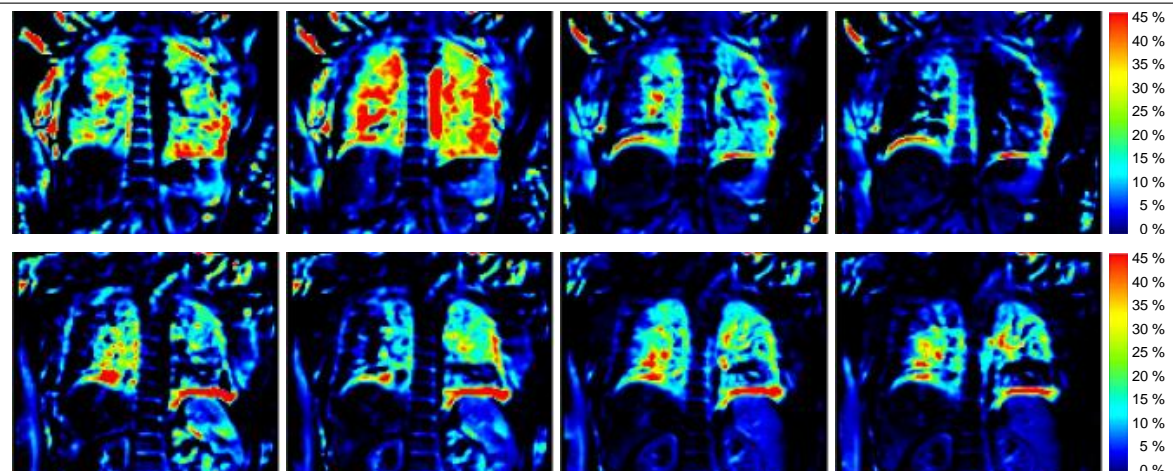


Figure 3: Maps of relative signal increase at different saturation recovery times (from left to right: $T_{SR} = 100, 250, 1000,$ and 1500 ms ; top row: volunteer #2, bottom row: volunteer #1).