Oxygen-enhanced T1-mapping of the lung: Reproducibility and Impact of different gas delivery methods

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Target audience: Both clinicians interested in pulmonary magnetic resonance imaging (MRI) as well as scientists dedicated to find novel applications using oxygen enhanced pulmonary imaging for early disease detection or monitoring.

Purpose: T1-mapping MRI of the lung is a promising tool in the development of new early detection markers for pulmonary diseases as well as for monitoring treatment effects. T1 values under room air as well as under 100% oxygen may serve as parameters. Furthermore the oxygen transfer function [1] has been established, a compound marker representing local information about air flow, oxygen diffusion capacity and regional blood oxygenation. The aim of this study was to evaluate the reproducibility in a group of healthy volunteers as well as the impact of two different oxygen delivery methods in a clinical environment.

Methods: Two MRI scans of 8 healthy volunteers each (median age 31y, range 25-46y, 7 male) were performed 7-10 days apart. We used an inversion recovery SnapShot fast low-angle shot (FLASH) sequence (T_E: 0.8ms, T_R: 3.0ms, FA: 8°, 32 inv. times [100ms-6000ms], matrix size: 128x64, FOV: 50cm x 50cm, slice thickness 15mm, gap 5mm) on a 1.5T MRI with an 8 channel torso phased array coil. 32 Images were acquired in single breath holds. The volunteers were instructed to breathe normally and stop breathing at the end of a normal inspiration. For oxygen delivery we used two different face masks: a clinically available non-tight face mask with reservoir (Adult Non Re-Breather Mask) and a closed O(2) delivery system composed by a tightly fitting face mask and a 3-L reservoir bag (Air Cushion Face Mask). Registration of the magnitude images obtained under 100% oxygen to the room air images was performed using non-rigid image registration. Afterwards T1 maps were calculated using a self-developed MATLAB script: segmentation of both lungs, exclusion of the great vessels and calculation of T1 mean under room air, T1 mean under 100% oxygen as well as OTF for each lung. Statistical analysis was performed using Kruskall-Wallis, Wilcoxon test and Bland Altman Plot. Results are given as median and 25% - 75% quartile.

Results: There was a significant difference in the T1-values between the two MRI scans. Mean values for the room air breathing maps changed from 1215ms (1207ms-1258ms) to 1243ms (1222ms-1265ms, p=0,02). Using the standard mask there was no significant difference between the two MRI scans (p=0,19) in the mean T1 values at 100% oxygen. In contrast, the full covering mask showed significantly higher values at the 2nd scan (1061ms [1051-1093] vs. 1078ms [1066-1108], p=0,01) at 100% oxygen. However, there were no significant differences in OTF between the two visits with both the standard as well as the full covering mask (p=0,27; p=0,86 respectively). Comparing both masks on a single visit there were significantly higher values for the full covering mask (9,2[6,7-11,3] x 10^{-4} s^{-1} %$O2^{-1}$ vs. 14,0[13,1-15,5] x10^{-4} s^{-1} %$O2^{-1}$; p=0,0003). Furthermore there was a broader scatter of OTF values with the standard mask compared to the full covering mask (Coefficient of variation: 35% vs. 13%). In a pairwise analysis (Bland-Altman plot analysis) comparing both visits for each volunteer the mean OTF difference was 0,8 x 10^{-4} s^{-1} %$O2^{-1}$, standard error 0,8 x 10^{-4} s^{-1} %$O2^{-1}$, p=0,31 for the standard mask and the mean OTF difference was 0,2 x 10^{-4} s^{-1} %$O2^{-1}$, standard error 0,5 x 10^{-4} s^{-1} %$O2^{-1}$, p=0,7 for the full covering mask.

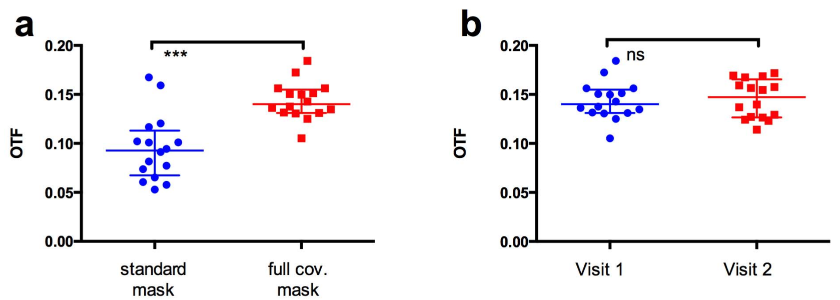

Figure 1: a) Oxygen transfer function differs significantly between images acquired using a standard or a full covering face mask for oxygen delivery (p=0,0003). Furthermore there is a broader variability of the OTF using the standard mask (Coefficient of variation 35% vs. 13%). b) OTF using the full covering mask is highly reproducible in healthy individuals on repeated scans (p=0,86).

Discussion: Our data show that the oxygen transfer function is a reproducible parameter using a full covering mask and therefore a promising marker for monitoring of pulmonary disease activity. Previous data suggested that the method of gas delivery has no impact on the obtained T1 values [2] . However, this study compared not the same volunteers at the two visits. In conclusion, a closed facemask does not only deliver better reproducibility, but also reduces the interindividual variability of OTF values in healthy volunteers.

References:

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