Cardiac triggering suppresses heart-motion artifacts in hyperpolarized-gas lung pO_2 maps

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Purpose: Lung pO_2 maps generated from T_1-weighted hyperpolarized-gas MR images often show physiologically impossible pO_2 values in the vicinity of the heart. These anomalous values are thought to result from cardiac motion during the breath-hold acquisition. The purpose of the present work is to test this hypothesis in human subjects, and to demonstrate that such artifacts can be eliminated by synchronizing image acquisition with the cardiac cycle.

Methods: Hyperpolarized ^{129}Xe imaging was performed in two healthy subjects using a 1.5T whole-body scanner (Siemens Avanto), homebuilt elliptical birdcage-style RF transceiver, and commercial prototype ^{129}Xe polarizer (Xemed LLC). In each subject, pO_2 maps were acquired of a single coronal slice through the middle of the lung at breath hold, following inhalation of a ~1.4 L mixture containing 175 ml O_2, 525 ml room air, and approximately 700 ml hyperpolarized ^{129}Xe.

A short-breath-hold implementation of a standard pO_2-mapping spoiled-gradient-echo pulse sequence was used [1], in which a total of three images are acquired with an oxygen-sensitization time of 4.5 seconds between the first and second images (Fig. 1a). Total imaging time was 6 s, not including trigger delays. Pulse sequence parameters included: 48×64 matrix, 7×7×50 mm voxel size, TR/TE = 8.5/3.3 ms. MRI-compatible ECG electrodes were placed on the subject's chest, and the pulse sequence was set to trigger image acquisition at the beginning of the cardiac cycle, according to the timing scheme depicted in Fig. 1b. A triggered and a non-triggered acquisition were performed in each subject.

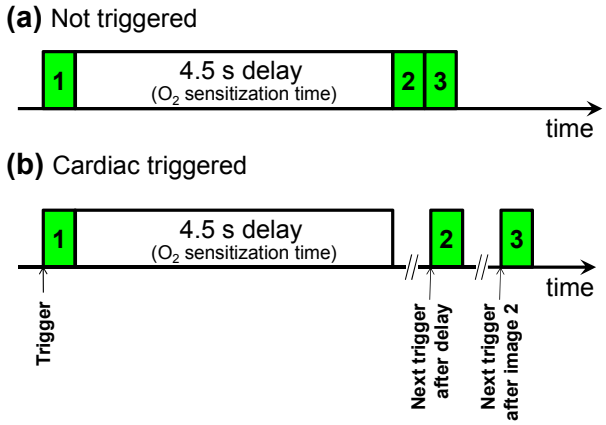

Fig. 1: Image acquisition timing diagram for **(a)** non-triggered and **(b)** cardiac-triggered acquisitions.

Results: Fig. 2 shows pO_2 maps obtained in both subjects with and without cardiac triggering. Highly unphysical values are evident near the heart in non-triggered scans of both subjects. Heart-motion artifacts are absent in the triggered acquisitions, although both triggered and non-triggered scans appear to have artifacts at the base of the lung due to diaphragm motion.

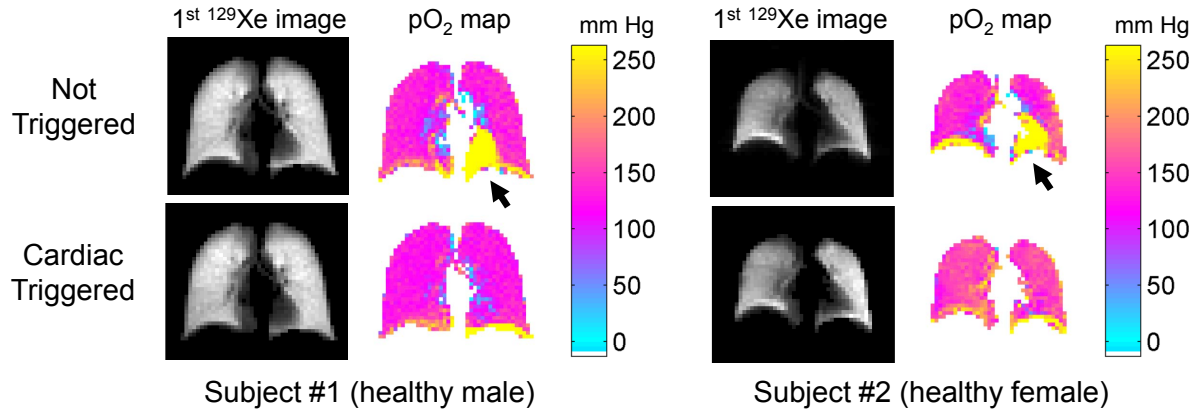

Fig.2 : ^{129}Xe images and pO_2 maps acquired without and with cardiac triggering (top and bottom rows, respectively), from both human subjects. Physiologically impossible pO_2 values are apparent near the heart (arrows) on the non-triggered acquisitions.

Conclusions: Cardiac triggering is highly effective at suppressing heart-motion artifacts. The particular slice orientation and position used here was chosen because it produces large signal variations during the cardiac cycle, as the part of the lung behind the heart moves in and out of the imaged slice, and thus provides a sensitive test of the effectiveness of cardiac triggering. Since the pO_2 map is computed pixel-by-pixel from the magnitude differences among the three images, such variations are falsely attributed to regional pO_2 variations. Synchronizing the imaging acquisitions with the cardiac cycle minimizes these signal variations, and thereby suppresses anomalous pO_2 values in the vicinity of the heart.

References: M.C. Fischer et al., *Magn Reson Med* 52:766 (2004).

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