Relevance of respiratory gating for proton Lung MRI

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Introduction: Lung imaging with MRI is challenging due to parenchyma low proton density combined with susceptibility artifacts that shorten T2 and cardio-respiratory motion. Radial k-space trajectories are considered to yield less pronounced motion artifacts due to the intrinsic oversampling of k-space center. Zurek et al[1] e.g. showed that cardiorespiratory gating does not improve image noise or sharpness for radial pulmonary acquisition in small animals. In this contribution, the effect of prospective respiratory gating on image sharpness in radial ultra-sshort T2 lung imaging has been evaluated in human volunteers.

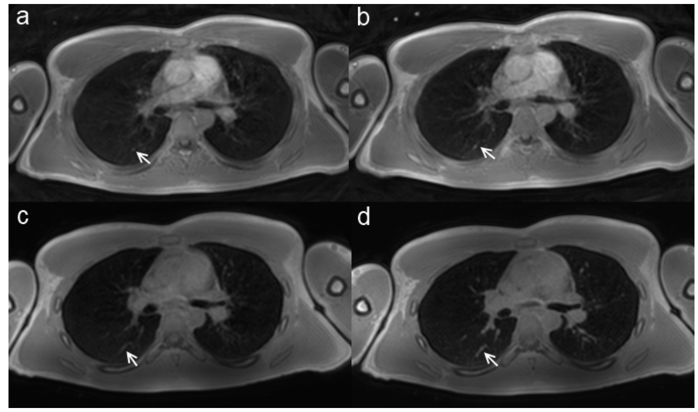

Figure1: comparison among THRIVE (higher, a/b) and UTE (lower, c/d), for not gated (left, a/c) and gated acquisition (right, b/d).

Methods: After obtaining informed consent, 5 healthy non-smoking subjects were scanned in a 3T scanner (Achieva, Philips Healthcare, Best, The Netherlands) with 16-channel phased-array commercial thoracic coil. Subjects were scanned by THRIVE[2] (stack of stars, FID encoding) and UTE[3] (kooshball, FID encoding) protocols. Relevant imaging parameters for THRIVE were: TE/TR=0.23/15 ms, FA=20°, 2x2x5mm³ spatial resolution, FOV=450 mm, 24 slices, yielding a nominal acquisition duration of 4 min. UTE parameters were as: TE/TR=0.16/2.4 ms, FA=5°, 2³mm³ isotropic spatial resolutions, FOV =450 mm, 2 averages, yielding a nominal acquisition duration of 7:50 min. To avoid severe back-folding artifacts, in UTE a slab excitation along feet-head direction equal to the FOV was used. Both techniques were additionally performed with prospective respiratory gating (6 mm acceptance window, navigator on right hemisphere of the diaphragm).

Images were semi-automatically segmented with Avizo® (FEI Visualization Sciences Group,Burlington, USA) to separate between lung and surrounding tissue. Image sharpness analysis was done with Matlab® (Matworks, Natick, USA). Image sharpness was quantified as the mean gradient of the lung signal. The gradient was computed applying a 2D (THRIVE) or 3D (UTE) Sobel operator. Back- and foreground signal was discriminated with the Otsu method. Statistical significance of the identified differences was assessed with a paired T-test with equal variance. P-values under 0.05 were considered significant.

Results: Figure 1 shows a comparison between gated and not gated THRIVE and UTE acquisitions. Even though no motion artifacts are obvious, an improved visualization of lung vessels and airways can clearly be appreciated in the gated acquisition. Average gating efficiency resulted to 50%. One THRIVE scan had to be excluded due to navigator failure. Figure 2 show the maximum intensity projection along a 3cm slab for an UTE acquisition (THRIVE has an inherent low definition on coronal direction, and is therefore not suitable for this visualization). A clear improvement of vessel conspicuously can be appreciated with the gated acquisition. These qualitative results were confirmed by the quantitative analysis, which showed highly significant improvement of image sharpness in all volunteers for UTE and in four volunteers THRIVE data sets.

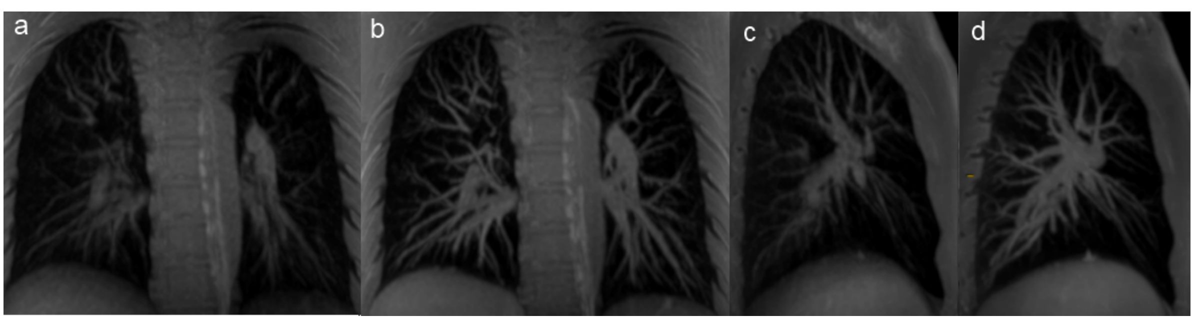

Figure2:Maximum intensity projection on a 3 cm thick coronal (a,b) and sagittal (c,d) slab, acquired without (a,c) and with (b,d) respiratory gating.

Discussion: No evident movement artifact was present in not-gated acquisitions, confirming robustness of radial acquisitions in regards of movement artifact. It should be noted that THRIVE uses Cartesian encoding in slice direction: movement artifacts along this direction may be present but are harder to be identified. Prospective respiratory gating improves image sharpness and depiction of vessel and airways, but also results in an almost doubled acquisition duration. The degree of this effect may be dependent on the efficiency of the gating, which can change among subjects, i.e. due to different anatomy and respiration pattern. In one THRIVE acquisition the difference between not gated and gated images did not get to a significant level probably due to suboptimal gating parameters. Maximum intensity projection of gated UTE acquisition allows excellent vessels depiction, without need of contrast agent injection.

Conclusion: Respiratory gating is necessary when high definition images of lung vessels and airways are needed. UTE acquisitions show promising results for vessels visualization without contrast agent.

References: [1] Zurek M, et al. MRM 2010;64: 401-407 [2] Lederlin M et al. JMRI 2013;doi:10.1002/jmri.24429 [ahead of print] [3] Ohno Y, et al. JMRI 2013;doi:10.1002/jmri.24232 [ahead of print]