Clinical Feasibility of 3D Ultra-Fast Balanced Steady-State Free Precession MRI of the Lung in Patients with Severely Limited Breath-holding Capability

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Target audience: Physicians and physicists interested in MR imaging of the lungs.

Purpose: A new 3D ultra-fast balanced steady-state free precession (ufSSFP) imaging technique was introduced recently to image morphological and functional properties of lung parenchyma in vivo at 1.5 T [1]. In this work, the clinical feasibility of this ufSSFP method was tested in four patients with advanced pulmonary disease and thus severely limited breath-holding capability.

Methods: Four patients (2 female, 2 male, age 28-69 years) with known pulmonary disease (2 Chronic Obstructive Pulmonary Disease (COPD) Global Initiative for Chronic Obstructive Lung Disease (GOLD) stage IV, 1 squamous cell lung cancer + COPD GOLD stage III, and 1 chronic pulmonary graft versus host disease (GvHD) with bronchiolitis obliterans (BO)) were enrolled in this IRB-approved study. All patients had severely reduced pulmonary function (forced expiratory volume in 1 second (FEV1) = 14- 45% of normal) secondary to their pulmonary disease and thus were not able to hold their breath for more than ten seconds. Examinations were performed on a clinical 1.5 T whole body MRI system (MAGNETOM Avanto, Siemens Healthcare, Erlangen, Germany) using a multi-channel array of surface receiver coils. Sequence parameters were: TR = 1.31 ms, TE = 0.54 ms, RF pulse length = 100 µs, FA = 15°, bandwidth = 1563 Hz/pixel, isotropic resolution = 2.5 mm^3, reconstruction matrix = 160^2 x 80, parallel imaging GRAPPA factor 2. Total acquisition time in inspiratory breath-hold was 9.8 s. Patients were provided with continuous oxygen supply via a face mask during the examination if clinically required. Computed tomography (CT) images of the chest acquired within a narrow time frame to MRI (0-7 days) were available for comparison in all cases. Image interpretation including assessment of image quality and a comparison of findings in MRI and CT was performed by a radiologist with seven years' experience in clinical MRI.

Results and Discussion: The ufSSFP sequence provided good image quality in all patients. Slight breathing artifacts oriented in the anterior-posterior direction were visible in one out of four patients. In none of the datasets, diagnosis was impaired by artifacts from breathing motion. Banding artifacts, which are usually problematic in the clinical application of bSSFP with large fields of view, were seen in none of the ufSSFP datasets. The salient pathology as appreciated on CT (tumor with cavitation, emphysema, bronchiectasis, infiltration and pleural effusion) was also visible on the ufSSFP MRI exam in all cases. Two sample cases are displayed in Figure 1.

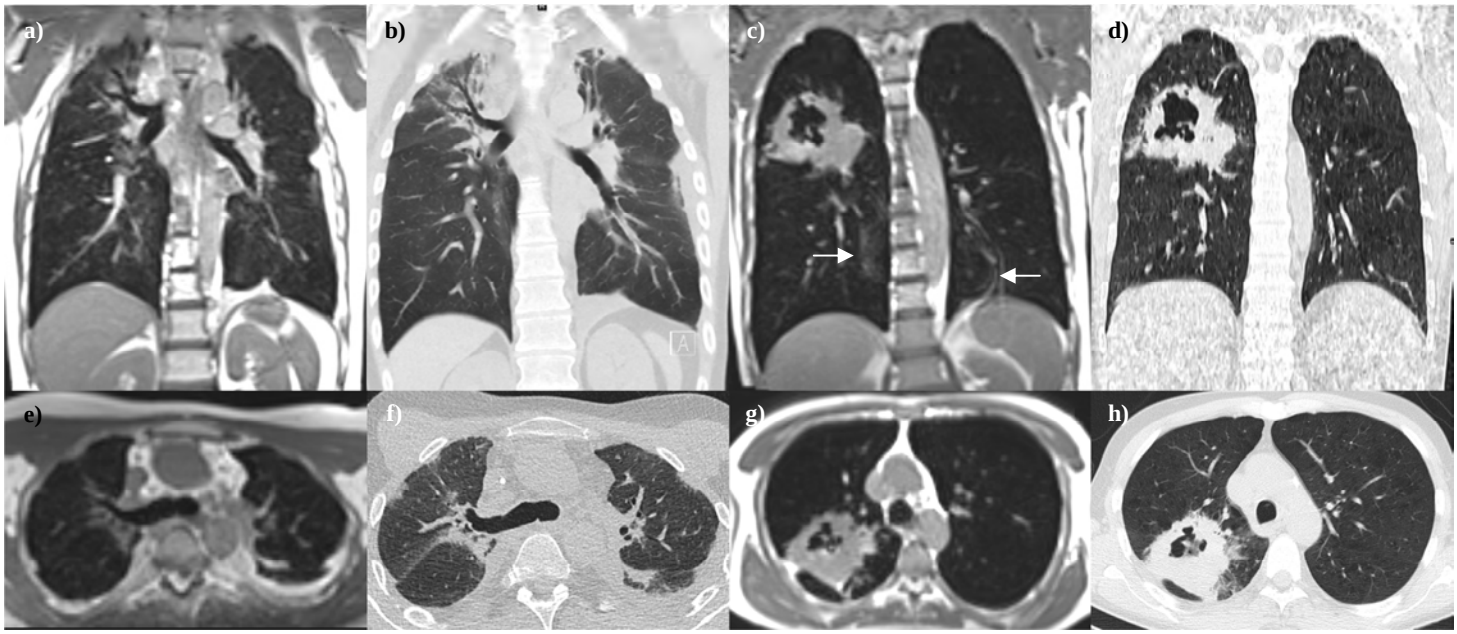

Figure 1: Sample images demonstrating coronal (a-d) and axial (e-h) reformats from 3D ufSSFP MRI (a, c, e, g) and CT (b, d, f, h) obtained in a 28 y old male with chronic pulmonary GvHD and BO (FEV1=14% of normal) (a, b, e, f) and in a 54 y old male with centrally necrotic lung cancer from the left upper lobe (FEV1=45% of normal) (c, d, g, h). Note the absence of banding and breathing motion artifacts in the ufSSFP images. Artifacts from cardiac pulsation, however, are still seen (arrows in c).

Conclusion: 3D ultra-fast bSSFP imaging of the lung is clinically feasible at 1.5 T even in patients with severely limited breath-holding capability. In our small case series, ufSSFP MRI was able to depict all relevant pathology in comparable manner to CT. The sensitivity of this method to depict morphologic changes in particular pulmonary diseases remains to be investigated.

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References: [1] Bieri O. Magn Reson Med 2013 Jun 28. doi:10.1002/mrm.24858