INFLAMMATION ASSESSMENT IN THE LUNGS OF LPS-CHALLENGED RODENTS: COMPARISON BETWEEN RADIAL ULTRA-SHORT ECHO TIME (UTE) AND CARTESIAN MR IMAGING

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Purpose: The exposure to the endotoxin lipopolysaccharide (LPS) is a well-established model of acute inflammation in rodents and similar to that observed in human Chronic Obstructive Pulmonary Disease (COPD). Conventional gradient-echo MR imaging has been recognized as an efficient tool in assessing the edema volume considering that a significant contrast is obtained with a dark-appearing lung parenchyma and a hyper intense edema. Furthermore, motion artifacts can be reduced by averaging [1]. Despite multiple averaging, Cartesian-based MRI in the lung remains sensitive to ghosting and motion blurring. This might lead to misevaluation of the inflammation extent. In contrast, a radial ultra short-echo time (UTE) sequence has been shown to be appropriate in pulmonary imaging due to its robustness against motion and its improved image resolution [2]. In this study, we evaluated the accuracy of edema detection using two protocols based on Cartesian and UTE radial imaging approaches.

Materials and Methods: Seven male Wistar rats (average weight of 250g) were anaesthetized and intubated. LPS (1mg/kg dissolved in 0.2 mg of saline) was selectively instilled into the left lung, while the right lung served as a control. MR imaging was performed 24h after LPS instillation on a 4.7 T scanner (Bruker Biospec 47/40). A set of axial images covering the entire lung volume was obtained using a multislice gradient echo sequence (TR/TE=150/3 ms, flip angle=30deg, FOV=60mm, matrix size of 256×256, slice thickness = 1.5mm). Twenty averages (NA) were applied to limit motion artifacts in the free-breathing animals. UTE images were then acquired using a radial sequence (800 radials/image, TE=670µs, TR=80ms, flip angle=20deg, slice thickness=1.9 mm, NA= 4). Neither cardiac nor respiratory gating was used. The total acquisition time was equal to 14 minutes and 8.5 minutes for the Cartesian and UTE sequences, respectively. The total edema volume was assessed using a semiautomatic segmentation procedure based on the evolution of the level set function [3].

Results: Representative axial slices acquired after exposure to LPS are shown in Fig. 1. For both MR sequences, the left lung instilled with LPS exhibited significant hyper intense regions, compared to the control (right) lung. Fig.2 shows the correlation of lesions volume quantified from the gradient-echo and UTE images for individual animals. The linear correlation coefficient was equal to r=0.95 (n=7).

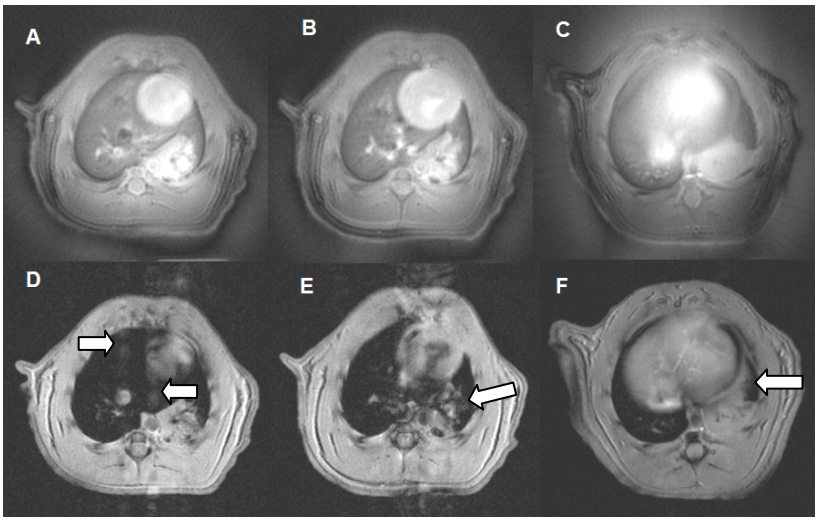

Fig.1. UTE radial images (A-C) and corresponding Cartesian images (D-F). Arrows indicate motion artifacts from arteries, the heart and diaphragam motion.

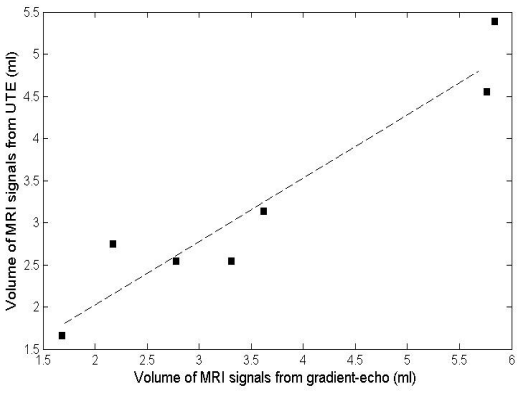

Fig.2 Correlation between the MRI assessments using a gradient-echo and UTE sequence in individual rats.

Discussion and conclusion: Images in Fig.1 illustrate the advantage of UTE radial sequences as compared to Cartesian-based acquisition when motions of organs are of concern. White arrows indicate the presence of motion artifacts due to the arterial flow (Fig 1D), heart beating (1E) or diaphragm motion (1F). None of these motion artifacts significantly affect the corresponding radial UTE images. In our experimental set-up, image contrast in UTE images was clearly superior for detecting inflamed regions (although improved contrast might be obtained using a shorter TR and a subsequently higher T1-weighting in Cartesian images). Despite degraded image quality in case of Cartesian images, similar inflammation extent was found for both approaches (Fig.2). However, this finding is highly observer-dependent, it requires a well-trained operator and would certainly fail in the case of a completely automated segmentation procedure or for images with more diffuse lesions.
In conclusion, radial UTE acquisitions can provide high resolution images with low artifacts and an appropriate contrast for detecting inflammation in rodent lungs. This technique, applied under free-breathing conditions, will certainly prove to be quite useful in routine MR investigations applied on models of lung diseases associated with inflammation or mucous hypersecretion.

References: [1] N. Beckmann et al. Am J Physiol Lung Cell Mol Physiol 283:22–30 (2002), [2] Glover et al. Magn Reson Med. 28:275–289 (1992), [3] C Li et al. Proceedings of the IEEE, 5:1063-6919 (2005).