MR Imaging of Ex-vivo Rat Lung with Acute Respiratory Distress Syndrome: Air-Inflation Fixation Method

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Introduction: MR imaging of diffuse lung disease is challenging because intrinsic low proton density, severe susceptibility caused by alveolar air / soft-tissue interfaces, and respiratory and cardiac motion may hamper signal acquisition from the lung parenchyma. However, MRI may have advantages for tissue characterization compared to computed-tomography (CT), which provides only anatomical information. In this study, we employed the air-inflation fixation method, which can preserve the physiologic condition of an injured lung, to eliminate respiratory and cardiac motion. Thus, we hypothesized that we could anatomically evaluate the acute respiratory distress syndrome (ARDS) model using this method, as well as characterizing the T1 and T2 relaxation times.

Materials and Methods:

Animal preparations: Ten wild-type rats (180-220g) were included. ARDS was induced in 7 rats by intravenous injection of 99% oleic acid (0.1 mL/body) (1), while saline (0.1 mL/body) was given to the other 3 rats as a control. After euthanasization, the lungs were inflated by tracheotomy to 20 cm H_2O pressure with air. Lungs and hearts were excised en bloc, then subjected to MR imaging.

MR imaging: We used a 1.5T clinical MR scanner (Signa, GE). Samples were placed between two 3-inch surface coils. For both groups (ARDS and control), after the acquisition of the localizer image, single-slice spin echo (SE) images (TR/TE/NEX: 2000 ms/ 10ms/ 1) were obtained as high-resolution anatomical images (in-plane resolution: 234 x 313 μm). The other parameters were as follows: a 6 cm x 6 cm field of view (FOV), a 256 x 192 matrix and a 3 mm slice thickness. The location was selected at the slice which showed the most representative abnormal finding. For the ARDS group, T1 and T2 measurements were performed at the same location and geometry.

CT imaging: We also obtained state-of-the-art CT images using an 8-detector raw CT scanner (Lightspeed Ultra, GE). The parameters were 200 mAs, a 9 cm x 9 cm FOV, and a 0.6 mm slice thickness. All images were reconstructed with a bone algorithm.

Results: In the ARDS group, fine reticular signal increase was demonstrated in the lung parenchyma on MR images in all subjects (Fig.1-A). Similar findings were visualized on CT images (Fig.1-B). This finding was not observed on either MR or CT images in the control group (Fig.2-A, B). We found that image quality was equivalent between MRI and CT. The T1 and T2 values of ARDS lungs were 883.1±176.5 ms and 54.6±8.3 ms (mean±S.D.), respectively. The microphotograph of the ARDS group lung (Fig.1-C) demonstrated considerable interstitial thickening and intra-alveolar exudates compared to that of the control lung (Fic. 2-C).

Discussion and Conclusions: In the visual assessment, we demonstrated that the image quality of MRI was equivalent to that of CT. Furthermore, fine reticular signal increase was demonstrated in the lung parenchyma in the ARDS group. Regarding relaxation times, T1 and T2 values longer than those of normal lung (2-3), were observed in the ARDS lung. Fine reticular signal increase in anatomical image and longer relaxation time may be supported by histological analysis, in which interstitial thickening and intra-alveolar exudates were significantly documented. In conclusion, the combination of MR imaging and the air-inflation fixation method could provide parametric information such as T1 and T2 values simultaneously with anatomical information in diffuse lung disease.

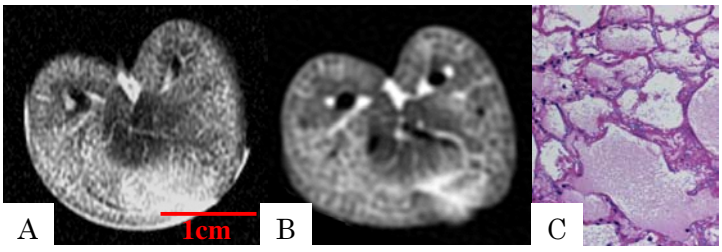

Fig. 1 ARDS lung A) High-resolution SE image, B) corresponding CT, C) microphotograph (H-E). Fine reticular signal increase is demonstrated in the lung parenchyma, which corresponds to the pathological change on the microphotograph.

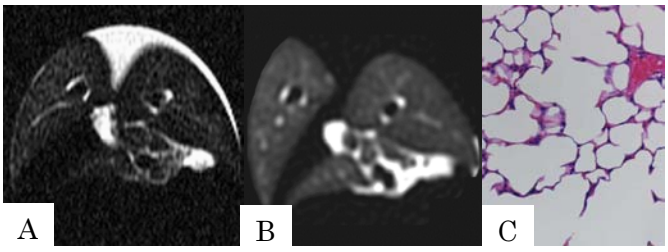

Fig. 2 Control lung A) SE image, B) corresponding CT, C) microphotograph (H-E).

Reference

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3. Unpublished data from our group.