MREIT Conductivity Imaging of Pneumonic Canine Lung: Preliminary Feasibility Study

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Target audience

This study may provide new contrast information of the chest imaging. It might be helpful to the people who are interested in the clinical applications of electromagnetic tissue property mapping.

Purpose

In this study, we evaluate the potential of the MREIT technique as a new MR-based conductivity imaging modality to differentiate the lung parenchyma without and with pneumonia.

Methods

Five healthy laboratory beagles were used as a control group. All of them were healthy without signs of neurological problems on physical examinations. Three mixed breed dogs had mucopurulent oculonasal discharge, severe moist coughing, retching, and signs of pulmonary disease. To prevent dribbling, we injected 0.1 mg/kg of atrophine sulfate. Ten minutes later, we anesthetized the dog with intramuscular injection of 0.2 ml/kg Tiletamine and Zolazepam (Zoletil 50, Virbac, France). Twenty minutes later, we sacrificed it with an intravenous injection of 80 mg/kg (Entobar, Hanrim Pharmacy, Korea). After clipping hair at four locations (dorsal, ventral and bilateral surfaces) on the chest, we attached four carbon-hydrogel electrodes and placed the dog inside the bore of our 3 T MRI scanner (Magnum3, Medinus, Korea). The experimental protocol was approved by the Institutional Animal Care and Use Committee (IACUC) of Konkuk University, Seoul, Korea.

Using a constant current source, we injected currents in two mutually orthogonal directions between two pairs of electrodes facing each other. The injection current amplitude ranged from 5 to 9 mA. Multi-echo ICNE pulse sequence was used to obtain the MR magnitude and magnetic flux density (B_z) images.[1] The imaging parameters were as follows: TR/TE = 900/20, 40, 60 ms (3 echoes), FOV = 240×240 mm^2, matrix size = 128×128, slice thickness = 5 mm (8 slices), NEX = 8, and total imaging time = 40 min. The single-step harmonic B_z algorithm implemented in CoReHA (conductivity reconstructor using harmonic algorithms) was used for multi-slice conductivity image reconstructions.[2]

Results and Discussion

Figure 1(a) shows chest images obtained from a normal dog. The lung parenchyma appears as dark regions in the MR magnitude image due to MR signal void there. In the reconstructed conductivity image, lung regions turn out to be noisy. The regions exhibit a peculiar pattern of salt and pepper noise. Outside the regions, the conductivity image reveals contrasts among the heart, thoracic longissimus muscle, and thoracic wall.

Figure 1(b) shows chest images obtained from a dog with pneumonia. The MR magnitude image shows somewhat increased contrast in the middle and caudal lung parenchyma due to the accumulation of pleural fluid. The corresponding conductivity image shows a significantly increased contrast (black arrows). Especially, the increased conductivity contrast in both left and right middle lung parenchyma may provide diagnostic information which is not available from MR magnitude images. Figure 2 shows multi-slice MR magnitude and conductivity images from normal and pneumonic canine chests.

Conclusion

This feasibility study demonstrates that current MREIT conductivity imaging can provide unique tissue contrast of chest *in situ* to be utilized in clinical applications.
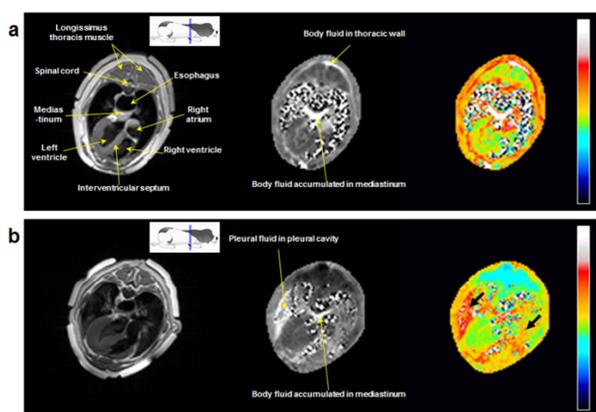

Fig. 1. MR magnitude, conductivity, and color-coded images obtained from (a) normal and (b) pneumonic model canine chest.

References

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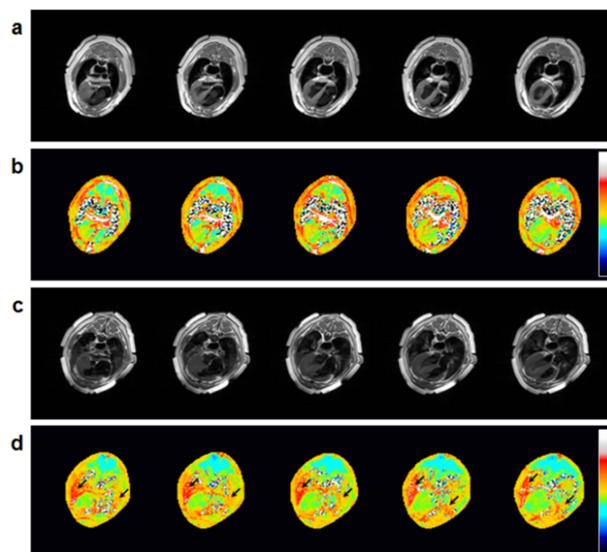
Fig. 2. Multi-slice (a) MR magnitude and (b) conductivity images of a normal canine chest. (c) and (d) are images of a pneumonic model canine chest. Black arrows indicate increased contrast compared to normal lung parenchyma.