Using Hyperpolarized ^{3}He MRI for Assessment of Radiation Treatment for NSCLC

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Introduction

Non-small cell lung cancer (NSCLC) is the largest cause of cancer deaths in the United States. Possible treatment modalities include surgery, chemotherapy and /or radiotherapy. Radiotherapy is often given together with chemotherapy, and may be used with curative intent in patients who are not eligible for surgery. Lung imaging plays a central role in the assessment of the treatment. Traditional proton MRI is difficult to perform in the lungs, due to the low density of water molecules in lung tissue and the inhomogeneous magnetic field inside the thorax. Although CT provides high-resolution images, it can not provide functional lung data. Hyperpolarized ^{3}He MRI offers a complementary approach to lung imaging in that it includes information on lung ventilation without the need for ionizing radiation. In this study, ^{3}He MRI was used to monitor radiotherapy treatment for NSCLC.

Materials and Methods

Three patients with NSCLC were enrolled in this pilot study. All MR imaging experiments were performed using a 1.5 T GE Signa whole-body scanner outfitted with a heterodyne system. The subject's pulse rate and blood oxygen saturation were monitored using a pulse oximeter with a peripheral plethysmographic finger cuff. Following the proton localizer scans, static ventilation HP ^{3}He MR scans were performed. For each ^{3}He MR scan, the subject was instructed to inhale 300-500 mL of HP ^{3}He, diluted to 1 L with inert N_2, from a Tedlar plastic bag. Multi-slice static imaging was performed during a 10s breath-hold. The Fast Gradient-Echo (Fast GRE) pulse sequence was used with 13 mm slice thickness to cover the entire lung region. Imaging parameters were as follows: field-of-view 46 cm, matrix size 256 x 128, and TE/TR 4.6/50 ms. The ^{3}He was hyperpolarized using a custom-built Rb spin-exchange polarizer with a polarization level of 10-20%

Results and Discussion

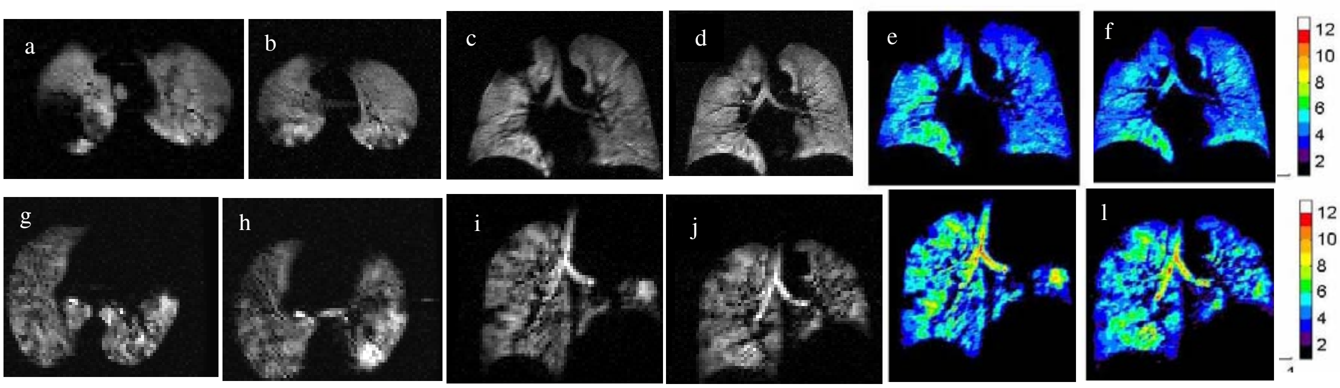

Figure 1. HP ^{3}He MRI images before (a,c,e,g,i,k) and after (b,d,f,h,j,l) radiation treatment in two patients (top and bottom rows) with NSCL cancer. Corresponding axial slices (a,b,g,h), coronal slices (c,d,i,j), and coronal fractional ventilation maps (e,f,k,l).

Figs. 1a,c,e,g,i,k were obtained before radiation therapy and Figs. 1b,d,f,h,j,l were obtained after 1 month of radiation treatment. The top row of figure 1 depicts the images from a 58 year old male patient with a large mass in the right upper lobe invading the chest wall, which was diagnosed as NSCL cancer. The pre-radiation HP ^{3}He images (Figs 1.a,c,e) show a large ventilation defect corresponding to the right upper lobe mass. In addition, there are multiple small peripheral ventilation defects scattered throughout both lungs. After radiation therapy, there is an increase in the functional area of ventilation observed in both the coronal and HP ^{3}H axial images (Figs 1.b,d,f) that corresponds to an interval reduction in size of the right apical soft tissue mass. The images in the bottom row of Fig. 1 were obtained from a 68 year old male patient with a large left upper lobe mass invading into the mediastinum and left hilum that was diagnosed as NSCL cancer. The pre radiation HP ^{3}H images (Figs 1.g,i,k) demonstrate a large ventilation defect in the left upper lobe. There is also elevation of the left hemidiaphragm which may indicate left phrenic nerve palsy. In addition, there are multiple small areas of decreased ventilation seen throughout both lungs. After radiation therapy treatment, the large left upper lobe mass invading the mediastinum and left hilum has been markedly decreased in size, which is reflected in the HP ^{3}H images by a restoration of the ventilation to the left upper lobe (Figs 1.h,j,l). Multiple peripheral ventilation defects remaining throughout both lungs can be observed as heterogeneity in the ventilation maps (Figs 1.k,l). There is also continued elevation of the left hemidiaphragm.

Conclusion

^{3}He MRI enables complementary lung imaging that provides information on essential pulmonary processes, such as ventilation, homogeneity, which offers a combination of functional and morphologic information that was previously not achievable. The lack of ionizing radiation in ^{3}He MRI allows repeated studies performed in radiotherapy trials with noninvasive nature and safety. The results of our study demonstrated that ^{3}He MRI can assist in a more detailed understanding of pulmonary pathophysiology, and the potential effects of therapeutic intervention.

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