Robust lung morphology assessment in children with cystic fibrosis (CF) using ultra-short TR/TE 2D Steady State Free Precession (SSFP)

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Introduction

Today most of the MR sequences used for lung imaging (like T2-w HASTE, T1-w VIBE and T2-w TSE) are performed in adults. There are now also reports in children, but the major drawback is the relative long scanning time and artifacts due to respiratory and cardiac motion. There is a need for a robust MR sequence which have a good resolution comparable with a Computed Tomography (CT) of the lung. Ultra-short TR/TE 2D SSFP MRI represents a radiation free technique which can be easily performed in children and can be used in addition to CT for monitoring of lung disease.

Purpose

To demonstrate the feasibility and diagnostic quality of ultra-short TR/TE 2D SSFP scans for imaging CF and to compare CT scans made in the previous year.

Materials

20 CF patients (6-17 years) underwent MRI at 1.5T in 2006. 10-second breath-hold scans were acquired in axial, coronal and sagittal plane, in full inspiration and end-expiration, with TR/TE 2.2/0.7 ms, flip angle 35º, section thickness 8 mmin and in-plane resolution of 2.8x2.0 mm^2. An additional 6 mm high resolution scan (in-plane resolution of 2.3 x 1.4 mm^2) was acquired for better evaluation of the airways and comparison with CT. The examination took 15 minutes to complete. CT and MRI scans were evaluated using a modified Brody scoring system for the presence or absence of: major bronchiectasis (≥ Brody 2), bronchiectasis (any size), mucous plugging, atelectasis/consolidations and air trapping. The McNemar test was used to evaluate the significance of differences between CT and MRI; Kappa was used to assess the agreement between the two techniques.

Results

A stable condition was assessed in 15 patients. Progression of disease was observed in 4 patients. Only one patient showed improvement of the Brody score. The difference between the two techniques was not statistically significant in detection of major bronchiectasis (Figure 1), mucous plugging, atelectasis and air trapping. A very good agreement between CT and MRI was found for major bronchiectasis (K 0.95), a good agreement for mucous plugging and atelectasis (K 0.65/0.63) and a moderate agreement for the whole range of bronchiectasis (K 0.42). For air trapping the CT-MRI agreement was fair (K 0.26).

Discussion

Ultra-short TR/TE 2D SSFP provided a good visualization of lung parenchyma without ghosting artifacts from cardiac and respiratory motion. Although MRI clearly depicted major bronchiectasis, it was less precise in detection of the smallest dilated bronchi. However, it was possible to assess a stable condition or evolution of CF lung disease. The most important advance in knowledge of this study is air trapping detection. In MRI expiratory scans we expected homogeneously increased signal intensity from lung parenchyma. Patches of lower signal intensity could be observed and were interpreted as areas of trapped air (Figure 2), corresponding to air trapping on CT scans.

The main limit of this study was that in some patients the different features observed in CT and MRI were related to progression of disease or improvement of reversible abnormalities during the elapsing year.

Conclusions

Ultra-short TR/TE 2D SSFP MRI is a feasible and robust method to evaluate lung disease. Our lung MRI protocol is time efficient and patient friendly. Lung MRI can be used in addition to CT to monitor CF patients, especially because of the biological safety profile of this technique.

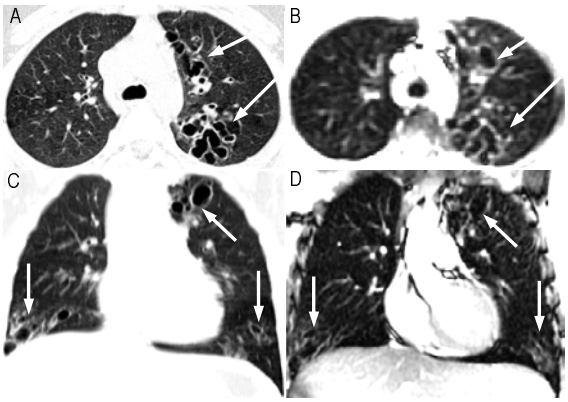

Figure 1

14 years old boy. Major bronchiectasis, right lower lobe, left upper and lower lobe.
A) Axial 2.5 mm CT, inspiration. **B)** Axial 6mm High Resolution ultra-short TR/TE 2D SSFP, inspiration. **C)** CT 4 mm coronal reconstruction, inspiration. **D)** Coronal 8 mm ultra-short TR/TE 2D SSFP, inspiration.

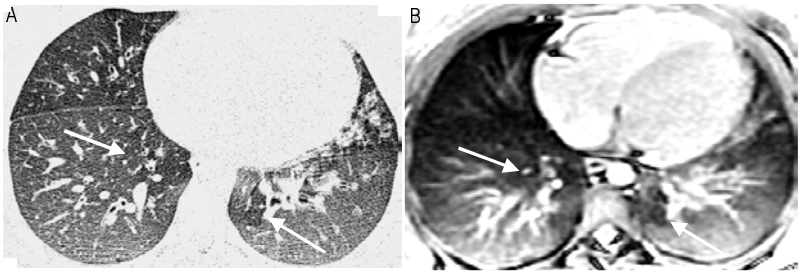

Figure 2

14 years old boy. Air trapping, right and left lower lobes.
A) Axial 1 mm CT, expiration.
B) Axial 8 mm ultra-short TR/TE 2D SSFP, expiration. This image is SNR-enhanced by surface coil correction and smoothing adaptive filtering to increase the signal-to-noise ratio (SNR).