Use of an Anatomical Atlas to Enhance Pulmonary EIT images in Children with Cystic Fibrosis

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Background

- Electrical impedance tomography (EIT) is a radiation-free, non-invasive imaging technology in which low frequency, low amplitude current is applied on electrodes and voltages are measured.
- While the spatial resolution of EIT is low, the temporal resolution is high, and can image ventilation and perfusion in real time.
- EIT has clinically useful potential for assessing the effectiveness of airway clearance therapy in patients with CF and assessing the extent of resolution of a pulmonary exacerbation.

Collection & Analysis of EIT Data

EIT data collected during PFTs for two patients with CF were used to study the effectiveness of the post processing method. The data were archival, collected under COMIRB approval number 14-0652. The patients received CT scans as part of their care.

Patient 1
Patient 1 was a 17 year-old male in stable condition with no air trapping, consolidation, or bronchiectasis noted in the radiologist’s report.

Patient 2
Patient 2 was an 18 year-old male. The radiology report indicated that air trapping was suggested through the majority of the right lung, as well as the presence of peripheral mucous plugging most prominent within the right lobe, and cylindrical bronchiectasis throughout the chest bilaterally greater on the right.

Outcomes

Results were compared to CT scans from the patients by creating EIT “ground truth” images from the scans.

Constructions of the anatomical atlas

Archival CT scans of 74 adult male subjects collected at the University of Sao Paulo (CAE 52619216.2.0000.0068) were used to construct an anatomical atlas. All possible sets of 10 equidistant slices in a range of 200 mm were used, resulting in 1,589 data sets. Conductivity values were assigned to the segmented tissues following a normal distribution. EIT data was simulated for each conductivity distribution using the finite element method (FEM).

Reconstructions were computed by the D-bar method. Schur complement matrices

\[ A_\delta = \Gamma_{\delta}(I_{\Omega} + \kappa I)^{-1} \]

\[ b_\delta = (I_{\Omega} + \Gamma_{\delta}(I_{\Omega} + \kappa I)^{-1})_{\delta} \]

were computed and applied to the D-bar reconstruction using the formula:

\[ E(\sigma, \delta) \approx \sigma = A_\delta \sigma_{\text{true}} + b_\delta \]

Post-processed Reconstructions

Patient 1
Patient 1
Patient 2
Patient 2

SSIM measures the agreement between images with 1 indicating identical images. Patient 1: SSIM = 0.68  Patient 2: SSIM = 0.69

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