The off-plane sensitivity of EIT

Andy Adler[1], Inéz Frerichs[2], Bartłomiej Grychtol[3]

[1]Carleton University, Ottawa, Canada [2]Department of Anesthesiology and Intensive Care Medicine, University Medical Center Schleswig-Holstein, Kiel, Germany [3]Fraunhofer Project Group for Automation in Medicine and Biotechnology PAMB, Mannheim, Germany

Abstract

EIT is sensitive to off-plane conductivity changes. For chest EIT, the sensitive region has been described as “lens shaped" and half of the body diameter. In fact, many factors affect the size and shape of this region. We explore the effect of the separation of the stimulation and measurement electrodes.

Methods and Results

An elliptical FEM was generated (with Netgen) with 16 equidistant electrodes in a horizontal plane. The stimulation and measurement *skip* distance, s, is the number of electrodes between the drive and receive electrode pairs. The adjacent pattern has $s = 0$, the opposite pattern has $s = 7$.

The EIT sensitivity ($\|\Delta\text{Measurements}\|_2$) is calculated for all locations in a coronal plane through the body centre. The sensitivity in each image is normalized to its maximum (the value in the electrode plane).

Without normalization, images would be dominated by the contribution close to the edge, to which EIT is most sensitive.

Introduction

Thoracic applications of EIT place electrodes in a plane on the chest, and are thus sensitive to conductivity changes in a region above and below the plane of interest. For interpretation of EIT images, it is important to understand the spatial extent of EIT sensitivity. For example, in some cases, the compression of abdominal gas has been indicated as a source of EIT image artefacts. The extent to which this is possible is determined by the vertical sensitivity profile.

The EIT sensitivity region has been described as “lens shaped", extending to $\frac{1}{2}$ of the body diameter above and below the electrode plane. Clearly, the sensitivity region depends on numerous other factors, such as the anatomical parameters:

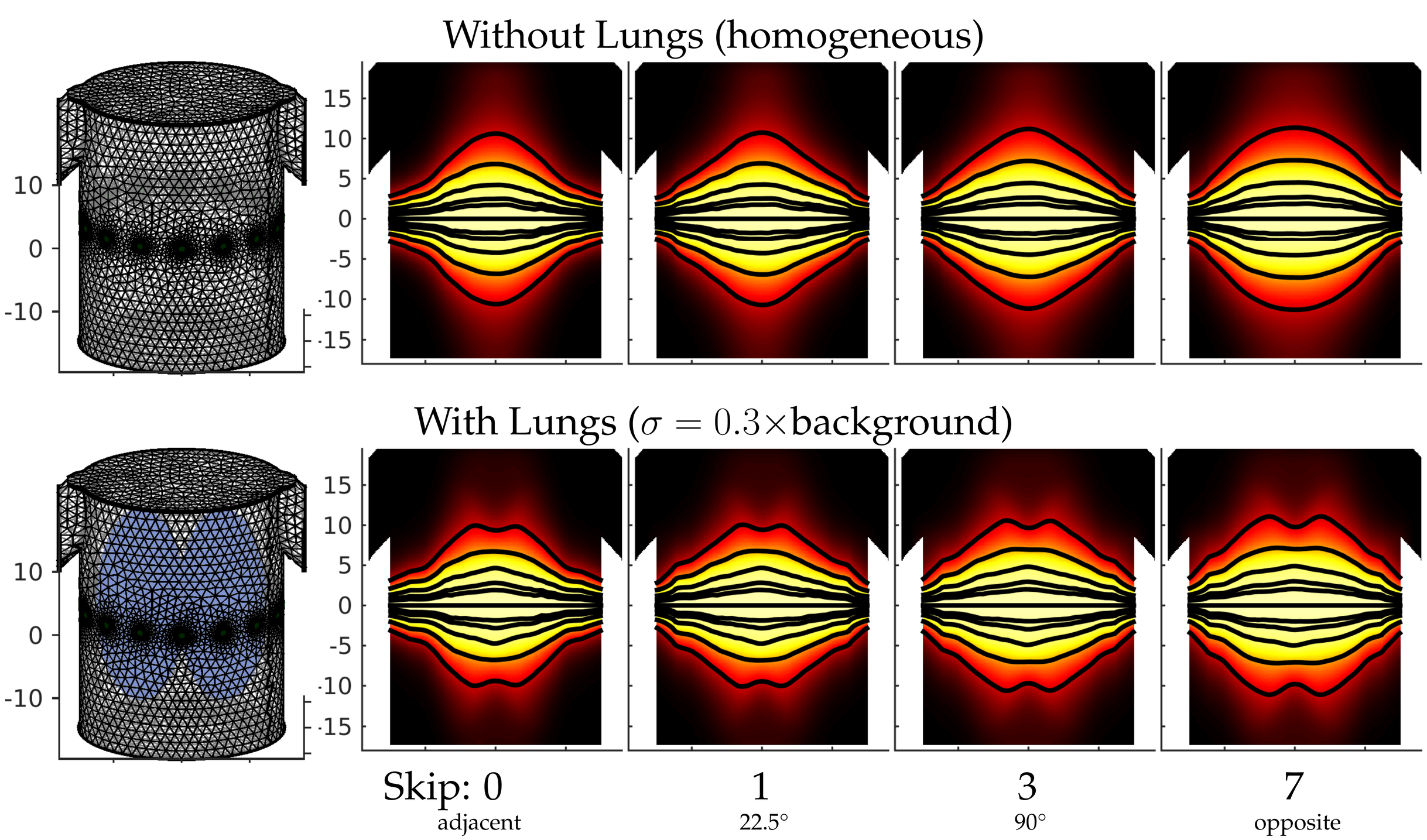
- Ratio of conductivity of lung tissue to other chest tissue
- Chest wall thickness (i.e. depth to lungs from skin)
- Ratio of circumference of chest to waist
- Ratio of anteroposterior to lateral dimension

In this paper, we consider only the effects of stimulation and measurement pattern and the lung/tissue conductivity ratio. Patterns which use nearby electrodes (such as the adjacent pattern) would be expected to show less vertical sensitivity than those which use further apart electrodes.

Discussion

Higher s values give a larger, and less peaked vertical EIT sensitivity region. Also, the lungs have a large effect on the sensitivity profile, especially near the tops of the lungs in this (crude) model. Results suggest that a more detailed understanding of the structure of EIT’s off-plane sensitivity is warranted in order to gain an improved understanding of the possible artefacts in EIT images. Such work should also consider the anatomical factors listed, as well as the effect of the choice of image reconstruction algorithm.

Results



Coronal plane sensitivities vs. skip patterns (indicated below figures). Upper images: homogeneous FEM model. Lower images: FEM model with ellipsoid lung regions with conductivity of $0.3\times$ the background. Black lines on images indicate the sensitivity contours with respect to the maximum (on plane): 95%, 90%, 75%, 50%, 25%.