The off-plane sensitivity of EIT

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Abstract: Due to the diffuse nature of current propagation, EIT is sensitive to off-plane conductivity changes. Traditionally, for chest EIT, the sensitive region is described as “lens shaped" and half of the body diameter. In fact, many factors affect the size and shape of this region. In this paper, we explore the effect of the separation of the stimulation and measurement electrodes.

1 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.

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

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

In this paper, we consider the only effect of the stimulation and measurement pattern of the EIT capture device. 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.

2 Methods

A cylindrical finite element model is created (using Netgen[2]) to model the geometry with 16 equi-distant electrodes in a horizontal plane. Using this simulation mode, the EIT sensitivity (defined as $\|\Delta\text{Measurements}\|_2$) is calculated for all locations in a coronal plane through the body centre. Bipolar stimulation and measurement patterns were simulated and measurements on any driven electrode excluded.

We define the stimulation and measurement *skip* distance, s, as the number of electrodes between the drive and receive electrode pairs. Using this definition, the adjacent pattern has $s = 0$, the opposite pattern has $s = 7$, and a stimulation between electrodes #1 and #4 has $s = 2$.

3 Results

The coronal plane sensitivities are shown in fig. 1 for different values of the skip distance. In each image, 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.

4 Discussion

We consider the off-plane sensitivity of EIT as a function of the “skip" in the stimulation and measurement patterns. As shown in fig. 1, the sensitivity varies significantly with the change in s. Higher s values give a larger, and less peaked vertical EIT sensitivity region.

These 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.

References

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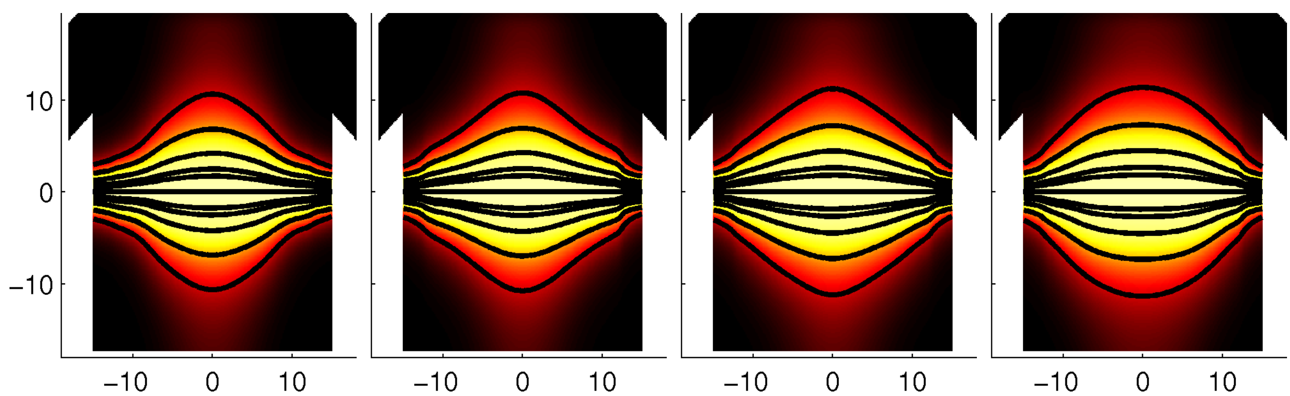

Figure 1: Coronal plane sensitivities for different skip patterns, with a horizontal electrode plane at 0. From left: $s = 0$ (adjacent) $s = 1$, $s = 3$ (90°), $s = 7$ (opposite). Black lines are the sensitivity contours (from the electrode plane): 95%, 90%, 75%, 50%, 25%.