Evaluation of Reconstructed Images of Regional Lung Changes Using a Model

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INTRODUCTION Recent studies have shown that using EIT to monitor ventilator dependent patients appears to have much promise (Frerichs et al. 2006). Its application allows a possible view of regional ventilation that is dependant on the amount of positive end expiratory pressure (PEEP). Since EIT is a low resolution imaging modality with nonlinear characteristics, questions arise as to where in the image and to how large will be the area of change. Using a model, this study attempts to answer these questions. This approach would be useful in evaluating various reconstruction algorithms as suggested by Alder et al 2010.

MEDHODS The model was created from human MR images that were obtained with a 1.5 T Siemens Sonata scanner. Forty-three thoracic transverse images were obtained from abdomen to neck and gated to coincide with end-diastole. The images were digitized at a spatial resolution of 1.5 mm/pixel in right-left and anterior-posterior directions. The resolution in the cranial-caudal direction was 5 mm/pixel identical to the MRI slice thickness. Upon segmentation, thirty-six tissue types and blood containing regions were obtained. Each tissue was assigned an appropriate electrical resistivity.. A 3D electrical model of the thorax at the end of diastole was thus created, with a resolution of 1.5×1.5×5 mm^3 and 3.8 million elements. The model was solved using a finite difference program developed in our laboratory (Belalcazar A and Patterson 2004, Yang and Patterson 2010).

In order to answer questions about regional lung changes, two regions were created in the posterior portion of the right lung where the resistivity can be independently varied (Figure 1). Each region was created in all of the 43 layers in the same anterior-posterior position. Using the model the lung resistivity in each region was changed in 200 Ω-cm steps from 600 Ω-cm up to 2200 Ω-cm. The difference images were created using the reference frame with the entire right and left lung at 1400 Ω -cm, which is assume to be a typical value at end expiration.

The image reconstructions were created using both the Sheffield (Brown and Seagar, 1987) and NOSER (Cheney et al. 1990) algorithms. The areas of the resulting images of the regional modifications were calculated using 40% and 80% of the maximal change averaged over 10 pixels.

RESULTS Examples of the results for one case of reduced lung resistivity are shown in Figures 1 and 2. Figures 3 shows the percentage change of the resistivity as viewed in the image as a function of lung resistivity using the Sheffield algorithm. Figure 4 show the image area changes for the same case as shown in Figure 3.

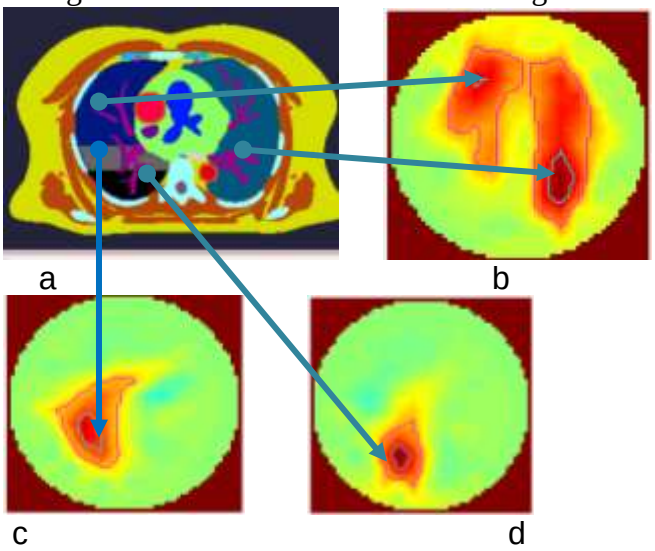

Figure 1, Reconstrction using Sheffield algorithm (a)- Modified regions of the right lung in the segmented mid-thorax of the model. (b)- Difference image when left lung and unmodified regions of the right lung were changed from 1400 to 1000 Ω -cm. (c)- Difference image when the mid-right lung region was changed from 1400 Ω-cm to 1000 h Ω-cm. (d)- Difference image when the lower modified of the right lung was changed from 1400 to 1000 Ω -cm.

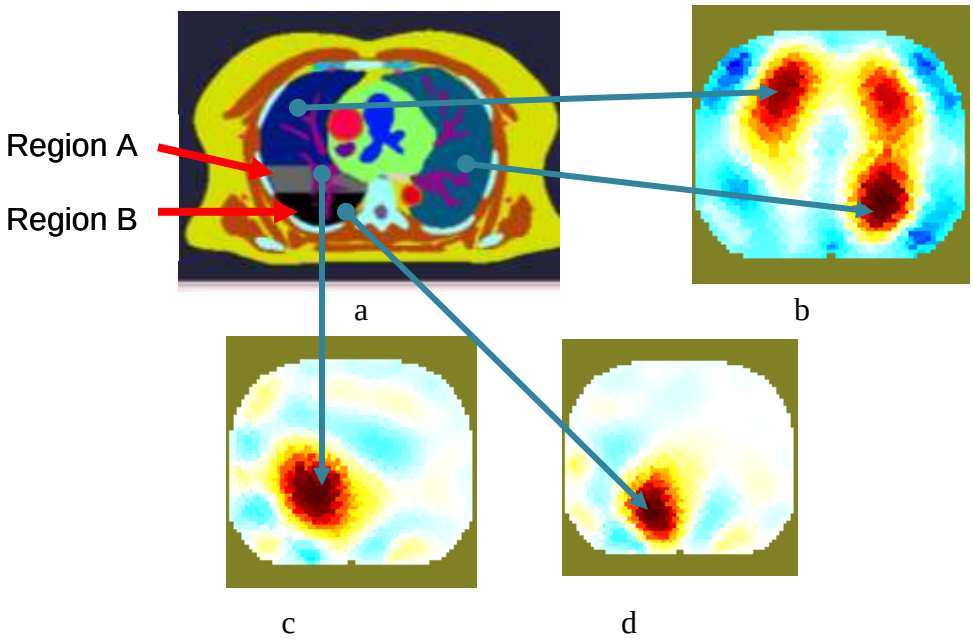

Figure 2, Reconstrction using NOAS algorithm (a)- Modified regions of the right lung in the segmented mid-thorax of the model. (b)- Difference image when left lung and unmodified regions of the right lung were changed from 1400 to 1000 Ω -cm. (c)- Difference image when the mid-right lung region was changed from 1400 - Ω cm to 1000

Ω -cm. (d)- Difference image when the lower modified region of the right lung was changed from 1400 to 1000 Ω -cm.

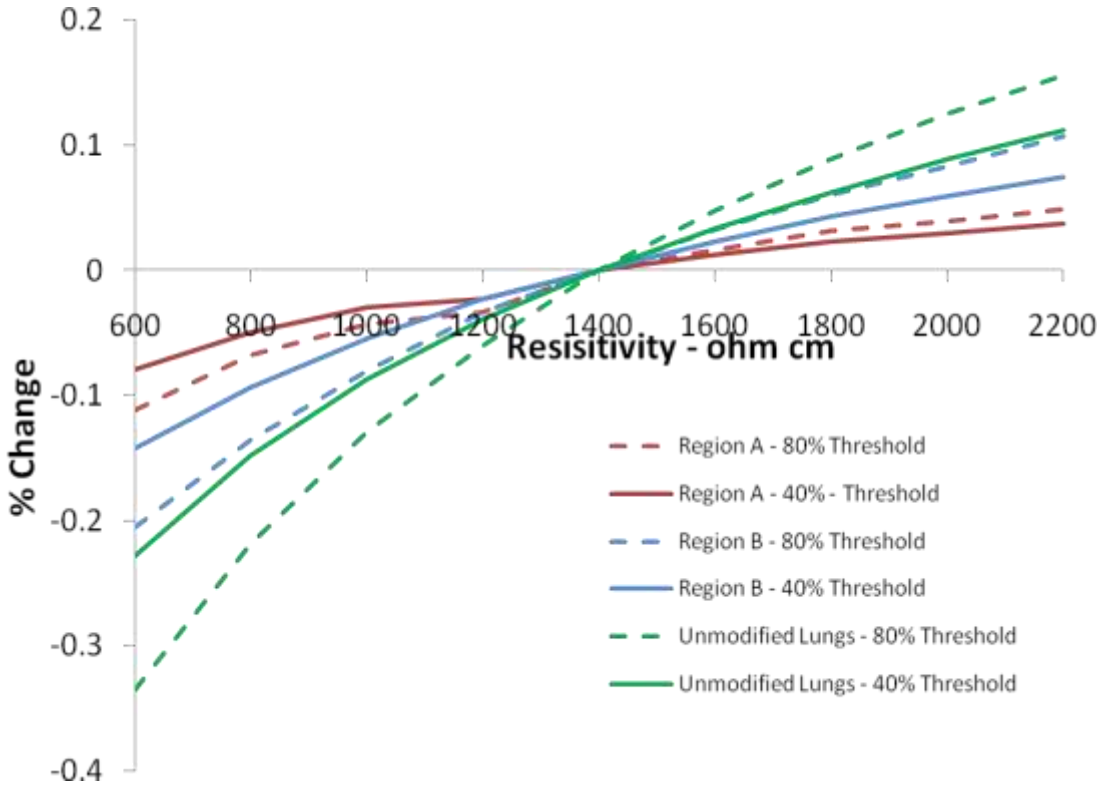

Figure 3. The percentage change in the image area as a function of lung resistivity for the reconstructed image using the Sheffield algorithm

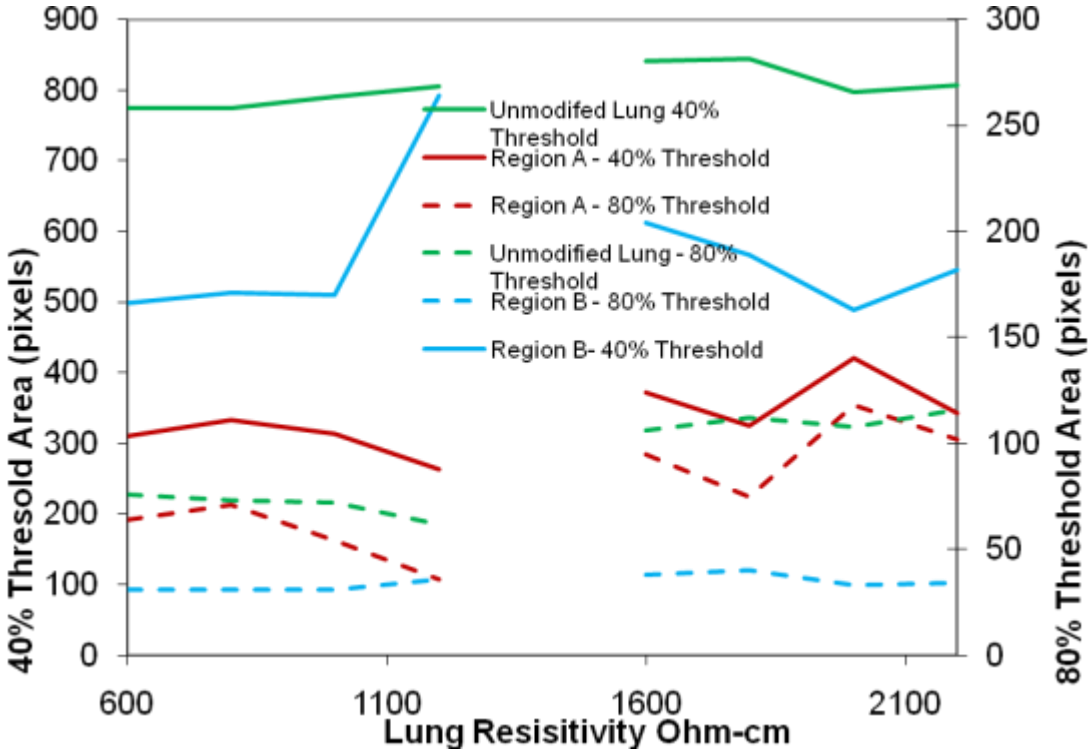

Figure 4 The change in image area as a function of lung resistivity using the Sheffield reconstruction algorithm

DISCUSSION - The percentage change in the image resulting from changing lung resistivity is slightly nonlinear with the change with decreasing lung resistivity approximately twice that for the same about of increased lung resistivity. The area of the lung shows some change as a function of lung resistivity, but there are no consistent patterns. The examples shown for both reconstruction algorithm (figures 1 and 2) show an overlap in modified regions A and B. Clearly, the shape of the change in the image differs from the shape shown in the lung model. The shape, overlap and the location of the change in the image need to be studied more.

This approach, using an actual high resolution thorax model, can be useful in studying and comparing different reconstruction algorithms.

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