# Comparison between regional lung CT values and lung densities estimated using EIT

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**Abstract:** In this paper we report the results of our study in which we compared lung density values obtained from EIT and CT values (HU) within a region of interest. The purpose was to verify clinical use of lung density estimation using EIT data. Image resolution of CT images, which was originally 512*512 pixels, was changed to 16*16 pixels, to match that of the EIT images. The CT and EIT images were recorded from eight patients in an intensive care unit and the results showed a correlation coefficient of 0.66 ($p<0.05$) between the CT values (HU) and the lung density values (kg/m$^3$) obtained from EIT.

## 1 Introduction

Electrical Impedance Tomography (EIT) has become a feasible technique to evaluate lung function [1]. However, it is yet to be considered as a clinically acceptable method for evaluation of lung density. We had proposed the use of 'lung density' as an absolute measure of lung function using EIT data sets, but had not compared it with clinical results from patients with lung disease. In this study, CT values (HU) and lung density (kg/m$^3$), though representing different physical properties of lung tissue, were compared to verify the feasibility of using lung density values for clinical monitoring of lung disease.

## 2 Methods

Eight patents, connected to a ventilator, were studied by recording CT and EIT images within 24 hours of each other. Shefield Mk3.5 [3] EIT system with 8 electrodes and 16*16 image resolution was used in this study. To achieve pixel by pixel comparison between CT values and lung densities, the thorax shape of the CT image was deformed to be circular and its spatial resolution, which was originally 512*512 pixels, was changed into 16*16, similar to that of EIT. EIT was reconstructed with the Sheffield back projection method using a sensitivity matrix [4]. The lung density at each pixel was estimated using 1 minute data set, measured at four frequencies between 2 kHz and 768 kHz. A region of interest (ROI) over the lungs was chosen manually. We calculated the correlation coefficient between the CT values (HU) and lung densities (kg/m$^3$) in all of subjects.

## 3 Results and discussions

Figure 1 shows a result of comparison between CT value and lung density in one patient. They are in reasonable agreement around both lung collapsed and consolidated regions. All the data from eight patients is plotted in Figure 2. The correlation coefficient was 0.66 ($p<0.05$) between CT value and lung density and can be considered acceptably high. However, deformation of the thorax shape into a circular shape and manual determination of the ROI are likely to have introduced errors. Furthermore, we could not make both CT and EIT measurements on the same day because of the limited availability of ICU clinical staff required to be present. The extent of the lung disease is likely to have changed between the measurements and so would have reduced the correlation between the CT and EIT measurements related to lung density.

Although the CT values and lung density are not directly comparable, the results of this study suggest that lung density could be a feasible index to evaluate lung disease. Further experiments need to be carried out to verify this finding by increasing the number of patients.

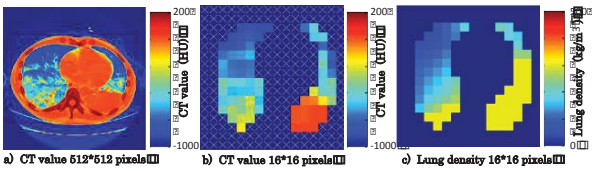


**Figure 1:** An example of comparison between CT values (HU) and Lung density (kg/m$^3$) in a patient.

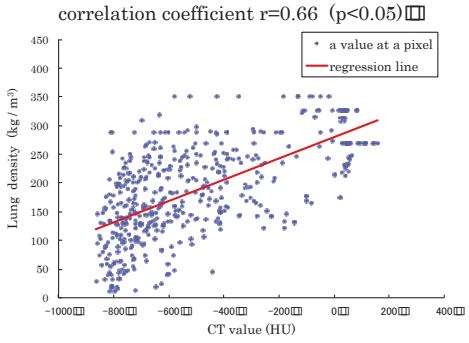


**Figure 2:** Relationship between CT values (HU) and Lung density (kg/m$^3$) in eight patients.

## References

[1] Adler A, Amato MB, Arnold JH *et. al.*, Whither lung EIT: where are we, where do we want to go and what do we need to get there? *Physiol Meas.***33**: 679-94, 2012.
[2] Nebuya S, Mills GH, Miles P, Brown BH, Indirect measurement of lung density and air volume from electrical impedance tomography (EIT) data.*Physiol Meas.***32**: 1957-67, 2011.
[3] Wilson AJ, Milnes P, Waterworth AR *et. al.*, Mk3.5: a modular, multi-frequency successor to the Mk3a EIS/EIT system. *Physiol Meas.***22**: 49-54, 2001.
[4] P. Metherall, Barber DC, Smallwood RH *et. al.*: Three-dimensional electrical impedance tomography, *Nature*, **380**, 509-12, 19

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