Separation of ventilation and cardiac activity on recorded voltages before EIT image reconstruction

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Abstract: Electrical impedance tomography is mostly employed to monitor the patients ventilation. However, it contains also their cardiac activity. Here we separate the ventilation and the cardiac activity signals through an harmonic analysis directly from the EIT voltages and reconstruct ventilation and cardiac-related independent images.

1 Introduction

Electrical Impedance Tomography (EIT) is used to monitor the variation of impedance. It is usually employed to observe the ventilation of a patient at the bedside as the inhalation and exhalation of air has a large influence on the lungs' conductivity.

Nevertheless, the heart deformation and blood flow produced by the cardiac activity also produces a change on the local conductivity [1]. However, these changes are order of magnitude smaller than those induced by the patient's ventilation [1]. Nevertheless, we showed that through an harmonic analysis it is possible to separate the signals belonging to the ventilation from those belonging to the cardiac dynamics [2, 3]. This was achieved working on the pixels of the EIT frames after the EIT images were already reconstructed from the raw data.

However, EIT image reconstruction is an ill-posed nonlinear inverse problem which inevitably add artifacts to the images. Separating the cardiac-related signals from the reconstructed images may exacerbate these artifacts. Here, we show that it is possible to apply the harmonic analysis on the raw voltages directly as displayed in Fig. 1. The first row shows the model and the trend of the voltages measurements. From these two sets of raw data are then obtained: one containing only the ventilation signals and one with only the cardiac activity (second raw of Fig. 1). Then finally two series of EIT images can be reconstructed (third row of Fig. 1). These images contain information pertinent to only the cardiac activity and to only the ventilation.

2 Methods

Simulated data and clinical data were used. The separation of ventilation and cardiac-related signals was applied on the EIT voltages as well as directly on the EIT images.

3 Results

The harmonic analysis performs well on to the raw data of the EIT consisting of voltage measurements. It generates two sets of voltages measurements, one with only the conductivity changes given by the ventilation and one with the changes given by the cardiac-related signals. These can be successfully used to reconstruct two sets of EIT images which independently display the ventilation and the cardiac activity.

Moreover, some noise from the voltage measurements can be rejected, which we expect it may increase the stability and reliability of the EIT image reconstruction.

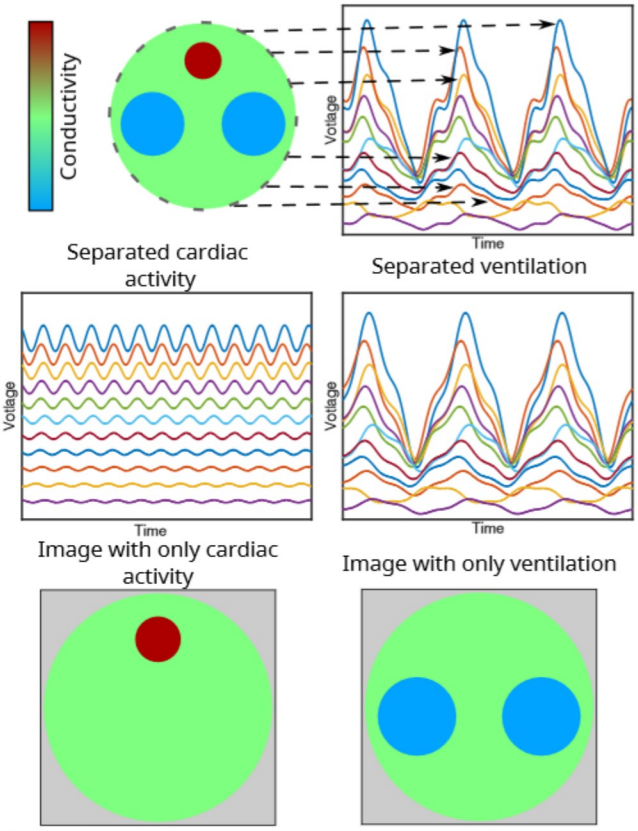

Figure 1: Schematic to represent the procedure to construct EIT images containing only the ventilation and only the cardiac activity from the EIT raw voltage measurements.

However, the quality of the independent reconstructed images is affected by the specific reconstruction algorithm employed.

4 Conclusions

It is possible to separate ventilation and cardiac-related signals in EIT directly from the raw voltage measurements and use the separated signals to reconstruct EIT images which display separately the activity of the ventilation and of the cardiac dynamics.

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