Lung tissue measured in EIT may change depending on the positioning of electrode plane

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Abstract: EIT measurements were performed in 3 different transverse thoracic planes during pulmonary function test. Ratios between relative impedance changes and volume changes were different depending on the positioning of electrode planes. Since atelectasis should be minima in the healthy volunteers, the change of ratios may be explained by activity of respiratory muscles, which lead to changes in amount of lung tissue captured by EIT.

1 Introduction

Multiple EIT measurements in different transverse thoracic planes indicate that relative impedance change (ΔI) to volume change (ΔV) ratio may differ at different ventilation levels [1-2]. Since these studies were performed in animals or patients under mechanical ventilation, researchers suspected that the differences of the ratio in various electrode planes were due to different recruitment rates in these thoracic planes or capturing other organs. We conducted a prospective study in healthy volunteers with spontaneous breathing. We hypothesized that due to the movement of respiratory muscles (mainly diaphragm), the amount of lung tissue captured in certain EIT electrode planes may change, causing the change of ratio between ΔI and ΔV at different ventilation levels.

2 Methods

Pulmonary function test was performed in 3 healthy males with body plethysmography (Ganshorn, Germany). Each of the volunteers was asked to perform normal tidal breathing for about 2 minutes before deep exhalation aiming the residual volume and then deep inhalation to total lung capacity. This procedure was repeated 3 times, during which EIT measurements were performed at 3 different transverse thoracic levels (Pulmovista 500, Dräger, Germany). The EIT electrode belt was placed at (1) about 3rd or 4th intercostal space, (2) at about 5th or 6th intercostals space, (3) at about 7th intercostals space. The instruments were special manufactured so that body plethysmography and EIT can be applied at the same time. Functional residual capacity (FRC) was measured to confirm that the volunteers had similar ventilation level in each measurement prior to the vital capacity manoeuvre. Tidal volume (V_T), ins- and expiratory reserve volume (IRV, ERV) were measured. Corresponding relative impedance change ΔI_{VT}, ΔI_{IRV}, and ΔI_{ERV} were calculated, as well as the ratio between those ΔI and volumes.

3 Results

Figure 1 exemplarily shows 3 relative impedance curves of 1 volunteer in 3 transverse thoracic planes. Although the end-expiratory lung impedance values were different because of individual reference baselines, in fact, in all 3 measurements of each volunteer, FRC levels were similar (mean coefficient of variation 0.04). ΔI_{ERV}/ERV at cranial level were slightly higher than ΔI_{IRV}/IRV, while that were totally the opposite at caudal level (Fig. 2).

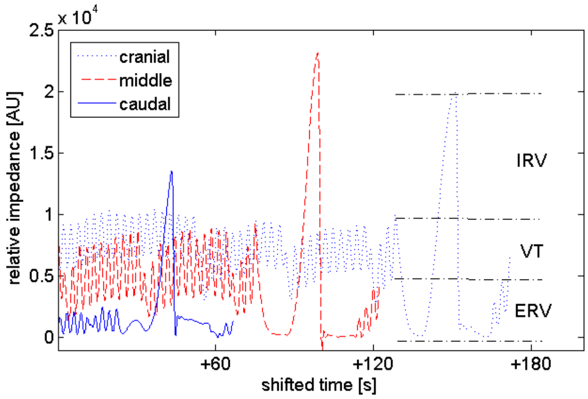

Figure 1: Relative impedance curves of 1 volunteer at 3 different thoracic levels.

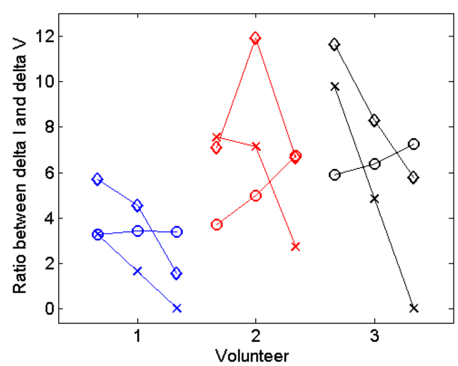

Figure 2: Ratios between various ΔI and volumes in three volunteers. Circle, diamond, and x-mark represented EIT measurements at cranial, middle and caudal thoracic levels, respectively. Within one measurement, three ratios from left to right were ΔI_{IRV}/IRV, ΔI_{VT}/VT and ΔI_{ERV}/ERV, respectively.

4 Discussion and conclusions

We found in the present study that ratios between ΔI and ΔV were different during total lung capacity maneuver depending on the positioning of electrode planes. Since atelectasis should be negligible in the healthy volunteers, the change of ratios may be explained by the activity of respiratory muscles, influencing the amount of lung tissue captured in certain EIT planes. In extreme case, totally different lung tissue is captured in EIT at different ventilation levels, if the electrode positioning is not ideal, so that the EIT images may be misinterpreted.

References

[1] Bikker IG, et al. Crit Care 15:R193, 2011
[2] Frerichs I, et al. IEEE Trans Med Imaging 18: 764-73, 1999