Optimizing PEEP in ARDS: comparison of diverse EIT parameters

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Abstract: Although EIT is a promising technique optimizing ventilator settings, the best approach that leads to an improved clinical outcome is still unknown. Against the background that diverse EIT derived parameters have been published in the last years, clinical studies focusing on defined outcome parameters have to clarify pros and cons of these measures. The aim of this study was to compare several EIT parameters in an animal trial of ARDS.

1 Introduction

Regarding intensive care medicine, EIT is a promising technique optimizing ventilator settings particularly in severely diseased patients suffering from Acute Respiratory Distress Syndrome (ARDS). To ensure a so-called protective ventilation, optimal PEEP settings are crucial. Although EIT enables to visualize ventilation and manoeuvre-dependent changes in air distribution such as stepwise PEEP variation, the optimal target parameter or clinical proceeding are unknown. This study aims to compare already published and new parameters in an animal model of ARDS and to correlate them with common clinical outcome parameters.

2 Methods

The study was approved by the German governmental institution (84-02.04.2012.A173). It was carried out considering the declaration of Helsinki in the care and use of animals. In this trial 6 pigs weighting 33.7 kg (30-36.1 kg) were used. After an initial measurement, experimental ARDS was induced in a double-hit approach. First, surfactant has been washout by repeated lavages. Second, tidal volume was increased to 20 ml/kg body weight leading to a ventilator induced lung injury. Periodic measurements of hemodynamics, blood gas analysis and EIT recording were performed at fixed points in time over 24 hours after established ARDS (“ALI1” to “ALI25”). After ALI1, randomization to either EIT or control group was carried out. At each point in time, FiO_2 setting was adapted to the current pO_2 measure obtained from blood gas analysis (target: 55-80 mmHg). In the control group, PEEP was set according to ARDS network table (table 1).

In EIT group, a PEEP trial was performed: PEEP was changed as follows: +4, +2, 0, -2, -4 cmH_2O. After a two minutes equilibration period, an EIT sequence of 1 min was recorded and diverse parameters were calculated using MATLAB for each step: (1) center of gravidy [1], (2) Impedance Ratio [2], (3) Global inhomogeneity index [3], (4) Regional Ventilation Delay Index [4], (5) Difference in end-expiratory lung impedance [5], (6) Hyperdistension and collaps index [6]. EIT was defined to be best when Global Inhomogeneity Index was lowest that means when regional ventilation was as homogenous as possible.

Post mortem, (1) wet-to-dry ratios were assessed using lung tissue samples and (2) histopathologic measurements were performed.

3 Results

The described double hit approach led to a severe ARDS in all animals. All control pigs survived the entire study whereas two animals from the EIT group died 8 hours after presence of ARDS. PEEP was significantly higher in the EIT group (21.7 vs. 8.5 mbar, $p<0.0001$) leading to a higher peak inspiratory pressure (PIP) as well (47.0 vs. 34.4 mbar, $p<0.0001$). Although the EIT-guided PEEP setting obviously led to a more individual setting, it seems to be insufficient to solely focus on homogenous distribution of ventilation by using the GI index. In most cases high PEEPs led to high homogeneity but also to overdistension. It should be wise to limit PEEP e.g. by considering overdistension index. In histophathologic analysis it could clearly be seen that all lung tissue samples showed oedema, atelectasis and haemorrhage. A tendency towards less alveolar oedema and pronounced barotrauma was determined in EIT group as compared to the control group.

4 Conclusions

A combination of overdistension and homogeneity-related indexes should be used for optimizing PEEP settings.

References

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Table 1: Tandem settings of FiO_2 and PEEP. To ensure objectivity, the mean was selected from the published PEEP range (Brower RG et al., 2004).

FiO_2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1,0
PEEP	5	6 [5-8]	9 [8-10]	10	12 [10-14]	14	17[16-18]	21[18-24]