Electrical impedance tomography in high frequency ventilated preterm infants: the search for the Holy Grail

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Outline of this thesis
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As discussed in chapter 1 the lung volume in newborn preterm infants is often below FRC and this can seriously compromise lung function leading to respiratory failure. One of the basic aims of mechanical ventilation is to establish adequate gas exchange and minimize VILI by optimizing lung volume. HFOV combined with an OLV strategy is the most widely used mode to optimize lung volume in preterm infants with RDS. Due to the lack of non-invasive bedside tools to monitor changes in lung volume, lung recruitment during open lung HFOV is mainly guided by oxygenation, which is an indirect marker of lung volume. EIT is a promising non-invasive tool able to detect regional changes in lung volumes by measuring cross-sectional impedance changes in a slice of the chest. These changes are highly correlated with actual changes in air content. This makes EIT an ideal candidate for assessing lung volume changes in HFOV preterm infants during OLV, which is the basic aim of this thesis.

The outline of this thesis is described in detail in chapter 2. Chapter 3 illustrates the importance of regional information provided by EIT, by describing an unexpected uni-lateral pneumothorax in a preterm infant with respiratory failure.

Endotracheal tube (ETT) suctioning is a standardized intervention in NICU population to maintain adequate airway patency. In conventional ventilated infants ETT suctioning has a negative impact on lung volume. In chapter 4 we explore if this was also present during open lung HFOV.

In chapter 5, we assess the changes in lung volume measured by EIT during an oxygenation guided recruitment procedure in HFOV preterm infants with RDS of less than 72 hours postnatal age. We explore the pressure-volume relationships based on the EIT and oxygenation data and assess possible regional differences in lung volume changes. Chapter 6 describes the direct effects of surfactant treatment in this population on lung volume measured by EIT. In addition, the effect on lung volume stabilization is assessed by reconstructing the deflation limb of the pressure-volume curves before and after surfactant treatment. Again possible differences in regional behavior are also explored.

In chapter 7 we investigate the stabilization time of lung volume changes in response to each pressure step during the recruitment procedure. The impact of surfactant, the position of ventilation in the pressure-volume envelope, and regional effects are also explored.

In chapter 8 we challenge the theory that during HFOV changes in CDP only affect oxygenation and changes in pressure amplitude only ventilation. The association between oscillation volumes, measured by EIT, and changes in CDP or pressure amplitude are determined and related to changes in $T_{c}PCO_{2}$.

Chapter 9 summarizes the most important results of this thesis and we discuss some future perspectives on the use of EIT in the neonatal intensive care setting.