EIT-based synchronized positive pressure ventilation in newborns

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Abstract: Synchronizing ventilation with patient efforts is associated with improved outcomes, but it is challenging to reliably detect weak breathing efforts without false positives. We propose that electrical impedance tomography (EIT) may allow improved and more accurate detection of the breath efforts. Retrospective data is analyzed to suggest that such EIT-based detection could be useful.

1 Introduction

Synchronized ventilation is widely used in neonatal care and associated with improved outcomes[1, 2]. Commonly used methods for synchronization include pneumatic capsules, flow or pressure sensors, and neurally adjusted ventilator assist (NAVA) [3]. During noninvasive ventilation, synchronization with the baby's breaths is challenging, requiring enough sensitivity to detect weak breathing efforts, while avoiding auto-triggering with nasal or oral leaks. Another concern is if the ventilator is triggered by the opening/closing of the glottis, leading to triggered breaths which ventilate the pharynx rather than the lungs.

Electrical impedance tomography (EIT) uses body-surface electrodes to image the ventilation distribution. We propose that the EIT signal may be particularly useful to improve patient-ventilator synchrony in the neonatal population.

2 Methods & Results

EIT data were recorded during spontaneous tidal ven- tilation in a five-week-old preterm infant (26 weeks gestational age at birth) as part of a larger study (ACTRN12616001516471). During regular spontaneous tidal ventilation, EIT could detect the start of inspiration (Fig 1A). EIT could detect the absence of spontaneous ventilation during apnea (Fig 1B) and may distinguish an opened vs. closed glottis. If the glottis is opened, the ventilator would provide a normal unsynchronized positive pressure support. If the glottis is closed, a sensory stimulation together with a back-up rate would be provided.

EIT also provides useful information on the expiratory lung impedance. The EIT signal could be used in a closed-loop configuration to trigger an increase in positive end expiratory pressure. It would sustain functional residual capacity (FRC) and be a clear clinical benefit for neonates.

We identify the following advantages & challenges:

Advantages	Challenges
- Regional information and therefore more sensitive	- EIT measures cardiac and ventilation related changes
- Non-invasive lung measure without physiological delay	- EIT is sensitive to movement artefacts
- No time delay e.g. compared to pressure signal	- EIT has lower sampling frequency
- Works in NIV & invasive modes	

3 Discussion

We propose that EIT has the potential to improve patient-ventilator synchrony and may be used as a close-loop system to optimize ventilator settings such as PEEP.

References

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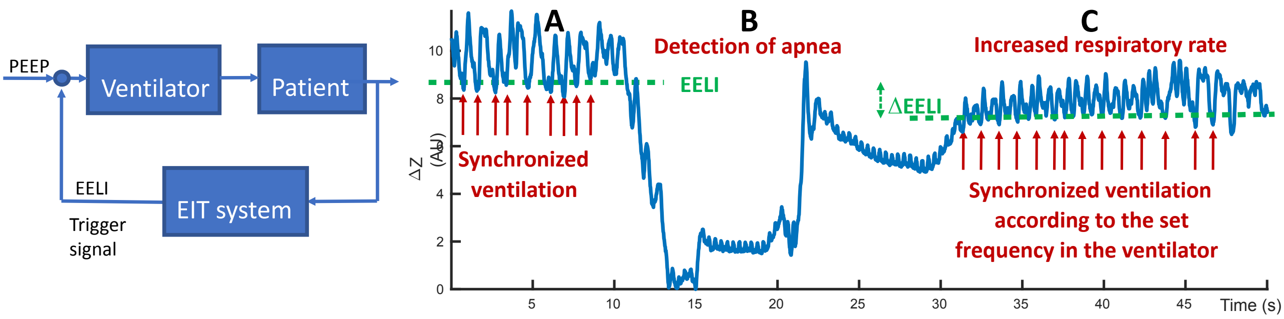

Figure 1: (left) Interaction between ventilator, patient and EIT system, (right) global EIT (arbitrary units) vs. time. A: Patient triggered ventilation, EIT detects the start of inspiration, triggers the ventilation, which then supports the patient, red arrows show the synchronized breath, B: Patient without regular spontaneous breathing, and decreasing end expiratory lung impedance (EELI) decreases, EIT would detect the apnea sequence and support the patient and if needed trigger an alarm, C: the patient starts to breath again and EIT recognize the spontaneous breathing again, EIT triggers the ventilator according to the maximal set breath rate. The EELI drops during the depicted sequence (green part); EIT recognizes the drop of the EELI, send a signal to the ventilator and the ventilator adjusts e.g. PEEP according to the measured EELI. The closed loop system may result in improved support.