A pressure reconstruction method for spontaneous breathing effort monitoring.

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Introduction:
Estimating respiratory mechanics of mechanically ventilated (MV) patients is unreliable when patients exhibit spontaneous breathing (SB) efforts on top of ventilator support. This reverse triggering effect [1] results in an M-wave shaped pressure wave. A model-based method to reconstruct the affected airway pressure curve is presented to enable estimation of the true underlying respiratory mechanics of these patients.

Methods:
Airway pressure and flow data from 72 breaths of a pneumonia patient were used for proof of concept. A pressure wave reconstruction method ‘fills’ parts of the missing area caused by SB efforts and reverse triggering by connecting the peak pressure and end inspiration slope (Figure 1). A time-varying elastance model [2] is then used to identify underlying respiratory elastance ($AUE_{drs}$). The area of the unreconstructed M-wave has less pressure, resulting in a lower overall $AUE_{drs}$ without reconstruction. The missing area of the airway pressure or $AUE_{drs}$ is hypothesized to be a surrogate of patient-specific inspiratory to assess the strength of SB efforts. $AUE_{drs}$ and missing area $A_2$ are compared with/without reconstruction.

Results:
Median $AUE_{drs}$ and breath-specific effort using reconstruction were 24.99[IQR:22.90-25.98] cmH₂O/l and 3.64[IQR:0.00-3.87] % versus $AUE_{drs}$ of 20.87[IQR:15.24-27.48] cmH₂O/l for unreconstructed M-wave data, indicating significant patient and breath specific SB effort, and the expected higher elastance (p < 0.05).

Conclusions:
A simple reconstruction method enables the real-time measurements respiratory system properties of a SB patient and measure the surrogate of the SB effort, that latter of which has clinical useful in deciding whether to extubate or re-sedate the patient.

References:
Figure 1. The $E_{Raw}$ for M-wave and reconstructed airway pressure at PEEP = 15 cmH₂O.