Possible Solutions for a respiratory module

Calculate Pmus via knowledge of compliance

During mechanical ventilation, compliance of the lungs (CL) can be calculated via knowledge of PS and resulting flow. However, compliance measurements can be inflated as a result of Pmus inflating the lungs alongside the delivered PS.

When PS is high, the patients Pmus becomes near zero. From this knowledge, CL can be calculated as shown in eq 1:

Delivered volume during inspiration is calculated from the integral of the flow signal, as shown in eq 2:

Thus, at high PS levels, we are able to calculate the patients lung compliance (CL).

Knowledge of the patients CL can be used to estimate Pmus. The relationship governing Pmus estimation, is shown in eq 3:

Eq3 shows, that any Ceff above CL must be a result of Pmus. Hence, it is theoretically possible to calculate the patients own breathing effort.

Calculating Ppl

In [Francesco et. Al, 2015], a common model of respiratory system is applied. The bioelectrical schematic of the model is depicted in fig 1.

A diagram of a graph

Description automatically generated

*Fig 1 - A bioelectrical model of the lungs. The model can be divided into two major sections: Pao, Raw, Pal and EL describe the path from the trachea to alveoli, whereas Ppl, RCW, ECw and Pmus describe the pleural cavity, chestwall and diaphragm.*

*In the first section, Pao is the pressure delivered by the ventilator, Raw is resistance of the airways, Pal is pressure at the alveoli and and EL is the elasticity of the lungs*

*In the second section, Ppl is the pleural pressure,RCW the resistance of the chest wall, ECw the elastance of the chest wall and Pmus the pressure generated by the respiratory muscles.*

[Francesco et. Al, 2015] used the second part of the model to compute Ppl, RCw andECW. They did this by using flow, volume and invasively measured Peso data at breaths where Pmus= 0 to fit the RCW and ECW parameters, by optimizing eq 4:

(eq 4)

For this project, Peso is not available. However, through the method described in the above section, Pmus can be calculated. Thus, Ppl can be estimated as shown in eq 5:

(eq 5)

Integrating the described methods with clinically acquired PPV data

For a quick overview, table 1 shows the parameters of the respiratory module, and table 2 shows the respiratory as well as cardiac state variables.

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| **Respiratory Parameters** | **Derivation method** |
| CL | at Pmus=0 |
| RL | Model fitting of patients Pao |
| CW | Model fitting |
| RW | Model fitting |

|  |  |
| --- | --- |
| **Respiratory State Variables** | **Cardiac State Variables** |
| Pao | PPa (Pulmonary Artery) |
| Ppl | PSa (Systemic Artery) |
| Pmus | PRv/PLv (Ventricles) |
| V | PRA/PLA (Atria) |
| Flow | Volume (Ventricles & Atria) |

Fig 2 shows a high level architecture of the model’s process. First, compliance is estimated from the patient data at Pmus=0. Then, Pmus can be calculated for the remaining data. Afterwards, the model is fit to the patient’s PPV data, after which the patient’s Ppl is obtained.

A diagram of a function

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