Real-Time Breath-to-Breath Aysnchrony Event Detection using Time-Varying Respiratory Elastance Model

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- *Conclusion*

Respiratory Failure

- Patients with impaired lung functions, collapse lung, resulting in poor gas exchange (Cant breath properly or not getting enough oxygen)
- Pneumonia, Trauma, Sepsis, Drowning, Drug overdose, aspiration…etc

Respiratory Failure and Mechanical Ventilation

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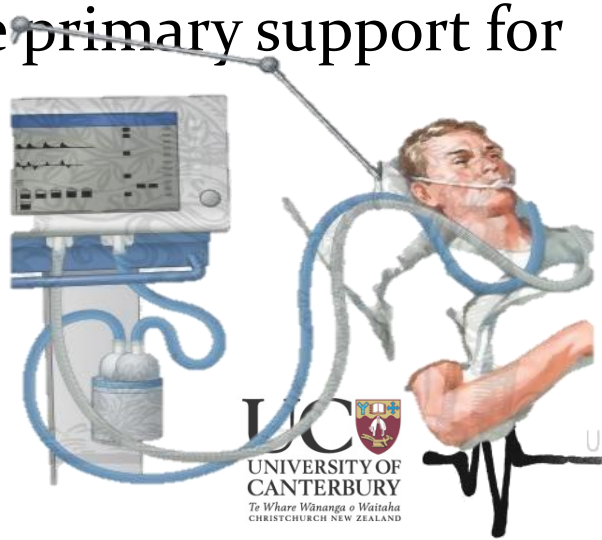
- Mechanical Ventilation (MV) is the primary support for patients with respiratory failure.
  - Provide a pressure/ air volume
    - Full control ventilation
    - Partial support
- Everything seems 'Good' but…



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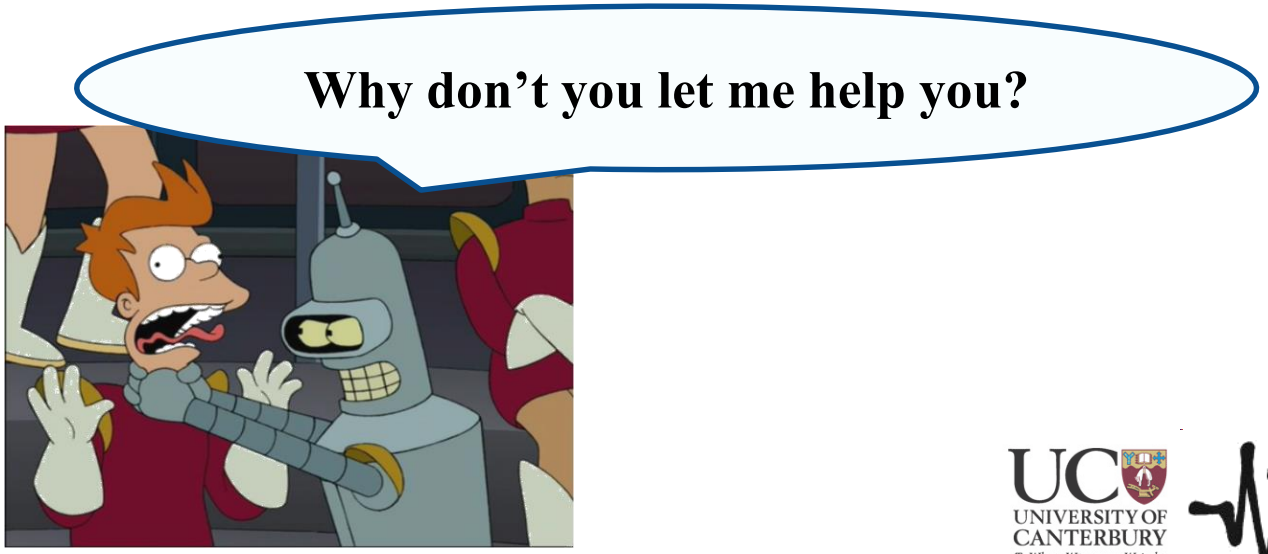
The Hidden Problem - Asynchrony

- An event which occurs when there is a mismatch between patient-ventilator interaction.
- Patient is no getting the support what they need from the ventilator
- Causes of Asynchronous events
  - Ventilator
    - Sub-optimal settings
    - No sensitive or over sensitive
  - Patient
    - Patients condition
    - Amount of Sedation

The Hidden Problem - Asynchrony

- These asynchronies risk inadequate oxygenation, ventilator associated lung injury, and cardiovascular events.



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The Hidden Problem - Asynchrony

- Patient-ventilator asynchrony events cannot be automatically detected in real-time.
- The standard approach is through manual calculation.

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Problem and Study Objective

- Patient-ventilator asynchrony events cannot be automatically detected in real-time.
- The standard approach is through manual calculation.
- Thus, the problem is essentially neglected.

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- There is a need to automate these AEs detection
- model-based method

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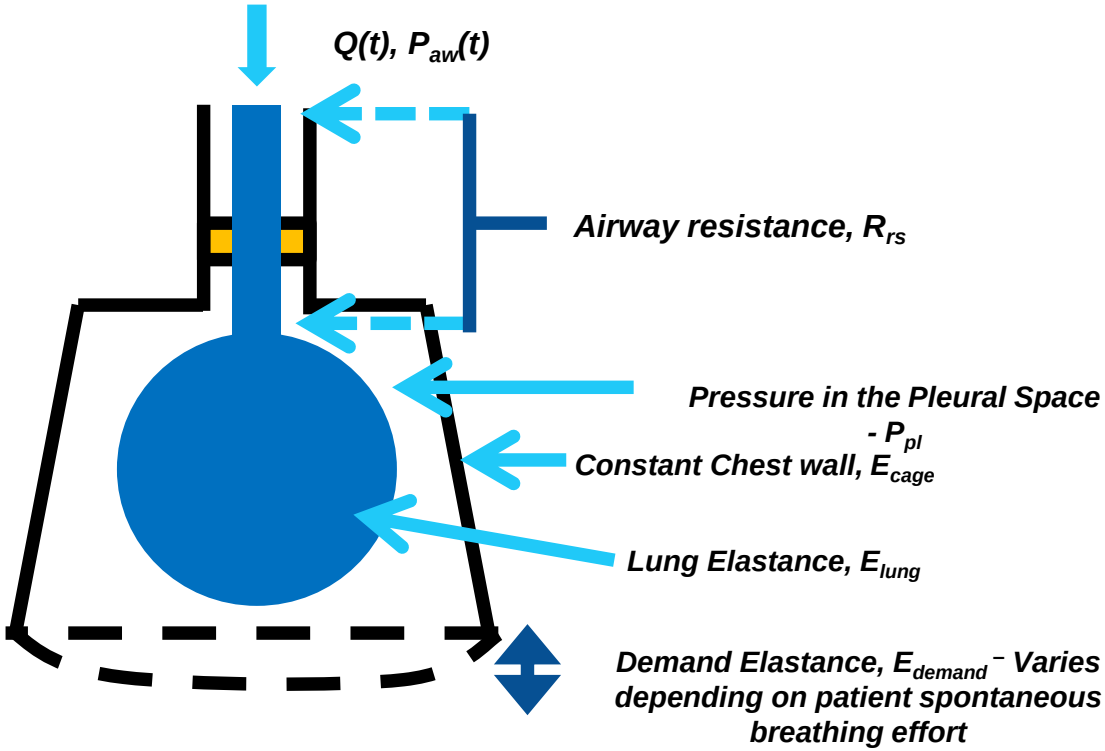
Patients data

- Observational Study in Christchurch Hospital, NZ
- 14 Respiratory Failure Patients requiring mechanical ventilation
- Ventilated using Puritan Bennett PB840
  - Bi-Level pressure ventilation
  - Synchronous Intermittent mandatory ventilation
  - Spontaneous Breathing mode
- Study and use of the data approved by the New Zealand South Regional Ethics Committee

Methods - *Model-based Asynchrony Events Detection*

- Quantify breath-to-breath time-varying respiratory system



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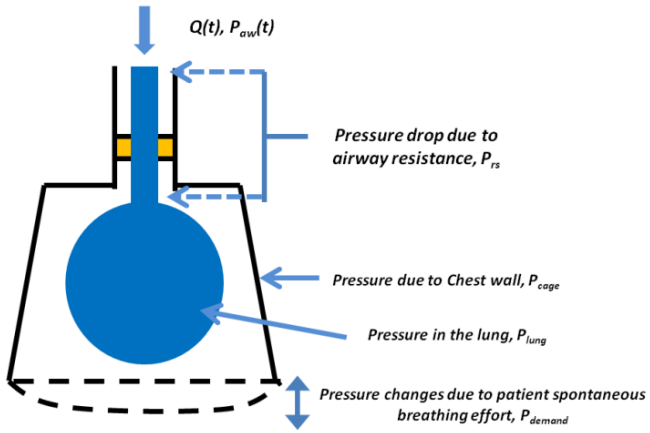
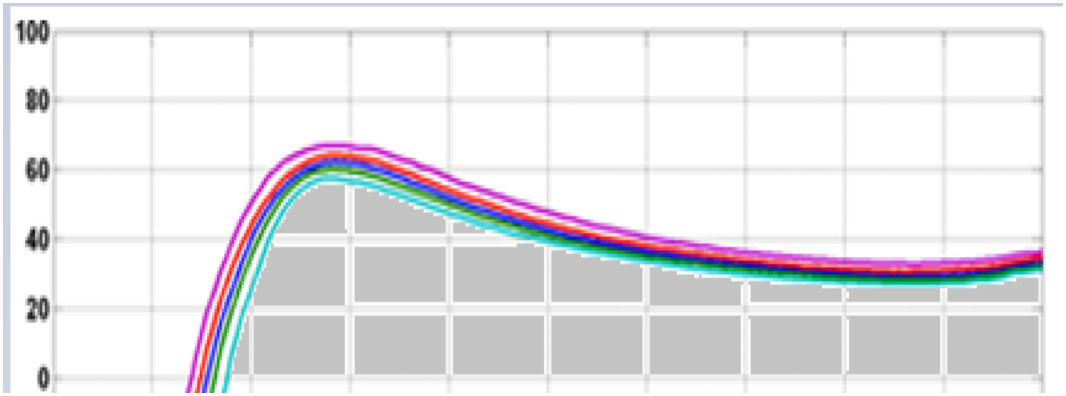


Time varying elastance model

$$P_{aw}(t)=E_{drs}(t)\times V(t)+R_{rs}\times Q(t)+\text{PEEP}$$

- For every breathing cycle…
- Area under the curve for time varying elastance ($AUCE_{drs}$)
- *Mismatch of Pressure and Flow*



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Results and Discussion

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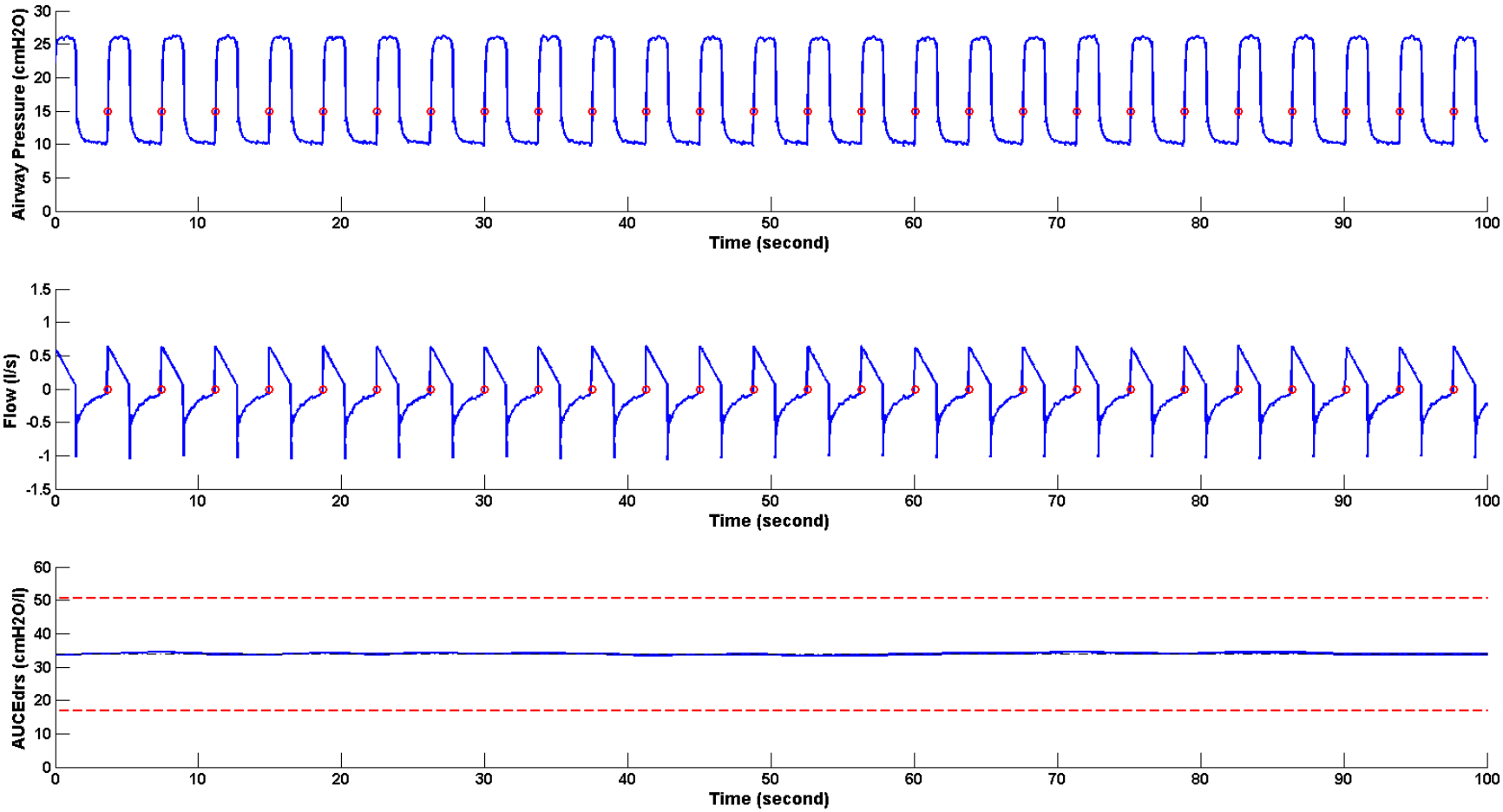
Case: No pressure and flow mismatch, resulting in a smooth and transient $AUCE_{drs}$.



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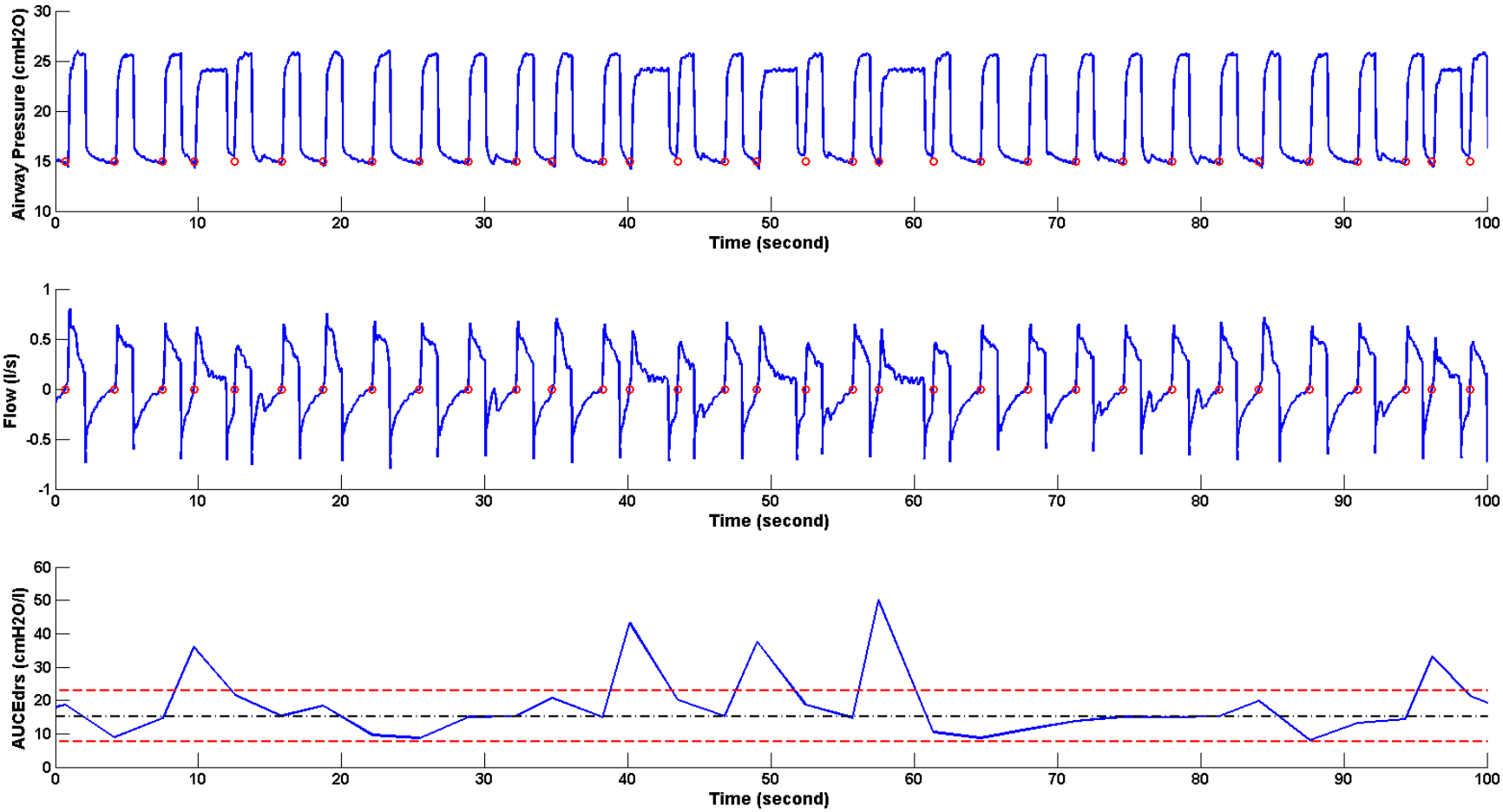
Pressure and flow mismatch resulted in sudden change of $AUCE_{drs}$ indicating an asynchrony event has occurred.



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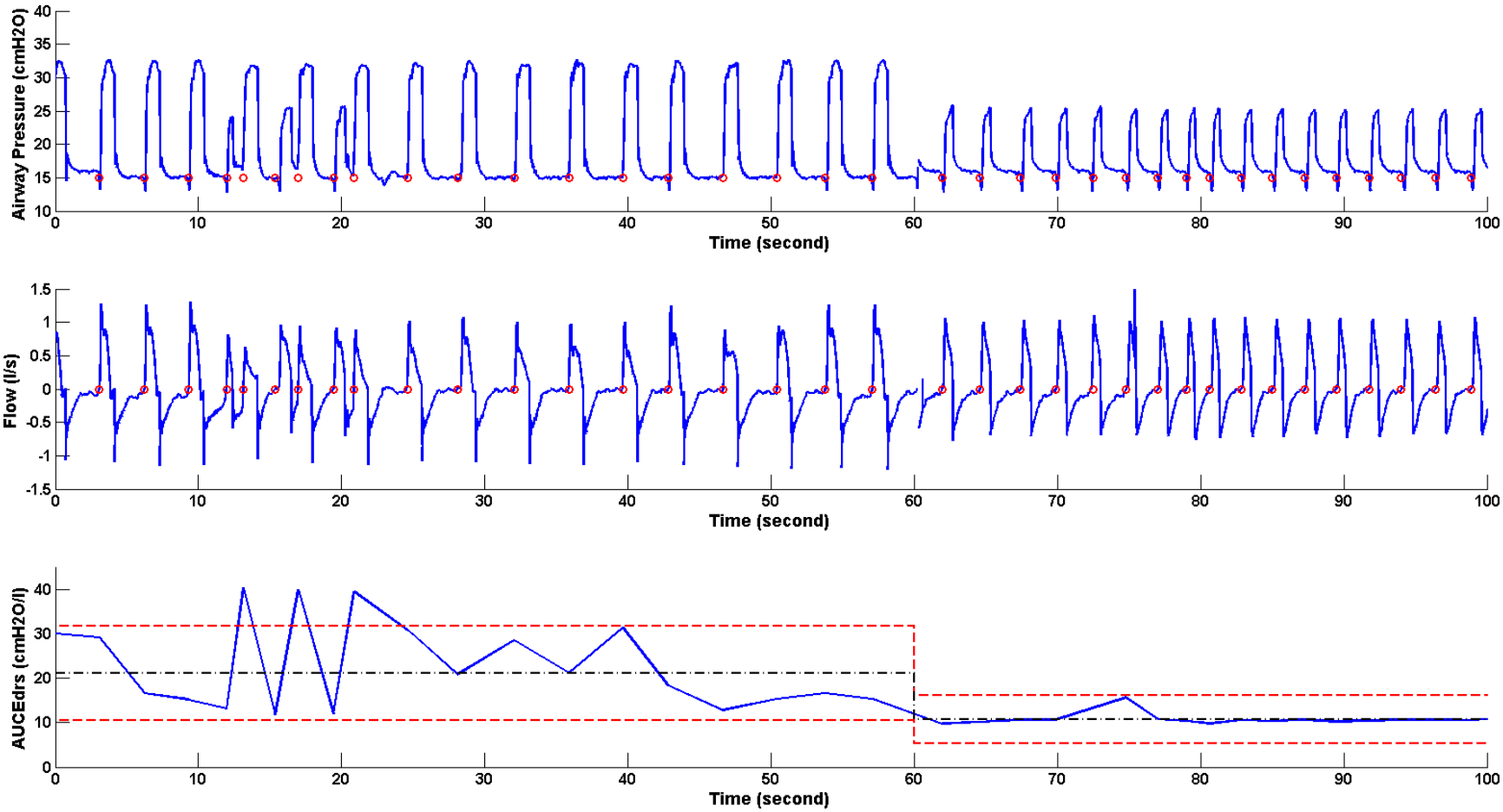
Change of ventilation mode: from BL to SPONT – A change of patient asynchrony index



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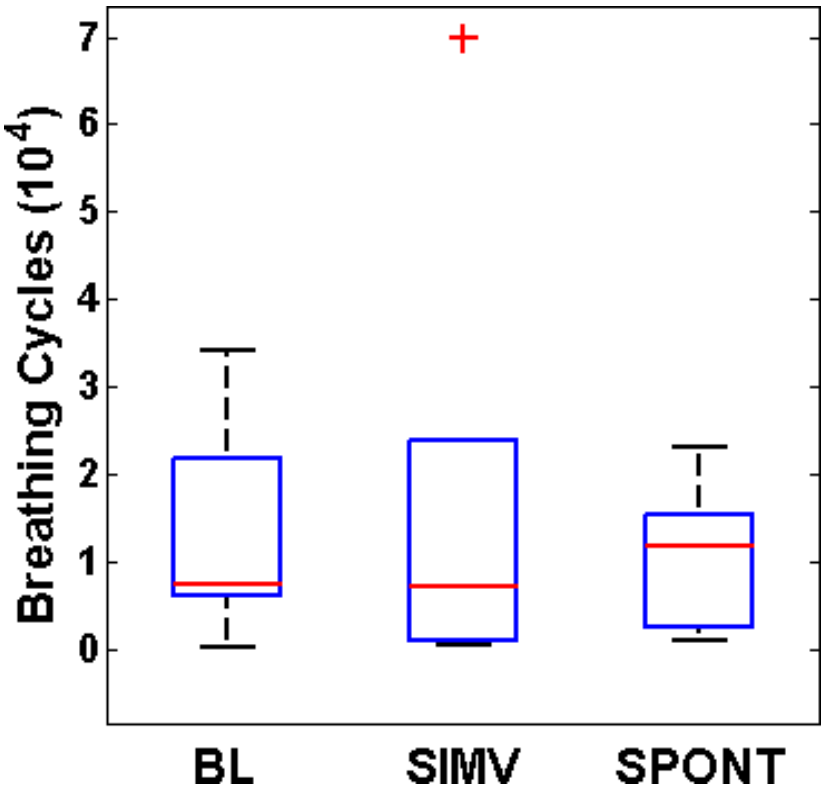

- > 20000 minutes of accumulated MV time (20639)
- > 400000 Breathing Cycles were analysed (416934)

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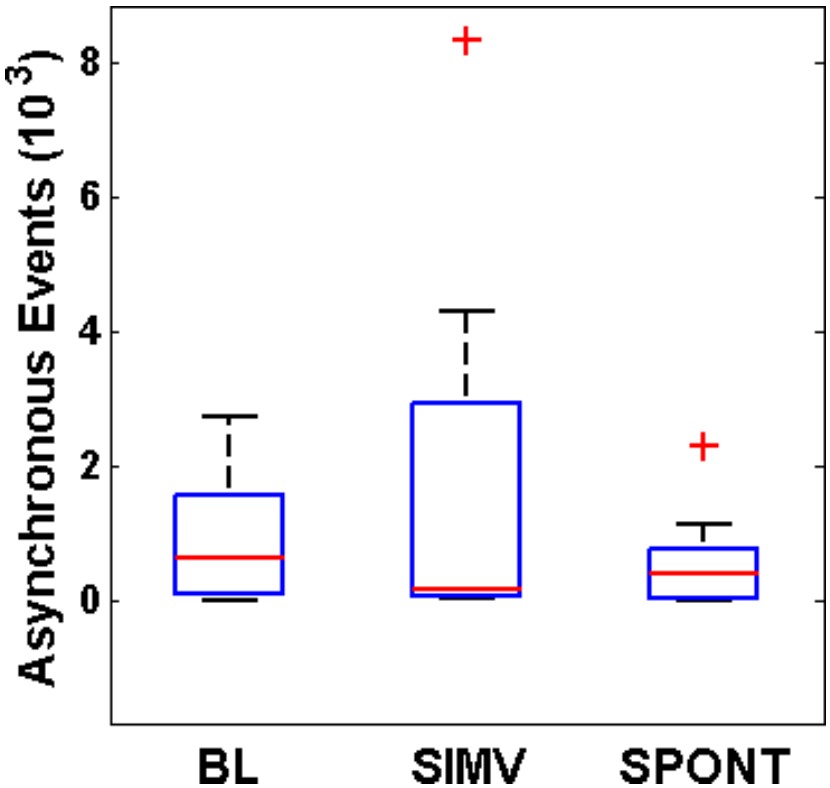

- A total of 34161 Asynchrony Events were detected in 416934 breaths analysed (8%)

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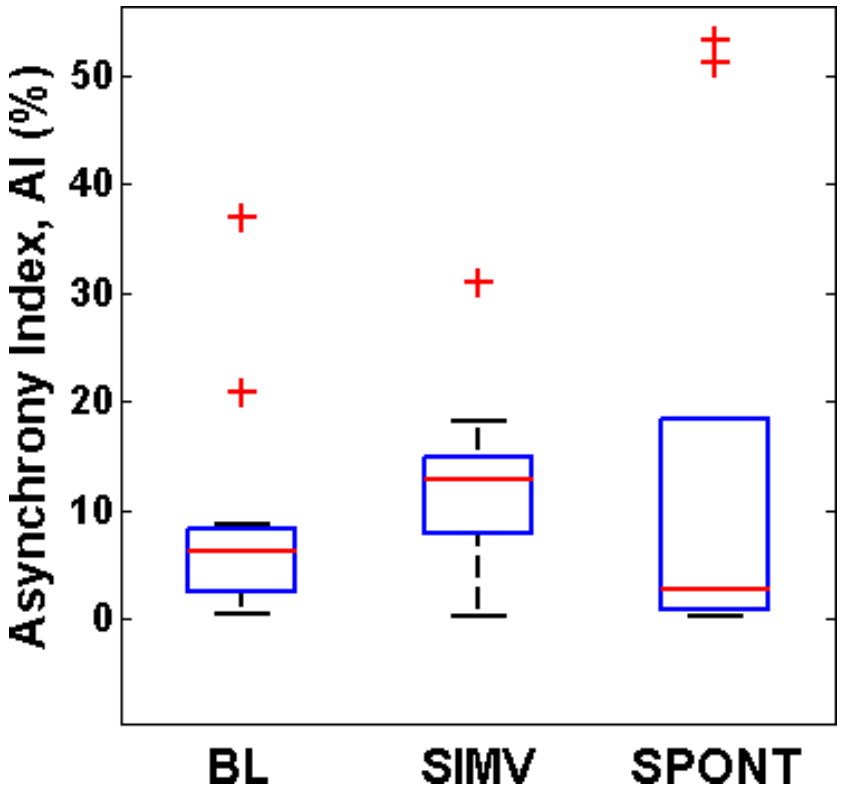

- Asynchrony index is for all 14 patients in different ventilation mode is median 5.00 [IQR: 0.45- 12.20]

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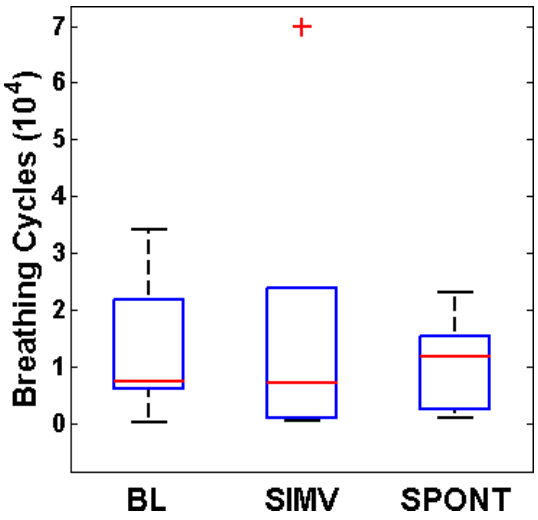

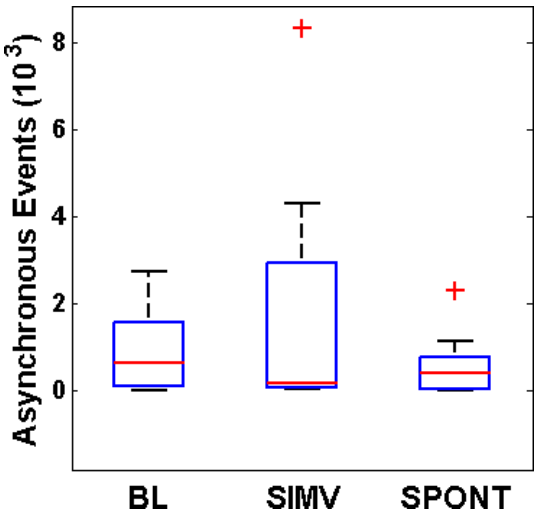

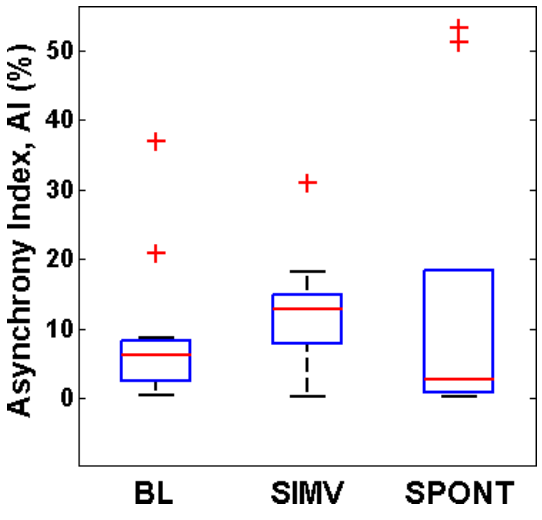

- This study focused on investigating the method to detect asynchrony event in real time.
- Not comparing which mode is better.

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Future Work

- The $AUCE_{drs}$ only focused on Asynchrony events that happens during inspiration and not expiration
- Observational study and no specific protocol, leading to variability in results reporting
- Classification of Asynchronous events
- Finding the optimal threshold
  - Sensitivity Testing
  - Receiver Operation Curve (ROC)

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Conclusions

- An automated asynchrony detection method is developed.
- It can be used to calculate asynchrony index in real time in both controlled or partial ventilation mode
- The AI can be used to assess the quality of patient-ventilator interaction.
- Providing opportunity to provide better ventilation care.

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Acknowledgement

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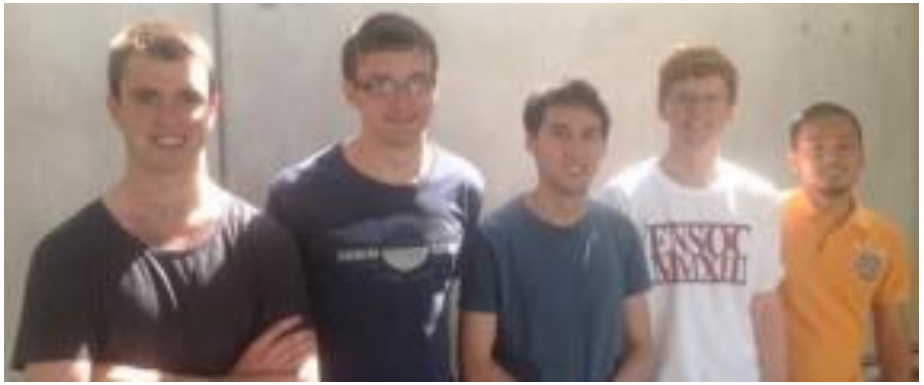
- Intensive Care Unit, Christchurch Hospital, New Zealand



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Acknowledgement

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Thank you

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