Identifying and resolving ventilator asynchronies

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Disclosure

✓ I am the Clinical Operations Manager for Hamilton Medical Inc.
Objectives

✓ Define Synchrony & Asynchrony
✓ Discuss the Equation of Motion
✓ Discuss Independent Vs. Dependent Variables
✓ Identify and Resolve Asynchronies utilizing ventilator graphics

Interactive Poll

✓ Text
  ✓ DAVIDGROOM805 to 22333

✓ Choose your answer and text A, B, C, or D to this thread.
1. What is happening here?

Options:

A. Double Trigger
B. Flow Starvation
C. Delayed Cycle
D. Reverse Triggering
E. I have no idea!
2. What is happening here?

A. Delayed Cycling
B. Early Cycling
C. Increased Inspiratory Effort
D. Flow Starvation
E. I have no freaking idea!

3. What is happening here?

A. Autotrigger
B. Patient Initiated Breath
C. Machine Initiated Breath
D. Reverse Trigger
E. I still have no stinking idea!!
Synchrony vs. Asynchrony

Synchrony Vs. Asynchrony

- **Synchrony**
  - “Simultaneous Occurrence”
  - “Harmonious interaction between ventilator and patients respiratory system”

- **Asynchrony**
  - “Absence or lack of concurrence in time”
  - “A lack of synchronization”
Synchrony

Asynchrony

Equation of Motion
Equation of Motion

✓ Passive
  ✓ $P_{AW} = P_{EEP_{TOT}} + P_{EL} + P_{RAW}$
  ✓ $P_{AW} = P_{EEP_{TOT}} + \left(\frac{V_{t}}{C_{stat}}\right) + (flow \times Raw)$
  ✓ $P_{AW} - P_{EEP_{TOT}} = \left(\frac{V_{t}}{C_{stat}}\right) + (flow \times Raw)$

✓ Active
  ✓ $P_{AW} + (P_{MUS} - P_{EEP_{TOT}}) = \left(\frac{V_{t}}{C_{stat}}\right) + (flow \times Raw)$

Independent Vs. Dependent Variables
Independent Vs. Dependent Variables

- **Independent Variable**
  - What you set/fix
  - Does not change

- **Dependent Variable**
  - Is not set/fixed
  - Changes (Response to the control)

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Independent vs. Dependent Variables

<table>
<thead>
<tr>
<th>Mode</th>
<th>Independent Variable</th>
<th>Dependent Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-CMV</td>
<td></td>
<td></td>
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<tr>
<td>P-CMV</td>
<td></td>
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<tr>
<td>Spontaneous (PSV)</td>
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</tbody>
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Independent vs. Dependent Variables

<table>
<thead>
<tr>
<th>Mode</th>
<th>Less Flexibility</th>
<th>More Flexibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Independent Variable</td>
<td>Volume Flow I-time</td>
<td>Pressure</td>
</tr>
<tr>
<td>Dependent Variable</td>
<td>Pressure</td>
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</table>

Servo-regulation

- Efferent
- Afferent
- Corollary discharges
- Pulmonary receptors, Chemoreceptors
- Motor cortex
- Sensory cortex
- Respiratory muscle
- Diminished response to request to increase tidal volume
- Message to ventilatory muscles to increase tidal volume
Asynchrony Classification & Learning Approach

- Trigger Asynchrony
- Flow Asynchrony
- Termination Asynchrony

Approach to understand
- Asynchrony title
- Asynchrony example
  - Basic
  - Advanced
- Asynchrony Causes
- Resolutions

Triggering Asynchrony
Delayed triggering

- Delay in reaching trigger threshold
- Inspiratory Flow occurs too long after trigger signal

Leung. AJRCCM. 1997
Delayed triggering (Basic)

0.3 sec delay

Extended time between positive deflection in flow (1) and delivery of support (2)

Delayed Triggering - Flow waveform

✓ Flow Waveform

✓ Extended time between positive deflection in flow (1) and delivery of support (2)
Delayed Trigger (Advanced)
Delayed Trigger - Possible Causes

- Too much inspiratory support
- Trigger sensitivity too high
- Ventilator Pneumatics
- AutoPEEP
- Weak respiratory drive
- Poor effort

Leung. AJRCCM. 1997

Delayed Trigger - Resolution

- Reduce level of inspiratory support
- Adjust trigger sensitivity
- Ventilator tubing/ remove restrictions
- Reduce autoPEEP

Leung. AJRCCM. 1997
Ineffective Effort

✓ Inspiratory effort does not trigger a mechanical breath

Vignaux. ICM. 2006

Ineffective Effort (Basic)
Ineffective Effort (Basic)

✓ Flow waveform
✓ Look for an abrupt change in the steepness of the waveform (1) not followed by delivery of ventilator support.
Ineffective Effort- Possible Causes

- Presence of AutoPEEP
- Trigger threshold set too high
- Pressure support too high
- Set frequency and/or inspiratory time too high (in controlled modes)
- Tidal volume set too high
- Low respiratory drive
- Weak inspiratory effort
- Sedation

Ineffective Effort- Resolution

- Minimize AutoPEEP
- Increase PEEP
- Adjust trigger to be more sensitive
- Reduce support
- Other- reduce sedation, increase patient strength
Double Triggering (Multiple Triggering)

- Two or more patient triggered breaths separated by minimal expiratory flow
- Mismatch of “machine” and “neural I-time”

Vignaux. ICM. 2006
Double Triggering - (Basic)

✓ Flow waveform
  ✓ Two assisted breaths without expiration between them or with an expiration interval of less than half of the mean inspiratory time
Double Triggering- Possible Causes

 ✓ I-time too short (VC & PC)
 ✓ Cycling criteria (ETS) set too high (PS)
 ✓ Insufficient support

Double Triggering- Resolution

 ✓ Lengthen I-time
 ✓ Adjust ETS
 ✓ Increase inspiratory support
Autotriggering

✓ A mechanical breath delivered without an inspiratory effort

Vignaux. ICM. 2006

Autotriggering (Basic)

✓ Pressure waveform
✓ Delivered breath showing no drop in airway pressure (1) at beginning of inspiratory phase
Autotriggering (Advanced)

Autotriggering- Possible Causes

- Trigger Sensitivity too low
- Leaks
- Oscillations in the tubing-secretions, water, cardiac
Autotriggering- Resolutions

- Adjust Sensitivity
- Resolve leak
- Clear environment causing autotrigger (secretions/water)

Flow Asynchrony
Flow Asynchrony

✓ The delivered flow does not meet the patient’s inspiratory flow demands potentially resulting in decreasing airway pressure

Flow Asynchrony

✓ Pressure waveform
  ✓ Upward concavity (1) preceding the end of the mechanical breath
Flow Asynchrony (Basic)

- Pressure waveform
  - Upward concavity (1) preceding the end of the mechanical breath

Flow Starvation (Advanced)

- Airway pressure during inspiration decreases to zero or below (lack of assistance)
Flow Asynchrony - Possible Causes

☑ Inappropriate selection of ventilation mode
☑ High inspiratory effort
☑ In volume-controlled modes:
  ☑ Inappropriate flow settings
  ☑ Decreased tidal volume
  ☑ I-time too long

☑ In pressure-controlled modes:
  ☑ Inappropriate P-ramp settings
  ☑ Decreased PC
  ☑ I-time too short

Flow Asynchrony - Resolutions

☑ Select a more appropriate mode - Variable flow mode
☑ Increase flow or Vt
Termination asynchronies

Early Cycling

- Neural inspiratory time longer than set inspiratory time
- Termination of inspiratory phase before relaxation of respiratory muscles.

Vignaux. ICM. 2006
Early Cycling (Basic)

- Flow waveform
  - Small bump at the beginning of expiration (1) (after peak expiratory flow) followed by an abrupt initial reversal in the expiratory flow (2)
Early Cycling - Possible Causes

In pressure support ventilation:
- ✓ Cycling criteria (ETS) set too high
- ✓ Low levels of ventilator pressure support
- ✓ Patient time constant too short

In time-cycled ventilation:
- ✓ Short inspiratory time setting

Early Cycling - Resolution

In pressure support ventilation:
- ✓ Lower the Cycling criteria (ETS)
- ✓ Increase ventilator pressure support

In time-cycled ventilation:
- ✓ Increase inspiratory time setting
Delayed Cycling

☐ Failure of breath to terminate in proportion to neural-I time.

Vignaux. ICM. 2006
Delayed Cycling (Advanced)

Delayed Cycling

Flow waveform: look for a change in the slope of the inspiratory flow:

✓ A fast decrease (1) followed by an exponential (less steep) decline (2)
Delayed Cycling- Possible Causes

✓ In pressure support ventilation:
  ✓ Cycling criteria (ETS) set too low
  ✓ Pressure support too high
  ✓ P-ramp too long

✓ In pressure control ventilation:
  ✓ I-time too long

✓ In volume control ventilation:
  ✓ Low flow
  ✓ Inspiratory time too long
  ✓ High tidal volume

Delayed Cycling- Resolutions

In pressure support ventilation:
✓ Raise Cycling criteria (ETS)
✓ Reduce Pressure support
✓ Reduce P-ramp

In pressure control ventilation:
✓ Raise cycling criteria (ETS) to shorten i-time

In volume control ventilation:
✓ Increase flow
✓ Decrease inspiratory time
✓ Reduce Vt
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Delayed Trigger

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Summary

✓ Dysynchronies/Asynchronies are common
✓ Ineffective effort and double trigger most common
✓ Usually a result of Ventilator/Neural I-time mismatching
✓ \HMI Asynchrony Reference Card 2019.pdf
Thank you for your attention!

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