Mechanisms of Patient-Ventilator Dyssynchrony

Laurent Brochard
Toronto
Conflicts of interest

• Our clinical research laboratory has received equipment or research grants for clinical research projects from the following companies:
  – Covidien (PAV+)
  – Air Liquide (CPR)
  – Sentec (tcPCO2)
  – Philips (Sleep)
  – Fisher Paykel (Optiflow)
ICU ventilators...
...ICU ventilators

- Medtronic
- PB
- Hamilton
- Avea
- Engström
- Draeger
- Maquet Getinge
- Air Liquide
Good Synchrony: Paw follows Pes
Arnaud W. Thille
Pablo Rodriguez
Belen Cabello
François Lellouche
Laurent Brochard

Patient-ventilator asynchrony during assisted mechanical ventilation

Lluís Blanch
Ana Villagra
Bernat Sales
Jaume Montanya
Umberto Lucangelo
Manel Luján
Oscar García-Esquiro

Asynchronies during mechanical ventilation are associated with mortality

Clusters of ineffective efforts during mechanical ventilation: impact on outcome

Katerina Vaporidi¹, Dimitris Babalis¹, Achilleas Chytas²,³, Emmanuel Lilitsis¹, Eumorfia Kondili¹, Vasilis Amargianitakis¹, Ioanna Chouvarda²,³, Nicos Maglaveras²,³ and Dimitris Georgopoulos¹
Clinical consequences of asynchronies

• 1) Excessive or insufficient ventilatory assistance
• 2) Dynamic hyperinflation
• 3) Sedation
• 4) Sleep fragmentation
• 5) Errors in assessing weaning readiness
• 6) Prolonged duration of ventilation
• 7) Respiratory sequelae...
Pes during controlled ventilation Vs. spontaneous breathing
From Murias G... Blanch L
Crit Care 2016

From Younes M, Brochard L...
ICM 2007
Assistance in excess

- Auto-triggering
- Apneas
- Ineffective Efforts or Missed Cycles
When to suspect auto-triggering?

**During controlled ventilation:**
- RR > adjusted RR
- Respiratory alkalosis

**During assisted ventilation:**
- Sudden increase or persistently high respiratory rate
- Absence of an airway pressure drop at beginning of the cycle
- PSV: short cycle with a flow signal distortion
- ACV: abrupt airway pressure increase
Both High Level Pressure Support Ventilation and Controlled Mechanical Ventilation Induce Diaphragm Dysfunction and Atrophy

Matthew B. Hudson¹, Ashley J. Smuder¹, W. Bradley Nelson¹, Christian S. Bruells², Sanford Levine³, and Scott K. Powers¹

Accuracy of Invasive and Noninvasive Parameters for Diagnosing Ventilatory Overassistance During Pressure Support Ventilation

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Bedside Detection of Overassistance During Pressure Support Ventilation*

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*Bedside detection of overassistance during pressure support ventilation:
- Respiratory rate less than or equal to 12 confirms with 100% specificity, whereas a respiratory rate equal to 30 excluded overassistance with 100%

STUDY LIMITATIONS
- One limitation of the study is the definition of overassistance. As they discuss it, an ideal definition should be clinical outcomes like mortality, duration of ventilation, and hospital length of stay or on dire diaphragm atrophy as a surrogate. They based
Pressure support ventilation
Pressure support ventilation
Wasted Effort: Ineffective breath

Esophageal Pressure (cmH$_2$O)

Airway Pressure (cmH$_2$O)

Flow (L/s)

Pressure drop
Flow increase
Time (s)

Intrinsic PEEP

Start of patient’s effort

Start of ventilator insufflation
Reduction of patient-ventilator asynchrony by reducing tidal volume during pressure-support ventilation.
Asynchrony Index (%)

Baseline PS-PEEP
Optimal PS

Thille et al., Intensive Care Med 2008
Insufficient Assistance

- Air hunger or flow starvation
- Double triggering, breath stacking and short cycles
Ventilation assistée-contrôlée
Ventilation assistée-contrôlée
Ventilation assistée-contrôlée
**Under Assistance**

Airway Pressure (cmH$_2$O)

Flow (L/min)

Double Triggering

Beginning of patient's effort

End of patient's effort

Continuation of patient’s effort

Under Assistance
**Under Assistance**

Airway Pressure (cmH\(_2\)O)

Flow (L/min)

Esophageal Pressure (cmH\(_2\)O)

**Beginning of patient’s effort**

**End of patient’s effort**

**Continuation of patient’s effort**

**Double Triggering**

**Under Assistance**

A

B
Effect of Lung Recruitment and Titrated Positive End-Expiratory Pressure (PEEP) vs Low PEEP on Mortality in Patients With Acute Respiratory Distress Syndrome
A Randomized Clinical Trial

Writing Group for the Alveolar Recruitment for Acute Respiratory Distress Syndrome Trial (ART) Investigators
Excessive Sedation?

• Respiratory Entrainement or Reverse Triggering
Accidental observation...
Respiratory Entrainment

Flow (L/sec)

Paw (cm H$_2$O)

EAdi (µV)

Akoumianaki E et al Chest 2012
Mechanical Ventilation-Induced Reverse-Triggered Breaths

A Frequently Unrecognized Form of Neuromechanical Coupling

Evangelia Akoumianaki, MD; Aissam Lyazidi, PhD; Nathalie Rey, MD; Dimitrios Matamis, MD; Nelly Perez-Martinez, MD; Raphael Giraud, MD; Jordi Mancebo, MD; Laurent Brochard, MD; and Jean-Christophe Marie Richard, MD, PhD
Clinical consequences: VT increase
Clinical consequences: **double cycle**

- **Flow (L/sec)**
- **Paw (cm H₂O)**
- **Pes (cm H₂O)**
Reverse triggering dyssynchrony 24 hours after initiation of mechanical ventilation
Ricard Mellado Artigas, L. Felipe Damiani, Thomas Piraino, ...Laurent Brochard
In revision

40% (1 μV) or 26% (3 μV) patients have > 10% RT
<table>
<thead>
<tr>
<th>Variable</th>
<th>RT&gt;8%</th>
<th>RT≤8%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median Peak Eadi, µV</td>
<td>1.7 (0.8-4.3)</td>
<td>0.7 (0.7-0.8)***</td>
</tr>
<tr>
<td>Patient-triggered breaths over the 1 hour recording, %</td>
<td>12 (8-26)</td>
<td>1 (0-3)***</td>
</tr>
<tr>
<td>Assisted mode/extubation within 24h</td>
<td><strong>13 (68)</strong></td>
<td>7 (35)*</td>
</tr>
</tbody>
</table>
ACV

Double triggering

Flow (L/s)

Airway Pressure (cmH₂O)

8 s

Time (s)
Reverse Triggering
May 15, 2019 | 3

Reverse triggering is a type of dyssynchrony that occurs when a patient effort occurs after (is triggered by) the initiation of a ventilator (non-patient triggered) breath. Usually, it is a phenomenon occurring over many consecutive breaths and also referred to as 'entrainment'.

Diagnosis The visual detecting of reverse triggering is slightly different between modes of...

Read More

Name this Asynchrony 4
May 7, 2019 | 5

Paw

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