Reverse triggering

Laurent Brochard
Conflicts of interest

• Our clinical research laboratory has received research grants for clinical trials from the following companies
  – Covidien (PAV+)
  – Dräger (SmartCare)
  – General Electric (FRC)
  – Respironics (NIV)
  – Fisher Paykel (Optiflow)
  – Vygon (CPAP)
What we know

‘in assist ventilatory modes patient efforts trigger the ventilator’
Can the ventilator also trigger the diaphragm???
Entrainment of Respiration in Humans by Periodic Lung Inflations
Effect of State and CO₂

PEGGY M. SIMON, ADEL S. ZUROB, WILLIBALD M. WIES, J. C. LEITER, and ROLF D. HUBMAYR
with the Technical Assistance of MERILYN L. JENSEN and RANDOLPH W. STROETZ

16 out of 53 healthy subjects
Accidental observation...
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
Materials and methods

- **Aim**: identification of entrainment phenomena and their characteristics in ICU patients

- **Study**: retrospective, observational

- **Setting**: medico-surgical adult ICU

- **Duration**: 3 months

- **Population**: 8 consecutive intubated and ventilated patients with recordings of esophageal pressure or diaphragm activity

- **Method**: analysis of all available recordings of $V'$, Paw, Pes or EAdi
# Results

<table>
<thead>
<tr>
<th>PT</th>
<th>Age</th>
<th>Sex</th>
<th>Diagnosis</th>
<th>RASS</th>
<th>Entrainment (s) (% of recording time)</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>73</td>
<td>F</td>
<td>ARDS-pneumonia</td>
<td>-5</td>
<td>407 (46%)</td>
</tr>
<tr>
<td>02</td>
<td>68</td>
<td>M</td>
<td>ARDS-sepsis</td>
<td>-5</td>
<td>58 (13%)</td>
</tr>
<tr>
<td>03</td>
<td>41</td>
<td>M</td>
<td>ARDS-sepsis</td>
<td>-4</td>
<td>184 (39%)</td>
</tr>
<tr>
<td>04</td>
<td>65</td>
<td>M</td>
<td>ARDS-sepsis</td>
<td>-5</td>
<td>1421 (86%)</td>
</tr>
<tr>
<td>05</td>
<td>61</td>
<td>F</td>
<td>ARDS-SIRS</td>
<td>-5</td>
<td>683 (44%)</td>
</tr>
<tr>
<td>06</td>
<td>34</td>
<td>M</td>
<td>ARDS-pneumonia</td>
<td>-4</td>
<td>619 (100%)</td>
</tr>
<tr>
<td>07</td>
<td>25</td>
<td>M</td>
<td>ARDS-polytrauma</td>
<td>-4</td>
<td>43 (12%)</td>
</tr>
<tr>
<td>08</td>
<td>43</td>
<td>M</td>
<td>ARDS-pneumonia</td>
<td>-5</td>
<td>246 (19%)</td>
</tr>
</tbody>
</table>
## Results – Measures

<table>
<thead>
<tr>
<th>Pt</th>
<th>RASS</th>
<th>Recording time (s)</th>
<th>Entrainment (s) (% of recording time)</th>
<th>Ratio (%)</th>
<th>PaO₂ (mmHg)</th>
<th>PaCO₂ (mmHg)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>-5</td>
<td>875</td>
<td>407 (46%)</td>
<td>27</td>
<td>66</td>
<td>7</td>
<td>60</td>
</tr>
<tr>
<td>02</td>
<td>-5</td>
<td>439</td>
<td>58 (13%)</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>55</td>
</tr>
<tr>
<td>03</td>
<td>-4</td>
<td>467</td>
<td>184 (39%)</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>86</td>
</tr>
<tr>
<td>04</td>
<td>-5</td>
<td>1658</td>
<td>1421 (86%)</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>68</td>
</tr>
<tr>
<td>05</td>
<td>-5</td>
<td>1538</td>
<td>683 (44%)</td>
<td>97</td>
<td>3</td>
<td>0</td>
<td>92</td>
</tr>
<tr>
<td>06</td>
<td>-4</td>
<td>619</td>
<td>619 (100%)</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>74</td>
</tr>
<tr>
<td>07</td>
<td>-4</td>
<td>365</td>
<td>43 (12%)</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>78</td>
</tr>
<tr>
<td>08</td>
<td>-5</td>
<td>1295</td>
<td>246 (19%)</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>63</td>
</tr>
</tbody>
</table>

Heavily sedated
Entrainment ratios

Flow

Paw

EAdi

1:1

1:2
Description
Measurement of the phase angle

Figure 1
Coefficients of variation for cycle duration

![Box plot showing CV for different conditions](image)
Clinical consequences: VT increase
Pplat unreliable

1:1

1:2
Clinical consequences: **double cycle**
Unresolved Issues

- Incidence in the general ICU population?
- Exact mechanism?
- Impact of ventilator settings, sedation, chemical influences
- Reverse triggering occurrence: bad or good?
Conclusions

- First description of a special form of neuro-mechanical coupling in ICU patients under controlled MV
- Observed in ALL consecutive ARDS patients assessed
- Responsible for increase in set VT and erroneous Pplat
- Consequences on diaphragm need to be explored