Spontaneous Breathing during HFOV

M. van Heerde, MD PhD
Pediatric Intensive Care
Spontaneous breathing during MV

WHAT IS THE ISSUE?
Long-Term Effects of Spontaneous Breathing During Ventilatory Support in Patients with Acute Lung Injury

CHRISTIAN PUTENSEN, SABINE ZECH, HERMANN WORIGGE, JÖRG ZINSSLING, FRANK STÜBER, TILMANN VON SPIEGEL, and NORBERT MUTZ

✓ 30 patients multiple trauma, ALI/ARDS, 1\textsuperscript{st} 72 h:

✓ APRV (spontaneous breathing) vs. PCV (paralyzed)

<table>
<thead>
<tr>
<th>TABLE 2. OUTCOME DATA*</th>
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</thead>
<tbody>
<tr>
<td></td>
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<tr>
<td>Length of ventilatory support, d</td>
</tr>
<tr>
<td>Length of intubation, d</td>
</tr>
<tr>
<td>Length of ICU stay, d</td>
</tr>
</tbody>
</table>
You Can’t Ignore Physics

GRAVITY, THE BELLY, AND THE DIAPHRAGM

Alison B. Froese
Effects of Anesthesia and Paralysis on Diaphragmatic Mechanics in Man

Alison B. Froese, M.D., and A. Charles Bryan, M.D., Ph.D., F.R.C.P.(C)†
Diaphragm & Recruitment

Transpulmonary Pressure
Weaning from MV

VENTILATOR-INDUCED RESPIRATORY MUSCLE WEAKNESS
Rapid Disuse Atrophy of Diaphragm Fibers in Mechanically Ventilated Humans

Sanford Levine, M.D., Taitan Nguyen, B.S.E., Nyali Taylor, M.D., M.P.H., Michael E. Friscia, M.D.,

✓ Case: brain-dead organ donors
✓ Duration of MV: 18 - 69 hours
Abnormalities of diaphragmatic muscle in neonates with ventilated lungs

A. S. Knisely, MD, Susana M. Leal, MD, and Don B. Singer, MD

Ventilation-induced diaphragmatic atrophy: MV

> 12 days

< 7 days
Back to the Future?

PARALYSIS IN (ALI)/ARDS
Neuromuscular Blockers in Early Acute Respiratory Distress Syndrome

Laurent Papazian, M.D., Ph.D., Jean-Marie Forel, M.D., Arnaud Gacouin, M.D., Christine Penot-Ragon, Pharm.D., Gilles Perrin, M.D., Anderson Loundou, Ph.D., Samir Jaber, M.D., Ph.D., Jean-Michel Arnal, M.D., Didier Perez, M.D., Jean-Marie Sehboyan, M.D., Jean-Michel Constantin, M.D., Ph.D., Pierre Courant, M.D., Jean-Yves Lefrant, M.D., Ph.D., Claude Guérin, M.D., Ph.D., Gwenaël Prat, M.D., Sophie Morange, M.D., and Antoine Roch, M.D., Ph.D., for the ACURASYS Study Investigators

Paralyzed
- Benefit mortality: \( \text{PaO}_2 / \text{FiO}_2 < 120 \)
- Less airleaks

Not paralyzed
- Dyssynchrony
- Breath stacking

48 hours
\( \text{PaO}_2 / \text{FiO}_2 < 150 \)

Figure 2. Probability of Survival through Day 90, According to Study Group.
Neuromuscular Blocking Agents in ARDS

Arthur S. Slutsky, M.D.

Editorial
The Theory of Minimal Work

MECHANICS OF BREATHING IN MAN
Theory of Minimal Work:

Example
✓ Alveolar ventilation 6 l
✓ Dead space 0,2 l

Optimal breath rate and tidal volume: Minimal work.
## Spontaneous breathing during MV

<table>
<thead>
<tr>
<th>Positive</th>
<th>Negative/Concerns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active diaphragm</td>
<td>Less control $V_T$</td>
</tr>
<tr>
<td>✓ Aeration</td>
<td>Dyssynchrony</td>
</tr>
<tr>
<td>✓ Muscle weakness</td>
<td>Active expiration</td>
</tr>
<tr>
<td>Less sedation</td>
<td>Paralysis beneficial severe ARDS ($\text{PaO}_2/\text{FiO}_2 &lt; 120$)</td>
</tr>
<tr>
<td>Shorter duration</td>
<td></td>
</tr>
<tr>
<td>✓ Mechanical ventilation</td>
<td></td>
</tr>
<tr>
<td>✓ ICU stay</td>
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</tbody>
</table>
Equipment Issues

SPONTANEOUS BREATHING DURING HFOV
HFO ventilation

✓ Optimal (Theory)

✓ Spontaneous breathing:
  • not necessary for gas exchange
  • beneficial
HFOV Equipment

Continuous (low) flow CPAP system, with an expiratory balloon valve
HFOV & imposed Work of Breathing

ET-tube

Circuit

Bias flow rate

Expiratory balloon valve

Trigger?
CPAP & imposed Work of Breathing

Solutions
1. Continuous high flow CPAP
2. Demand flow
3. (Balloon reservoir)
HFOV & Spontaneous Breathing

newborn
HFOV & Spontaneous Breathing

- High imposed work of breathing
- Interferes with ventilator function
- Cause: fixed (low) fresh gas flow rate

van Heerde 2006
Solution: Demand Flow
Demand flow facilitates spontaneous breathing during high-frequency oscillatory ventilation in a pig model

Marc van Heerde, MD; Karel Roubik, MS, PhD; Vit Kopelet, MS, PhD; Frans B. Plötz, MD, PhD; Dick G. Markhorst, MD, PhD
Spontaneous breathing during high-frequency oscillatory ventilation improves regional lung characteristics in experimental lung injury

M. van Heerde¹, K. Rouhek², V. Koepelent³, M. C. J. Kneyber¹,² and D. G. Markhorst³

Electrical Impedance Tomography (EIT)
✓ Preservation lung volume
✓ Improves ventilation dependent lung
✓ No regional hyperinflation
✓ More homogeneous distribution aeration
What Should We Do?

THERE IS NO COMMERCIALLY AVAILABLE SENSORMEDICS WITH DEMAND FLOW
Newborns & Infants

Spontaneous breathing during HFOV

✓ Well tolerated
✓ Continuous bias flow meets demand
✓ Synchronization no issue
✓ Avoid forceful respirations
Larger children & Adults

Spontaneous breathing during HFOV

✓ Sometimes difficult
✓ Continuous bias flow may not meet demand
✓ Synchronization no issue
✓ Avoid forceful respirations
Consider the Bias Flow Rate

van Heerde 2006
Bias flow does not affect ventilation during high-frequency oscillatory ventilation in a pediatric animal model of acute lung injury

David A. Turner, MD; David F. Adams, MD; Michael A. Gentile, RRT; Lee Williford, RRT; George A. Quick; P. Brian Smith, MD, MPH; Ira M. Cheifetz, MD, FCCM
Consider the Bias Flow Rate

van Heerde 2006
Consider the Bias Flow Rate

van Heerde 2006
Conclusions

✓ Spontaneous breathing during HFOV is beneficial

✓ At all costs? No