ARDS & TBI - Trading Off Ventilation Targets

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Conflict of interest

- Principal Investigator: RINO trial
  - Nasal high-flow vs Venturi mask after extubation
  - NCT02107183
  - Sponsored by Fisher & Paykel
- Received research grants from Fisher & Paykel and lecture fees from Draeger
ARDS in brain-injured patients: incidence

Development of ARDS in neurological pts:
- 19% in pts with GCS <=8 vs 9% in pts with GCS >8
- 24% in nonsurvivors vs 11% in survivors
- independently associated with a higher risk of death

ARDS in brain-injured patients: risk factors

• 192 pts with primary neurologic disorder and MV>48 h
• 35% developed ALI/ARDS
• Independent risk factors: pneumonia, shock and absence of gag or cough reflex
Protective lung approach in ARDS
Protective ventilatory approach for all

Ventilator-associated lung injury in patients without acute lung injury at the onset of mechanical ventilation

Ognjen Gajic, MD; Saqib I. Dara, MD; Jose L. Mendez, MD; Adebola O. Adesanya, MD; Emir Festic, MD; Sean M. Caples, MD; Rimki Rana, MD; Jennifer L. St. Sauver, PhD; James F. Lymp, PhD; Bekele Afessa, MD; Rolf D. Hubmayr, MD

Association Between Use of Lung-Protective Ventilation With Lower Tidal Volumes and Clinical Outcomes Among Patients Without Acute Respiratory Distress Syndrome: A Meta-analysis

6.5 ml/kg PEEP 6.4 vs 10.6 ml/kg PEEP 3.4

Gajic O et al. CCM 2004;32:1817-24

Serpa Neto A et al. JAMA 2012;308:1651-9
Protective ventilation: feasible in brain-injured pts?

The New England Journal of Medicine

VENTILATION WITH LOWER TIDAL VOLUMES AS COMPARED WITH TRADITIONAL TIDAL VOLUMES FOR ACUTE LUNG INJURY AND THE ACUTE RESPIRATORY DISTRESS SYNDROME

of 18 mm Hg or less. Patients were excluded if 36 hours had elapsed since they met the first three criteria; they were younger than 18 years of age; they had participated in other trials within 30 days before the first three criteria were met; they were pregnant; they had increased intracranial pressure, neuromuscular disease that could impair spontaneous breathing, sickle cell disease, or severe chronic respiratory disease; they weighed more than 1 kg per centimeter of height; they had burns over more than 30 percent of their body-surface area; they had other conditions with an estimated 6-month mortality rate of more than 50 percent; they had undergone bone marrow or lung transplantation; they had chronic liver disease (as defined by Child–Pugh class C); or their attending physician refused or was unwilling to agree to the use of full life support.

ARMA study, NEJM 2000

ALVEOLI study, NEJM 2004
Competing priorities in the management of neurological patients with ARDS

**ACUTE BRAIN INJURY**
(prevention of secondary injury)

- Tight CO2 control & O2 target
- Low PEEP

**ARDS**
(prevention of VILI)

- Low VT-pressure Ventilation
- Moderate-to-high PEEP
Brain injury exacerbates lung injury

AICH induces lung injury and also exacerbates preexisting damage.

Brain-lung crosstalk: a dangerous interaction

Mazzeo AT et al, Minerva Anestesiol 2013;79:299–309
Current ventilation practices in brain-injured pts

- Secondary analysis of a prospective observational study on MV
- 552 pts with acute cerebral injury undergoing MV
- Control group of 4030 mixed pts ventilated for non-neurologic reasons

In neurological patients:

Same tidal volume

Lower PEEP

Current ventilation practices in brain-injured pts with ARDS

Prospective observational study in 86 severely brain-injured pts (GCS<9), 22% developed ALI

- Brain-injured patients who developed ALI were initially ventilated with higher Vt/Kg (9.5±1 vs 10.4±1.1)
- High Vt was an independent predictor of ARDS

- After the onset of ALI/ARDS pts remained ventilated with high tidal volumes

Mascia L et al, Crit Care Med 2007;35:1815-20
High VT, a risk factor for ARDS & mortality

High Vt (>8ml/kg) was a risk factor for ARDS [HR 1.74 (1.08–2.81)] & hospital mortality [HR 2.52 (1.46–4.34)]
Decrease in deadspace for implementing low-VT ventilation in brain-injured patients with ARDS

Patients with severe brain injury (GCS<8) and ARDS < 24h

At the end of each step (45 min):
- arterial blood gases
- systemic hemodynamics
- respiratory parameters (Pplat, Crs, PV curve & deadspace)
- cerebral parameters (ICP, CPP, TCD of MCA)
Decreasing deadspace for lung protection in brain-injured patients with ARDS

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<th>IBW (kg)</th>
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<th>Causes of ALI</th>
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Mean: | 53 | 67 | 183 | 5.3 | 25.7 | 45.7 | 6   | 7.3 |
Decreasing deadspace for lung protection in brain-injured patients with ARDS
Decreasing deadspace for lung protection in brain-injured patients with ARDS
PEEP & cerebral hemodynamics

Effects of positive end-expiratory pressure on regional cerebral blood flow, intracranial pressure, and brain tissue oxygenation*

Elke Muench, MD; Christian Bauhuf, MD; Harry Roth, MD; Peter Horn, MD; Marc Phillips, MD; Natali Marquetant, MD; Michael Quintel, MD; Peter Vajkoczy, MD

MAP day 1

ICP day 1

PEEP & cerebral hemodynamics: role of recruitment

- 12 pts with severe brain injury & ALI, euvolemic
- Applied PEEP < ICP

<table>
<thead>
<tr>
<th></th>
<th>Recruited volume (ml)</th>
<th>Est.rs (cmH₂O/l)</th>
<th>PaO₂ (mmHg)</th>
<th>PaCO₂ (mmHg)</th>
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<td>PEEP 10</td>
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|                  | Non-Recruiters        |                  |             |              |
| Mean             |                       |                  |             |              |
|                  | PEEP 5                | 34***            | 28.2**      | 30           |
|                  | PEEP 10               | 46***            | 98          | 32.8*        |
|                  | ZEEP                  | 21.1             | 95          | 32.8*        |
|                  | PEEP 5                | 24*              | 93          | 34.6**       |
|                  | PEEP 10               | 4.1              | 10          | 34.6**       |
|                  | ZEEP                  | 4.2              | 7           | 2.3          |
|                  | PEEP 5                | 3.5              | 12          | 2.3          |
|                  | PEEP 10               | 4.2              | 10          | 2.3          |

In conclusion our data show that, in patients with ICP values higher than applied PEEP, effects of PEEP on cerebral hemodynamics depend on recruitment/hyperinflation of alveolar units and PaCO₂ variations may have major impact on brain perfusion.

Mascia L et al, Int Care Med 2005;31:373-79
PEEP & cerebral hemodynamics: role of lung compliance

Effects of PEEP on the Intracranial System of Patients With Head Injury and Subarachnoid Hemorrhage: The Role of Respiratory System Compliance

Anselmo Caricato, MD. Giorgio Conti, MD. Francesco Della Corte, MD. Aldo Mancino, MD.

- 21 pts with SAH or TBI: 13 with normal Crs (>45 ml/cmH2O), 8 with low Crs (<45 ml/cmH2O)
- 4 levels of PEEP applied in random order (0, 5, 8, 12 cmH2O)

PEEP has no significant effect on cerebral and systemic hemodynamics when respiratory system compliance is low

Caricato A et al, J Trauma 2005;58:571-76.
Other strategies for CO2 control in brain-injured pts

- Melcior MP et al, ICM 2004;30:2021-7
- Bein T et al, J Trauma 2005;58:1294-7

- Increased in lung hyperinflation
- Complications in 2 pts (40%)
- Retrospective analysis on 5 pts
- Hypercapnia eliminated
- ICP reduced
Conclusions

In brain-injured patients with ARDS:

• Use of a low-VT ventilation (6-8 ml/kg) is feasible and should be implemented.

• PEEP has an important role for assuring adequate oxygenation. Moderate-to-high levels of PEEP can be safely used provided that:
  – Adequate cerebral monitoring is in place
  – Euvolemia is ensured
  – PEEP is lower than ICP
  – Recruitment & overdistension are monitored