mechanical ventilation in patients with sepsis

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head of anaesthesia/intensive care med
Heidelberg ist eine Großstadt in Baden-Württemberg im Südwesten Deutschlands, unweit der Mündung des Neckars in den Rhein. [Wikipedia]

Bevölkerung: 150.335 (2013)
Fläche: 108,8 km²
Gegründet: 1196

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conflict of interest

consultant, travel expenses, lecture fees
What is your focus for a patient on the ventilator?

- Oxygenation
- CO$_2$ Elimination
- Lung protection
Best practice in mechanical ventilation?

- $V_T$: 6 ml/kg pbw for all patients?
  - NEJM 2000

- **PEEP**: ARDS network table based on Oxygenation?
  - NEJM 2000 or NEJM 2004

- **High PEEP**: for severe ARDS
  - JAMA 2010

- **Prone**: for severe ARDS
  - NEJM 2013

- **NMB**: for severe ARDS
  - NEJM 2010

- **No NIV** for severe ARDS
  - AJRCCM 2017
WHAT’S NEW IN INTENSIVE CARE

What’s new in mechanical ventilation in patients without ARDS: lessons from the ARDS literature

Ary Serpa Neto\textsuperscript{1,2,3} and Samir Jaber\textsuperscript{4*}

EDITORIAL

What’s new in ARDS: can we prevent it?

Roy G. Brower\textsuperscript{1} and Massimo Antonelli\textsuperscript{2*}
ARDS and Sepsis
ARDS and Sepsis
How often is ARDS in severe sepsis?
Fluids, Sepsis and ARDS

Fig. 2 Frequency of acute respiratory distress syndrome (ARDS) development according to amount of fluid administered during the first 6 h of hospital presentation.
Best practice in mechanical ventilation?

- $V_T$: 6 ml/kg pbw for all patients?
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Normalisation because of unknown size of the „baby“ lung

The NEW ENGLAND JOURNAL of MEDICINE

Driving Pressure and Survival in the Acute Respiratory Distress Syndrome

Marcelo B.P. Amato, M.D., Maureen O. Meade, M.D., Arthur S. Slutsky, M.D., Laurent Brochard, M.D., Eduardo L.V. Costa, M.D., David A. Schoenfeld, Ph.D., Thomas E. Stewart, M.D., Matthias Briel, M.D., Daniel Talmor, M.D., M.P.H., Alain Mercat, M.D., Jean-Christophe M. Richard, M.D., Carlos R.R. Carvalho, M.D., and Roy G. Brower, M.D.

Because respiratory-system compliance \( (C_{RS}) \) is strongly related to the volume of aerated remaining functional lung during disease (termed functional lung size), we hypothesized that driving pressure \( (\Delta P=V_T/C_{RS}) \), in which \( V_T \) is intrinsically normalized to functional lung size (instead of predicted lung size in healthy persons),

DOI: 10.1056/NEJMsa1410639
tidal volume should not longer be the target!
Oxygen Exposure Resulting in Arterial Oxygen Tensions Above the Protocol Goal Was Associated With Worse Clinical Outcomes in Acute Respiratory Distress Syndrome

Goal partial pressure of oxygen in arterial blood range of 55–80 mm Hg

$\text{f}_O^2$ of 0.5 = 0

Increasing deaths with higher oxygenation in all groups of ARDS severity
VENTILATION WITH LOWER TIDAL VOLUMES AS COMPARED WITH TRADITIONAL TIDAL VOLUMES FOR ACUTE LUNG INJURY AND THE ACUTE RESPIRATORY DISTRESS SYNDROME

The Acute Respiratory Distress Syndrome Network*
alveolar stability is unrelated to arterial oxygenation
Association Between Partial Pressure of Arterial Carbon Dioxide and Survival to Hospital Discharge Among Patients Diagnosed With Sepsis in the Emergency Department

- Odds Ratio to hospital discharge

- Rise in CO$_2$ of 1 mmHg with a 3% increase in odds of survival
The Rivers protocol

1. stratify according to severity
2. measure relevant parameter
3. individualize therapy
Personalizing mechanical ventilation according to physiologic parameters to stabilize alveoli and minimize ventilator induced lung injury (VILI)

Gary F. Nieman¹, Joshua Satalin¹, Penny Andrews², Hani Aiash¹, Nader M. Habashi³ and Louis A. Gatto⁴
1. End-expiratory lung volume (EELV) at a given PEEP

2. Transpulmonary pressure gradient

\[(P_{\text{plat}} - P_{\text{oes/El}}) - (\text{PEEP} - P_{\text{eos/EE}})\]
baby lung size $\approx$ EELV
Why oxygenation is not a good target

Kalenka et al, unpublished data
Tidal volume of 420 ml based on kg iBW at different FRC (EELV)

\[ \text{dynamic strain} = \frac{V_T}{\text{EELV}} \]
Dynamic strain = $\frac{V_T}{EELV}$

Aim for dynamic strain < 0.25
Assessing alveolar recruitment by EELV

Compliance = 30 ml/cmH2O
EELV = 1000 ml

No recruitment
EELV = 1300 ml

Expected EELV increase:
30 * 10 = 300 ml

PEEP = 0
PEEP = 10
Lung Stress and Strain during Mechanical Ventilation for Acute Respiratory Distress Syndrome

Davide Chiumello¹, Eleonora Carlesso², Paolo Cadrinher², Pietro Caironi¹,², Franco Valenza¹,², Federico Polli², Federica Tallerini², Paola Cozzi², Massimo Cressoni², Angelo Colombo¹, John J. Marini³, and Luciano Gattinoni¹,²

Strain: “the driving pressure“

\[ \frac{V_T}{EELV} \neq \frac{V_T}{ml/iKG} \]

Stress:

\[ P_{TP} \neq P_{AW} \]

\[ Stress = k \times Strain \]
\[ k = Specific\ Elastance\ (E_{L,s}) = \frac{Stress}{Strain} \]

Specific Elastance = 13 – 15 cmH₂O
Individualized titration of PEEP and $V_T$

$P_{pulm.} = P_{alv} - P_{pl} \sim P_{oes}$
optimize PEEP and $V_T$
with measurement of esophageal pressure and transpulmonary pressure gradient

1. $\text{PEEP} > \text{endexspiratory esophageal pressure}$

2. $V_{T_{\text{max}}} = \text{transpulmonary pressure gradient} < 10 \ (20)$

\[(P_{\text{plat}} - P_{\text{oes/El}}) - (\text{PEEP} - P_{\text{eos/EE}})\]
V_{T} and PEEP?

male
172 cm
86 kg
EF 20%
respiratory distress

high dose vasopressor
f_{i}O_{2} 0.9
s_{p}O_{2} 88 %
37

400/2000 = 0.2

400/1600 = 0.25
TPP = (35-26) - (20-18) = 9 - 2 = 7
SOP

EXPERTS’ OPINION

Friday night ventilation:
a safety starting tool kit for
mechanically ventilated patients

L. GATTINONI 1, 2, E. CARLESSO 2, L. BRAZZI 3, 4, M. CRESSONI 2
S. ROSSEAU 5, S. KLUGE 6, A. KALENKA 7, M. BACHMANN 8, L. TOEPFER 9
H. WRIGGE 10, F. REDAELLI 11, C. VETTER 12, M. WYSOCKI 13

„Friday night“ Minerva Anestesiologica 2014; 80: 1046
Set the ventilator:
- PEEP 10 cmH₂O
- I:E 1:1 or 1:2
- TV 6 ml/kg IBW
- RR 15 RPM,
- FiO₂ 0.6-0.8.

Control central venous blood gases and Lactate for hemodynamic status

Moderate Recruitment

decremental PEEP InView
Lung-Protective Ventilation Initiated in the Emergency Department (LOV-ED): A Quasi-Experimental, Before-After Trial

Initiate ED Ventilator Protocol

- Obtain accurate patient height
- After patient stabilized, use tape measure for height measurement
- Volutrauma
  - Set tidal volume = 6mL/kg PBW
  - Target 5 mL/kg PBW if possible ARDS
  - Range 6-8 mL/kg PBW if no ARDS
  - Use ARDSNet PBW tables
- Atelectrauma
  - Limit plateau pressure <30cm H₂O
  - In patients with stiff chest wall (e.g., obesity), can accept higher plateau
  - Set PEEP ≥ 5 cm H₂O
    - Estimated BMI >30, set PEEP to 8 cmH₂O
    - Estimated BMI >40, set PEEP to 10 cmH₂O
- Hyperoxia
  - Initiate F₂O₂ at 30-40 (not 1.0) after intubation
    - Titrate F₂O₂ for S₉O₂ 90-95% or P₁O₂ 55-60 mmHg
    - If hypoxic, use PEEP table for most appropriate F₂O₂-PEEP combo
- Ventilate appropriately
  - Set respiratory rate 20-30 breaths per minute
    - Monitor for iPEEP, as lower rates may be needed in these patients
- Aspiration precautions
  - Elevate head of bed > 30 degrees
    - Place naso- or oro-gastric tube

BILEVEL 34/18 mbar
VT 6.1 ml/kg
AF 18/min
FiO₂ 1.0
P/F 67 mmHg
PCO₂ 78 mmHg

BILEVEL 42/32 mbar
VT 5.7 ml/kg
AF 18/min
FiO₂ 0.4
P/F 244 mmHg
PCO₂ 38 mmHg
Résumé

It's a passion, not just a profession