UPV
v pronační poloze
- jak postupovat?

OA Dr. Stibor B.
ICU, Landesklinikum Baden bei Wien, Austria

no conflict of interest

OA Dr. Stibor B.

ICU, Landesklinikum Baden bei Wien, Austria

- Ashbaugh 1967

- Suter 1975

ARDS

PEEP

prone position

low V_t

- Guérin 2013

- ARDSnet 2000

HAMILTON MEDICAL
PCV+
Modi
60
7
39
Ppeak
cmH20
35
2.0
6.9
ExspMinVol
l/min
2400
50
343
VTE
ml
60
6
20
fTotal
bpm
1:1
I:E
Paw
cmH20
Ptrachea
Flow
l/min
20
bpm
Frequenz
22
cmH20
Pkontrol
16
cmH20
PEEP/CPAP
100
%
Sauerst.
Weiblich
166 cm
IBW: 58 kg
PCuff
0
cmH20
Rinsp
24
cmH2O/l/s
Cstat
18.9
ml/cmH2O
Oxygenierung
CO2-Elimin.
Spont./aktiv
Sauerst.
100
%
PEEP
16
cmH20
MinVol
6.9
l/min
Pinsp
22
cmH20
RSB

1/(l*min)
%fSpont
0
%
Parameter
Alarme
Monitoring
Grafiken
Tools
Ereignisse
System
2021-01-02
11:26:12
HAMILTON-C6 S

ESICM guidelines on acute respiratory distress syndrome: definition, phenotyping and respiratory support strategies

Check for updates

Abstract

The aim of these guidelines is to update the 2017 clinical practice guideline (CPG) of the European Society of Intensive Care Medicine (ESICM). The scope of this CPG is limited to adult patients and to non-pharmacological respiratory support strategies across different aspects of acute respiratory distress syndrome (ARDS), including ARDS due to coronavirus disease 2019 (COVID-19). These guidelines were formulated by an international panel of clinical experts, one methodologist and patients' representatives on behalf of the ESICM. The review was conducted in compliance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement recommendations. We followed the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach to assess the certainty of evidence and grade recommendations and the quality of reporting of each study based on the EQUATOR (Enhancing the QUAlity and Transparency Of health Research) network guidelines. The CPG addressed 21 questions and formulates 21 recommendations on the following domains: (1) definition; (2) phenotyping, and respiratory support strategies including (3) high-flow nasal cannula oxygen (HFNO); (4) non-invasive ventilation (NIV); (5) tidal volume setting; (6) positive end-expiratory pressure (PEEP) and recruitment maneuvers (RM); (7) prone positioning; (8) neuromuscular blockade, and (9) extracorporeal life support (ECLS). In addition, the CPG includes expert opinion on clinical practice and identifies the areas of future research.

Intensive Care Med (2023) 49:727–759

CONFERENCE REPORTS AND EXPERT PANEL

ESICM guidelines on acute respiratory distress syndrome: definition, phenotyping and respiratory support strategies

definition	phenotyping	HFNO
PEEP + RM	tidal volume setting	NIV
prone position	neuromuscular blockade	ECLS

PEEP

Domain 6: PEEP and recruitment maneuvers

Question 6.2: In patients with ARDS undergoing invasive mechanical ventilation, does *routine* PEEP titration based principally on respiratory mechanics compared to PEEP titration based principally on a standardized PEEP/FiO_2 table reduce mortality?

Recommendation 6.2

We are **unable to make a recommendation** for or against PEEP titration guided principally by respiratory mechanics, compared to PEEP titration based principally on PEEP/FiO_2 strategy, to reduce mortality in patients with ARDS.
No recommendation; high level of evidence of no effect.

This statement applies also to ARDS from COVID-19.
No recommendation; moderate level of evidence for indirectness.

low tidal volume

Table 1 Summary of studies comparing low vs high tidal volume ventilation

	Vt (ml/kg)		Paw Limit (cmH_2O)		Notes
	Interventional Arm	Control Arm	Interventional Arm	Control Arm	
Villar et al. [28]	5–8 PBW	9–11 PBW	PIP 35–40	PIP < 35–40	
Brochard et al. [95]	6–10 ABW	10–15 ABW	Pplat ≤ 25–30	PIP ≤ 60	
Amato et al. [96]	< 6 ABW	12 ABW	PIP < 40 and ΔP < 20	–	RM allowed – Explicit sedation protocol
Stewart et al. [97]	≤ 8 IBW	10–15 IBW	PIP ≤ 30	PIP ≤ 50	
Brower et al. [98]	5–8 PBW	10–12 PBW	Pplat < 30	Pplat < 45–55	
ARDS Net [99]	4–8 PBW	12 PBW	Pplat ≤ 30	Pplat ≤ 50	PP allowed – Explicit weaning protocol
Orme et al. [100]	4–8 PBW	10–15 PBW	Pplat < 40	Pplat < 70	Explicit sedation and weaning protocol

Vt Tidal Volume, *Paw* Airway Pressure, *PBW* Predicted Body Weight, *ABW* Adjusted Body Weight, *PIP* Peak airway pressure, *Pplat* Plateu airway pressure, *ΔP* Driving Pressure, *RM* Recruitment Manouver, *PP* Prone Positioning

Recommendation 5.1

We **recommend** the use of low tidal volume ventilation strategies (i.e., 4–8 ml/kg PBW), compared to larger tidal volumes (traditionally used to normalize blood gases), to reduce mortality in patients with ARDS not due to COVID-19.
Strong recommendation based on expert opinion despite lack of statistical significance; high level of evidence.

This recommendation applies also to ARDS from COVID-19.
Strong recommendation; moderate level of evidence for indirectness.

prone position

Domain 7: Prone positioning

Question 7.1: In intubated patients with ARDS, does prone position compared to supine position reduce mortality?

Recommendation 7.1

We **recommend** using prone position as compared to supine position for patients with moderate-severe ARDS (defined as $PaO_2/FiO_2 < 150$ mmHg and PEEP ≥ 5 cmH_2O, despite optimization of ventilation settings) to reduce mortality.
Strong recommendation, high level of evidence in favor.

This recommendation applies also to ARDS from COVID-19.
Strong recommendation; moderate level of evidence in favor for indirectness.

Domain 7: Prone positioning

Question 7.2: In patients with moderate-severe ARDS, when should prone positioning be started to reduce mortality?

Recommendation 7.2

We **recommend** starting prone position in patients with ARDS receiving invasive mechanical ventilation early after intubation, after a period of stabilization during which low tidal volume is applied and PEEP adjusted and at the end of which the PaO_2/FiO_2 remains < 150 mmHg; and proning should be applied for prolonged sessions (16 consecutive hours or more) to reduce mortality.
Strong recommendation; high level of evidence in favor.

This recommendation applies also to ARDS from COVID-19.
Strong recommendation; moderate level of evidence in favor for indirectness.


ventilation in prone position

ventilation in prone position

- the **gravitational gradient** of pleural pressure, regional end-expiratory and end-inspiratory lung volumes, regional ventilation and ventilation-perfusion ratios are all **more uniform** in the **prone** compared with the supine position

- the **inflation** of the pulmonary units is far more **homogeneous** in **prone** compared to supine

- the **forces** applied to distend the lungs (the trans-pulmonary pressure, i.e., the lung stress) are more **homogeneously** distributed

perfusion

in prone

position

perfusion in prone position

- **perfusion** distribution is **similar** in prone and supine positions
- gravitational **distribution** of pulmonary **blood flow** is only **minimally altered** by turning prone resulting in the bulk of perfusion continuing to go to **dorsal** regions when these are turned to the **nondependent** position
- *the observed changes in **gas exchange** (a direct function of the ventilation/perfusion ratio) are **primary** due to changes in **regional ventilation***

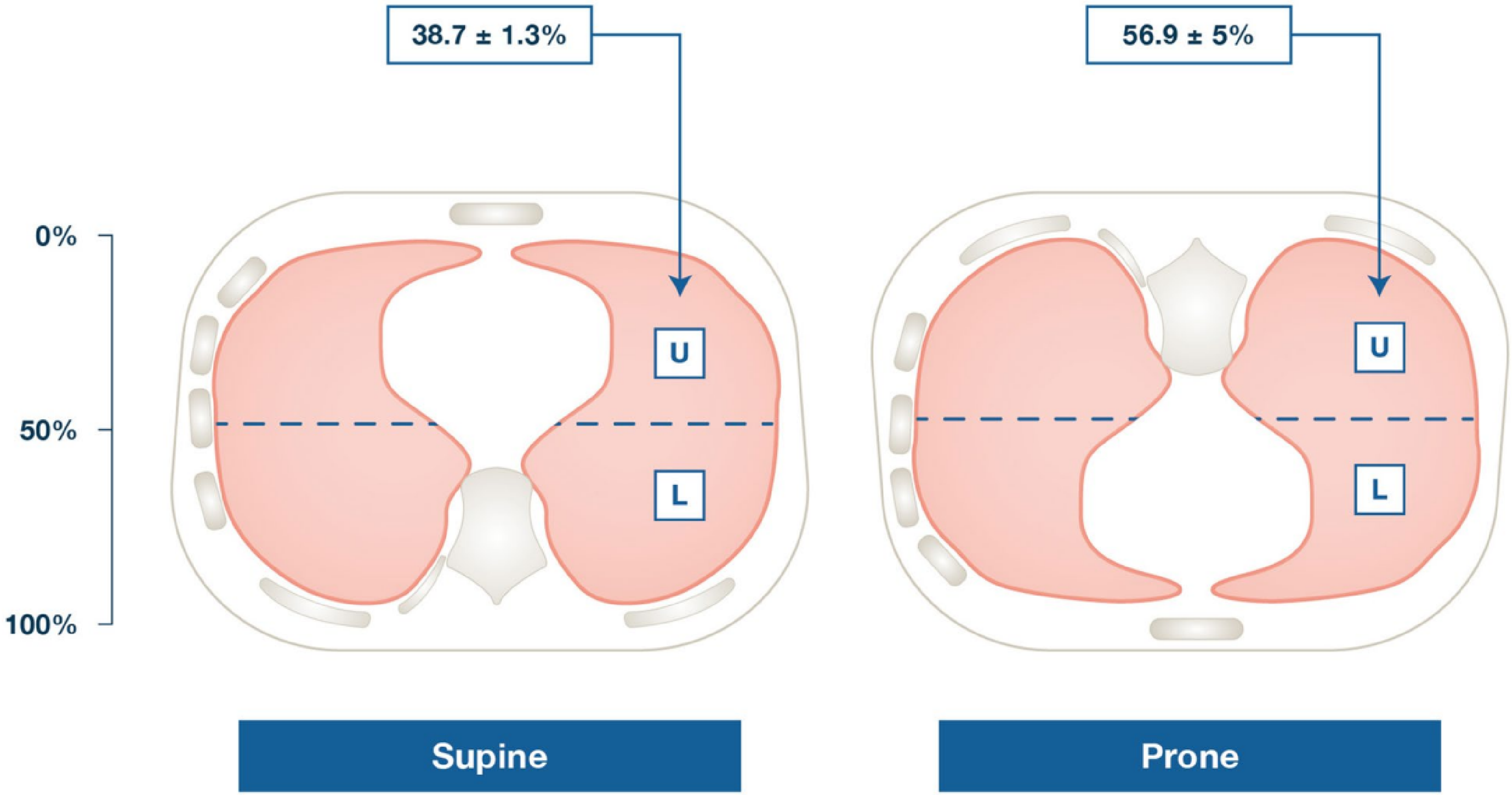


Fig. 2 Due to the anatomical design, in supine position, the open, non-dependent lung mass (at 50% of the sternum-vertebra distance) is about 40% of the total mass, while the dependent accounts for the 60%. As collapse is primarily a function of the superimposed hydrostatic pressure (including the shape and weight of the heart, which is mainly located in the left chest side), it follows that, while prone, more mass opens in the non-dependent zones than collapses in the dependent sternal regions

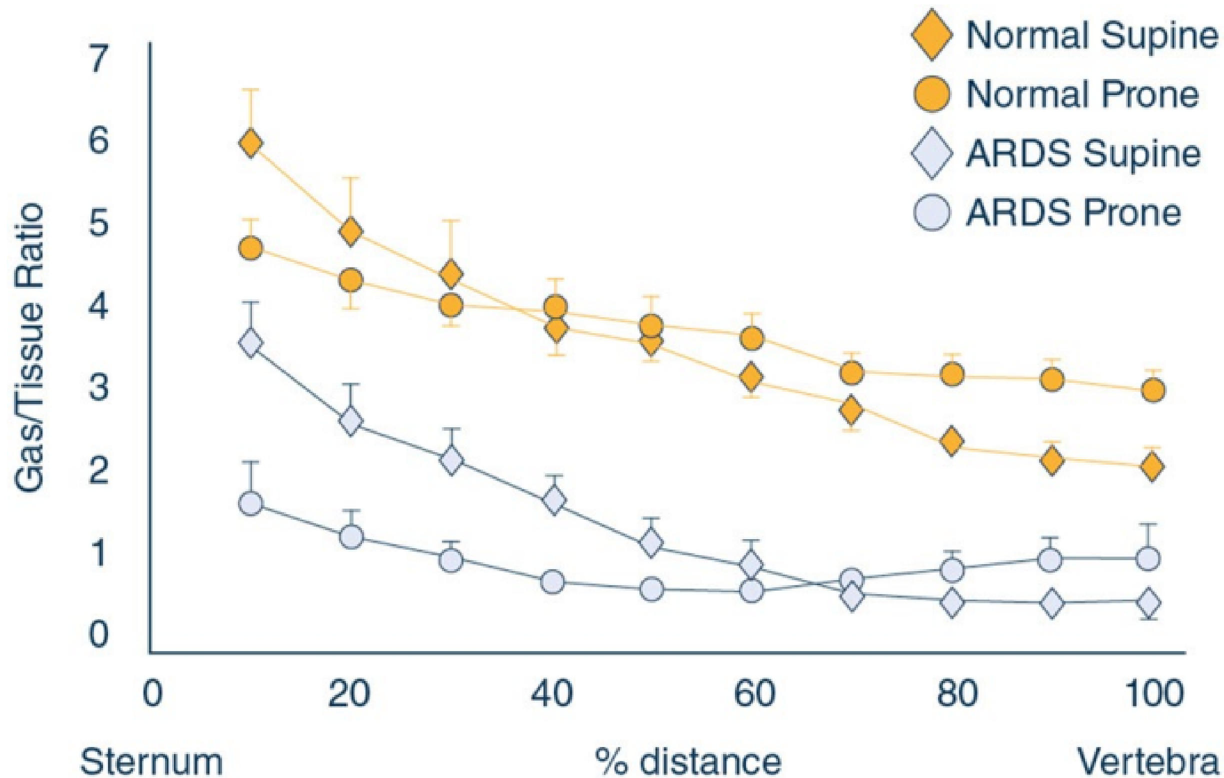


Fig. 1 The gas/tissue ratio (it may be thought as a volume of the pulmonary unit) as a function of the distance between the sternum and the vertebrae. As shown, in supine position, the gas/tissue ratio sharply decreases from the sternum to the vertebrae suggesting that both in normal and in ARDS patients the distending forces is about three times higher closer to the sternum than to the vertebrae. In prone position, the gas/tissue ratio is far more homogeneous, indicating a more even distribution of forces throughout the lung parenchyma

nastavení
PEEP

Techniques

(for setting the optimal PEEP)

- arterial oxygenation + hemodynamics 1970s
- pressure-volume (PV) loops 1980s
- PEEP/FiO_2 tables (ARDS Network) 2000s
- compliance, driving pressure, stress index
- transpulmonary pressures
- imaging
- electrical impedance tomography
- .....

TABLE 1 Lower PEEP/FiO_2 table.

ARDSNetwork N Engl J Med 2000;342:1301-8.

FiO_2	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.7	0.7	0.8	0.9	0.9	0.9	1.0
PEEP	5	5	8	8	10	10	10	12	14	14	14	16	18	18–24

Table to guide PEEP settings using incremental steps in FiO2 and PEEP to maintain a PaO_2 of 55–80 mmHg. This is commonly referred to as the lower PEEP/FiO_2 table. FiO_2, fraction of inspired oxygen; PaO_2, partial pressure of arterial oxygen. Adapted from: Ref. (1).

TABLE 2 Higher PEEP/FiO_2 table.

Network ARDS N Engl J Med 2004;351:327-36.

FiO_2	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.5–0.8	0.8	0.9	1.0
PEEP	5	8	10	12	14	14	16	16	18	20	22	22	22–24

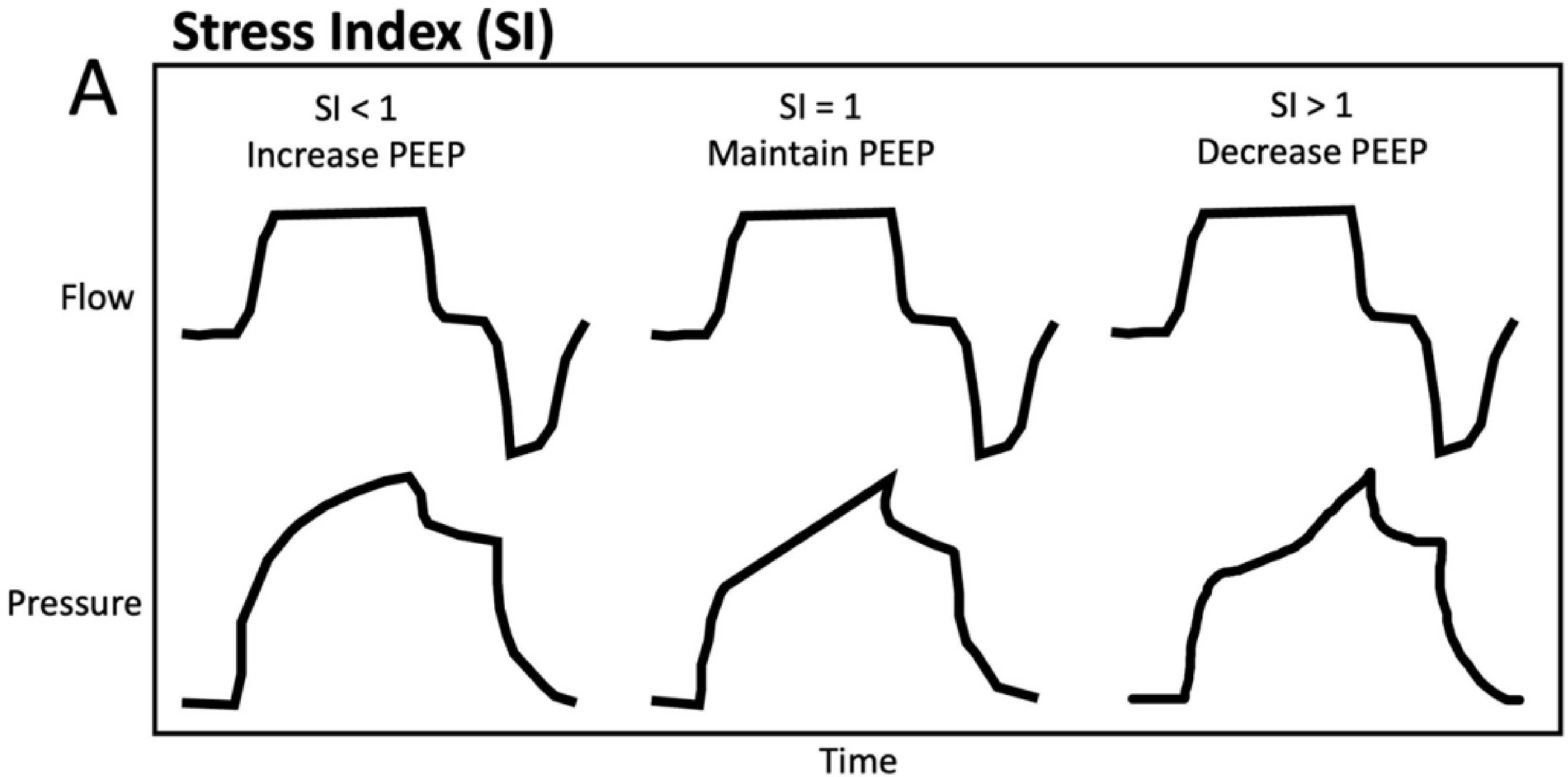
Table to guide PEEP settings using incremental steps in FiO_2 and PEEP to maintain a PaO_2 of 55–80 mmHg. This is commonly referred to as the higher PEEP/FiO_2 table. FiO_2, fraction of inspired oxygen; PaO_2, partial pressure of arterial oxygen. Adapted from: Ref. (26).

TABLE 3 Expiratory transpulmonary pressure table.

FiO_2	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	1.0
P_{TP}	0	0	2	2	4	4	6	6	8	8	10	10

Table to guide PEEP setting based on P_{TP}. Set PEEP to achieve P_{Tp} based on the FiO_2 to maintain PaO_2 of 55–120 mmHg. FiO_2, fraction of inspired oxygen; P_{Tp}, expiratory transpulmonary pressure; PaO_2: partial pressure of arterial oxygen. Adapted from Ref. (50).

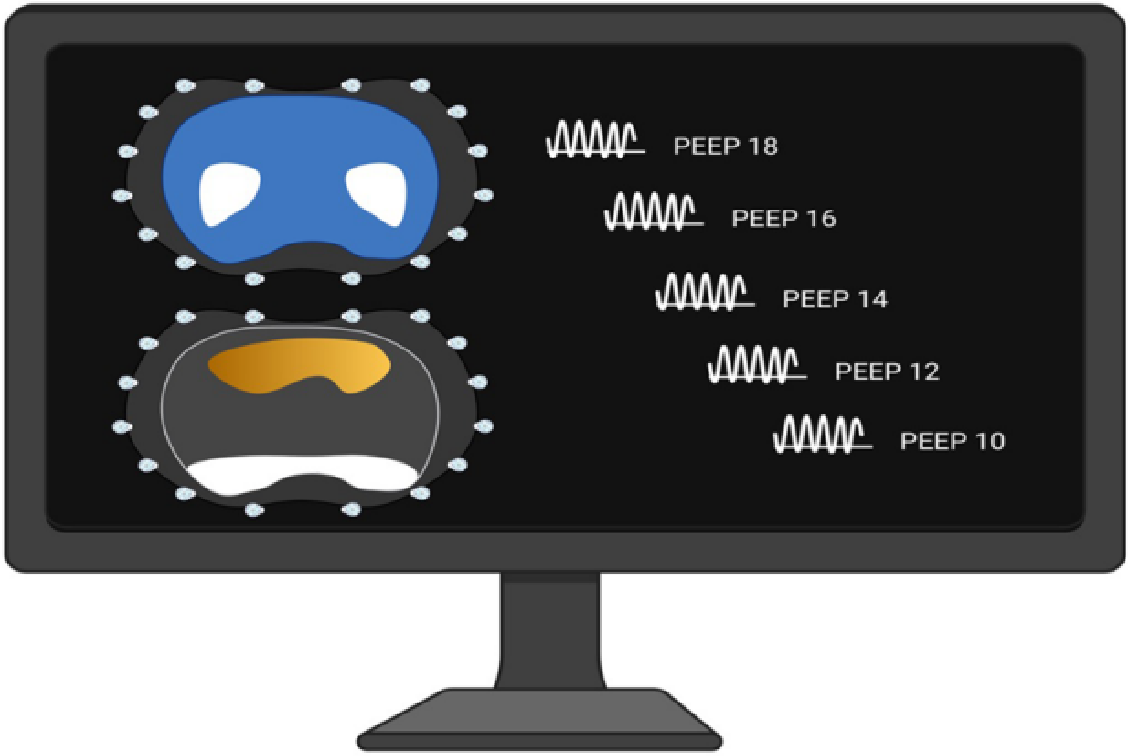
Advanced Methods for Individualized PEEP Titration



Advanced Methods for Individualized PEEP Titration

B

Electrical Impedance Tomography



Perform decremental PEEP titration to find intercept of collapse and over-distention curves ($PEEP_{ODCL}$).

Advanced Methods for Individualized PEEP Titration

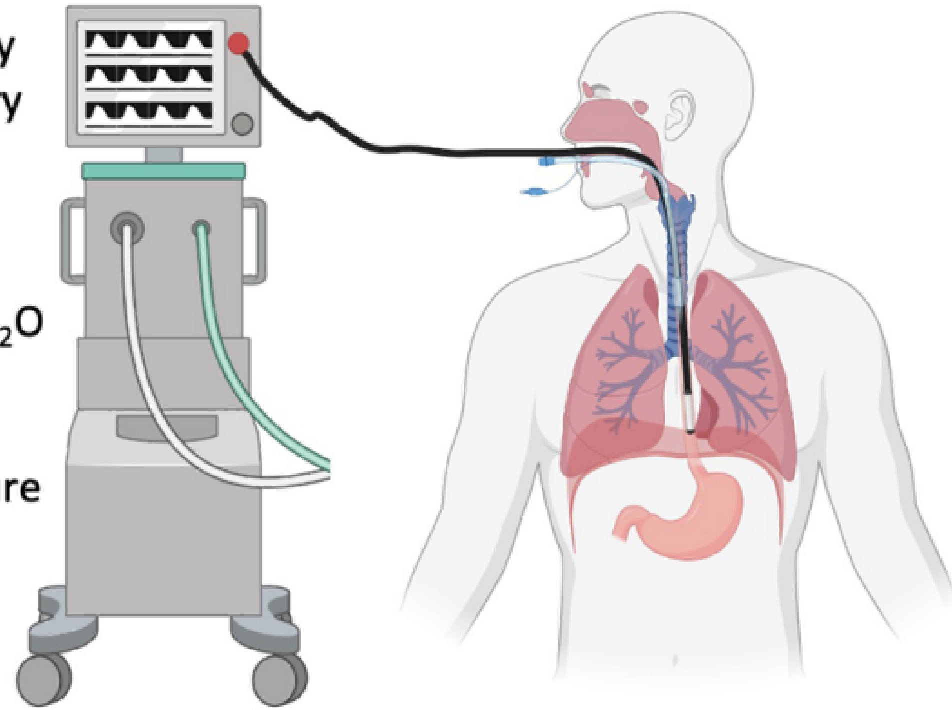
C

Esophageal Manometry

Titrate PEEP, monitor end-inspiratory P_L, end-expiratory P_L, transpulmonary driving pressure.

Goals:

1) End-Inspiratory $P_L < 15\text{-}20\ cmH_2O$
2) End-Expiratory $P_L = 0\ cmH_2O$ ($\pm 2\ cmH_2O$)
3) Transpulmonary Driving Pressure $< 10\text{-}12\ cmH_2O$



esophageal manometry

- esophageal pressure (P_{es}) ≈ intrapleural pressure (P_{pl})
- transpulmonary pressure (P_L)
- **$P_L = P_{ao} - P_{es}$**
  - $P_{ao} \approx P_{plat}$ (alveolar distending pressure at **end-inspiration**)
  - $P_{ao} \approx$ PEEP (alveolar distending pressure at **end-expiration**)

PEEP is titrated to a transpulmonary pressure **(P_L)** of **0 cm H_2O**

Effects of Prone Positioning on Transpulmonary Pressures and End-expiratory Volumes in Patients without Lung Disease

Abirami Kumaresan, M.D., Robert Gerber, B.S., Ariel Mueller, M.A., Stephen H. Loring, M.D., Daniel Talmor, M.D.

ABSTRACT

Background: The effects of prone positioning on esophageal pressures have not been investigated in mechanically ventilated patients. Our objective was to characterize effects of prone positioning on esophageal pressures, transpulmonary pressure, and lung volume, thereby assessing the potential utility of esophageal pressure measurements in setting positive end-expiratory pressure (PEEP) in prone patients.

Methods: We studied 16 patients undergoing spine surgery during general anesthesia and neuromuscular blockade. We measured airway pressure, esophageal pressures, airflow, and volume, and calculated the expiratory reserve volume and the elastances of the lung and chest wall in supine and prone positions.

(ANESTHESIOLOGY 2018; 128:1187-92)

from supine to prone	
Esophageal pressures (end exp) **decreased** by:	**5.64** cmH_2O at PEEP 0
Chest wall elastance **increased** by:	**7.32** cmH_2O at PEEP 0
	6.66 cmH_2O at PEEP 7
Median driving pressure **increased** by:	**3.70** cmH_2O at PEEP 0
	3.90 cmH_2O at PEEP 7
Transpulmonary pressure **increased** by:	**5.54** cmH_2O at PEEP 0
	4.96 cmH_2O at PEEP 7

Conclusions: End-expiratory esophageal pressure decreases, and end-expiratory transpulmonary pressure and expiratory reserve volume increase, when patients are moved from supine to prone position. Mean respiratory system driving pressure increases in the prone position due to increased chest wall elastance. The increase in end-expiratory transpulmonary pressure and expiratory reserve volume may be one mechanism for the observed clinical benefit with prone positioning. **(ANESTHESIOLOGY 2018; 128:1187-92)**

Clinical Trial › JAMA. 2019 Mar 5;321(9):846-857. doi: 10.1001/jama.2019.0555.

Effect of Titrating Positive End-Expiratory Pressure (PEEP) With an Esophageal Pressure-Guided Strategy vs an Empirical High PEEP-Fio2 Strategy on Death and Days Free From Mechanical Ventilation Among Patients With Acute Respiratory Distress Syndrome: A Randomized Clinical Trial

Jeremy R Beitler [1], Todd Sarge [2], Valerie M Banner-Goodspeed [2], Michelle N Gong [3], Deborah Cook [4], Victor Novack [5], Stephen H Loring [2], Daniel Talmor [2]; EPVent-2 Study Group

Kaplan-Meier Survival Analysis Through Day 60

Conclusions

Among patients with moderate to severe ARDS, P_{ES}-guided PEEP, compared with empirical high PEEP-F_{IO_2}, resulted in no significant difference in death and days free from mechanical ventilation. These findings do not support P_{ES}-guided PEEP titration in ARDS.

No. at risk							
P_{ES}-guided PEEP	102	88	75	68	67	64	63
Empirical PEEP-F_{IO_2}	98	81	71	68	65	64	61

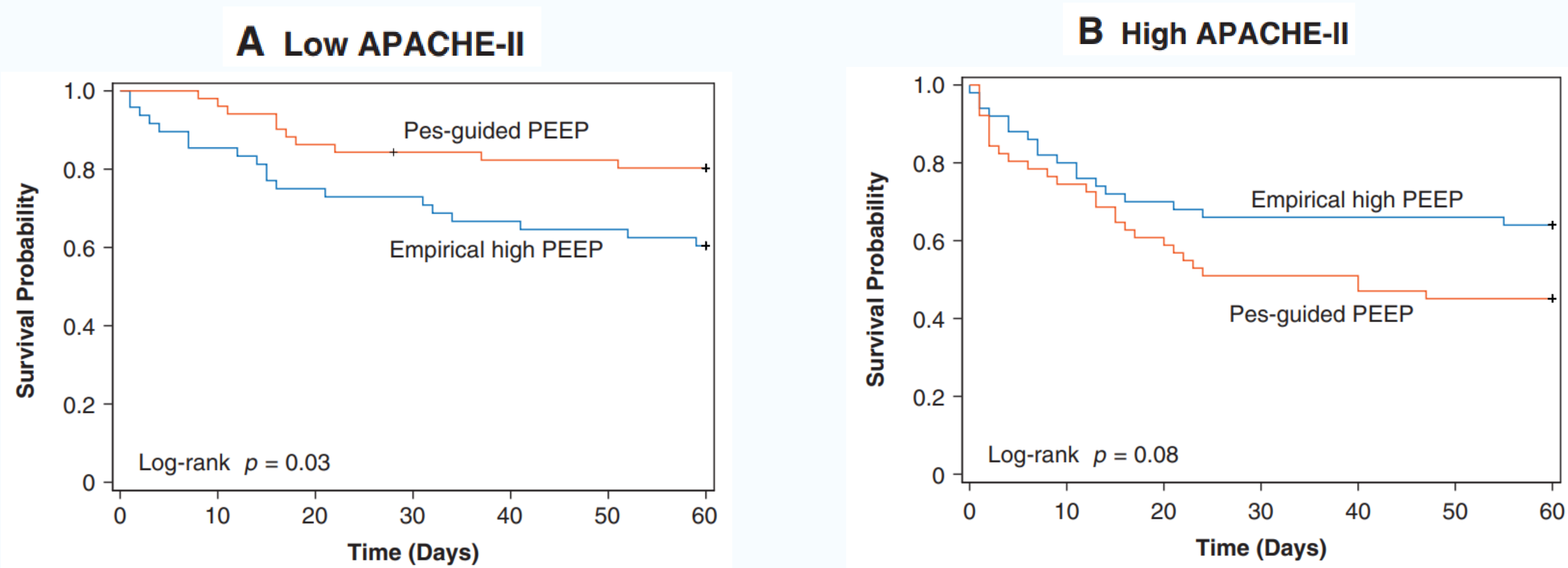
ORIGINAL ARTICLE

Effect of Esophageal Pressure–guided Positive End-Expiratory Pressure on Survival from Acute Respiratory Distress Syndrome

A Risk-based and Mechanistic Reanalysis of the EPVent-2 Trial

Todd Sarge[1], Elias Baedorf-Kassis[2], Valerie Banner-Goodspeed[1], Victor Novack[3], Stephen H. Loring[1], Michelle N. Gong[4], Deborah Cook[5], Daniel Talmor[1], and Jeremy R. Beitler[6]; for the EPVent-2 Study Group

Am J Respir Crit Care Med Vol 204, Iss 10, pp 1153–1163



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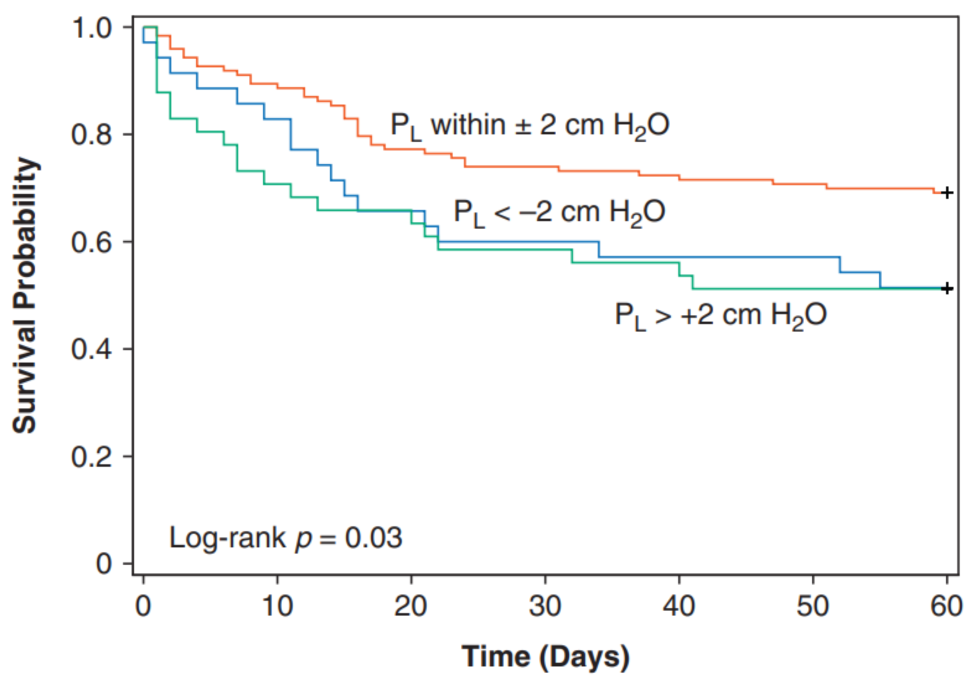

PEEP in prone position

Beitler *et al. Critical Care* (2015) 19:436
DOI 10.1186/s13054-015-1153-9

Critical Care

VIEWPOINT Open Access

PEEP titration during prone positioning for acute respiratory distress syndrome

Jeremy R. Beitler[1*], Claude Guérin[2,3], Louis Ayzac[4], Jordi Mancebo[5], Dina M. Bates[1], Atul Malhotra[1] and Daniel Talmor[6]

Abstract

No major trial evaluating prone positioning for acute respiratory distress syndrome (ARDS) has incorporated a high-positive end-expiratory pressure (high-PEEP) strategy despite complementary physiological rationales. We evaluated generalizability of three recent proning trials to patients receiving a high-PEEP strategy. All trials employed a relatively low-PEEP strategy. After protocol ventilator settings were initiated and the patient was positioned per treatment assignment, post-intervention PEEP was not more than 5 cm H_2O in 16.7 % and not more than 10 cm H_2O in 66.0 % of patients. Post-intervention PEEP would have been nearly twice the set PEEP had a high-PEEP strategy been employed. Use of either proning or high-PEEP likely improves survival in moderate-severe ARDS; the role for both concomitantly remains unknown.

Beitler *et al. Critical Care* (2015) 19:436
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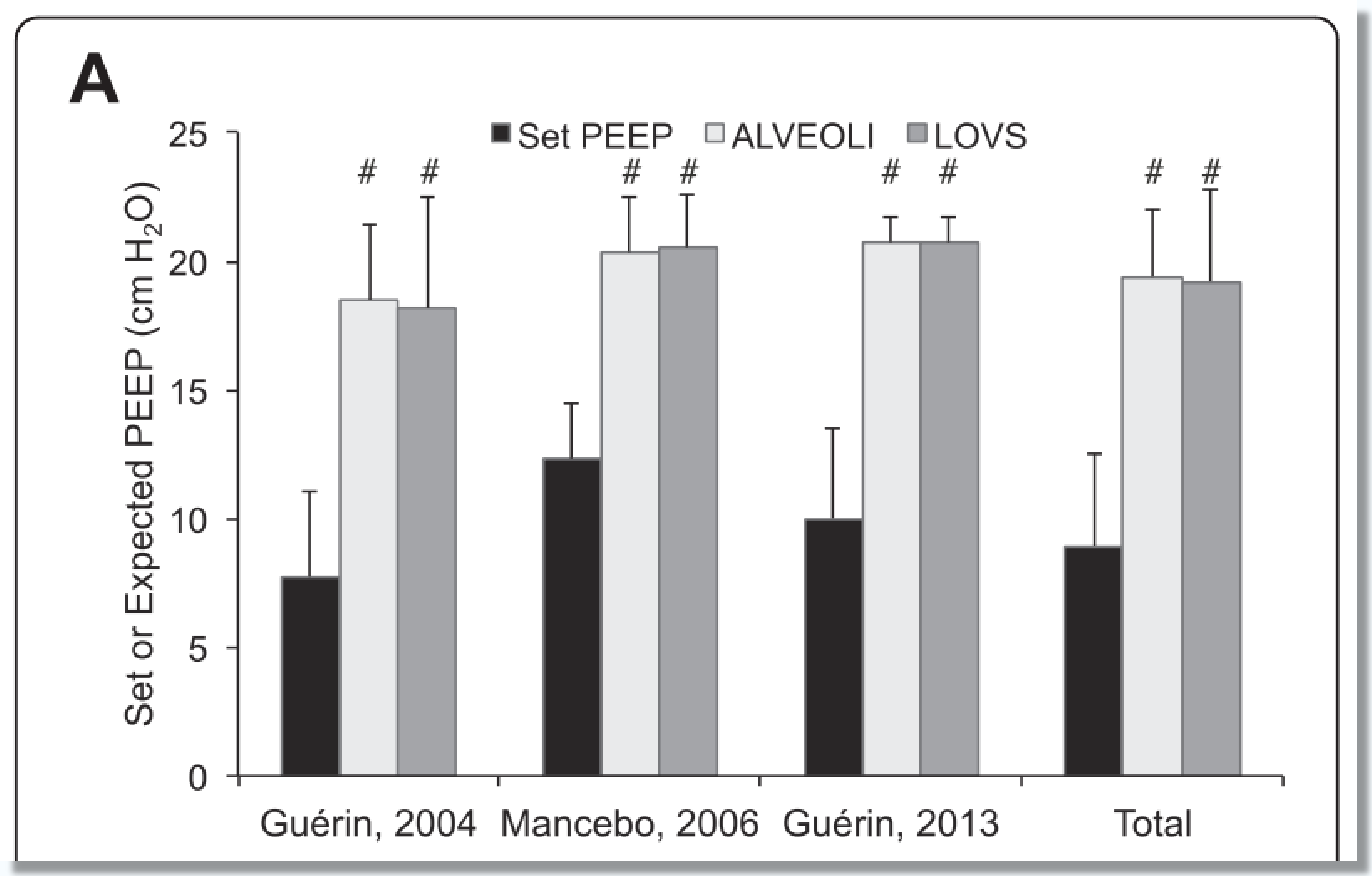
Critical Care

VIEWPOINT Open Access

PEEP titration during prone positioning for acute respiratory distress syndrome

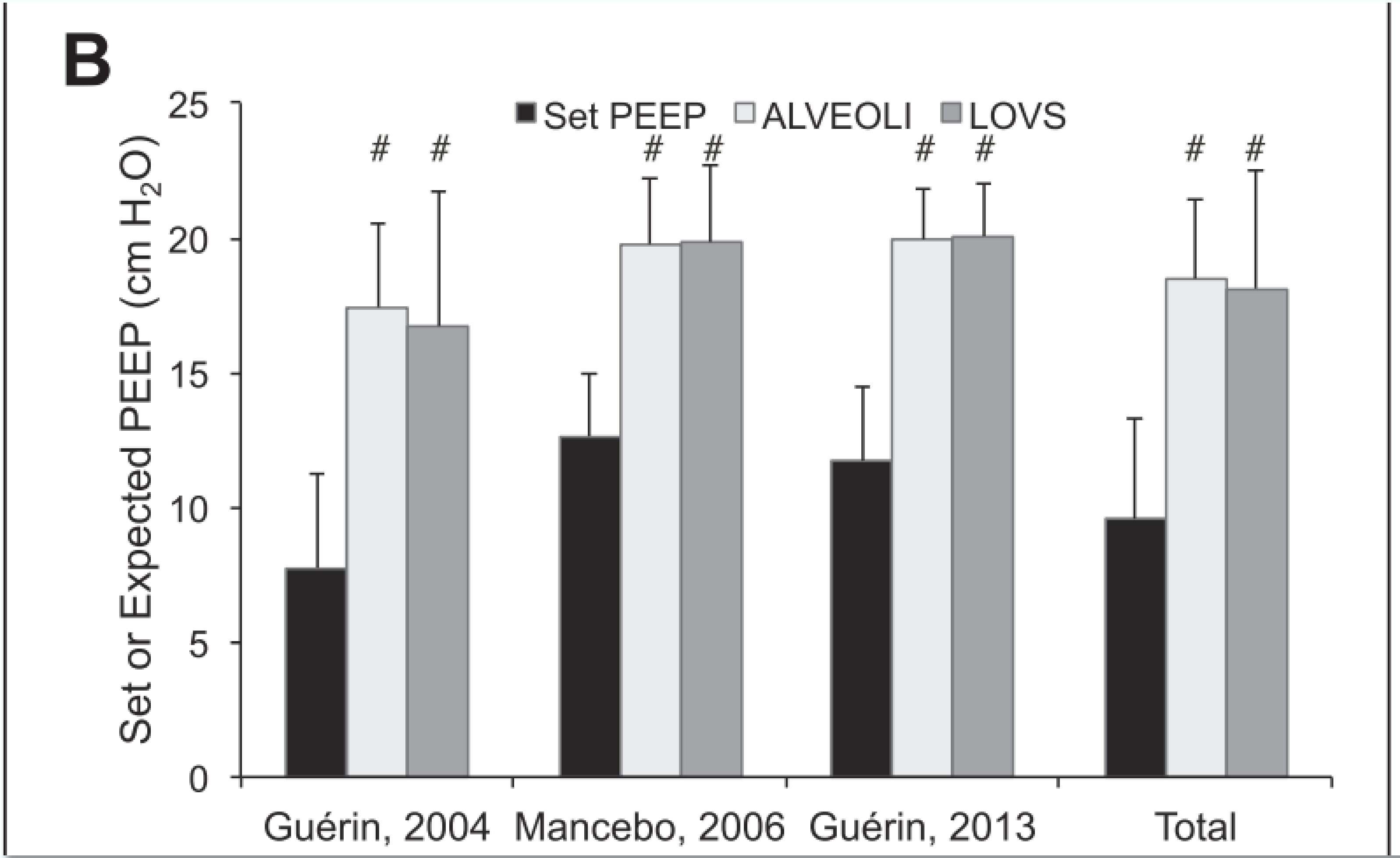
- **post-hoc** analysis of data from three recent **multicenter RCT**
- **examine** in detail the PEEP titration **strategies**
- 1365 patients
- study **protocol** PEEP titration strategy **differed** among included trials:
  - A) PEEP was titrated according to **nonprotocolized usual care**
  - B) PEEP was targeted to **10–15 cm H_2O**
  - C) PEEP was titrated according to the **low-PEEP** arm ALVEOLI (PROSEVA)

supine



PEEP used in proning clinical trials and **hypothetical PEEP** that would have been required under the ALVEOLI or LOVS PEEP protocols

prone



PEEP used in proning clinical trials and **hypothetical PEEP** that would have been required under the ALVEOLI or LOVS PEEP protocols

Table 1 Oxygenation and positive end-expiratory pressure measurements before and after study intervention

	Guerin et al. [11] (2004)	Mancebo et al. [13] (2006)	Guerin et al. [9] (2013)	All studies combined
Baseline				
FiO_2	66 ± 21	82 ± 20	79 ± 16	71 ± 20
PaO_2/FiO_2	152 ± 59	145 ± 84	104 ± 25	136 ± 58
PEEP, cm H_2O	8 ± 3	12 ± 2	10 ± 3	9 ± 4
PEEP ≤5 cm H_2O, %	27.2 %	0 %	18.9 %	21.8 %
PEEP ≤10 cm H_2O, %	85.8 %	29.4 %	62.6 %	72.7 %
Post-intervention				
FiO_2	59 ± 19	75 ± 20	73 ± 16	65 ± 20
PaO_2/FiO_2	179 ± 77	173 ± 88	153 ± 72	170 ± 77
PEEP, cm H_2O	8 ± 3	13 ± 2	12 ± 3	10 ± 4
PEEP ≤5 cm H_2O, %	28.0 %	0 %	2.1 %	16.7 %
PEEP ≤10 cm H_2O, %	83.3 %	24.1 %	48.7 %	66.0 %

Data are presented as mean ± standard deviation or percentage of study participants

FiO_2 fraction of inspired oxygen, *PaO_2* partial pressure of oxygen in arterial blood, *PEEP* positive end-expiratory pressure

Beitler *et al. Critical Care* (2015) 19:436
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Critical Care

VIEWPOINT Open Access

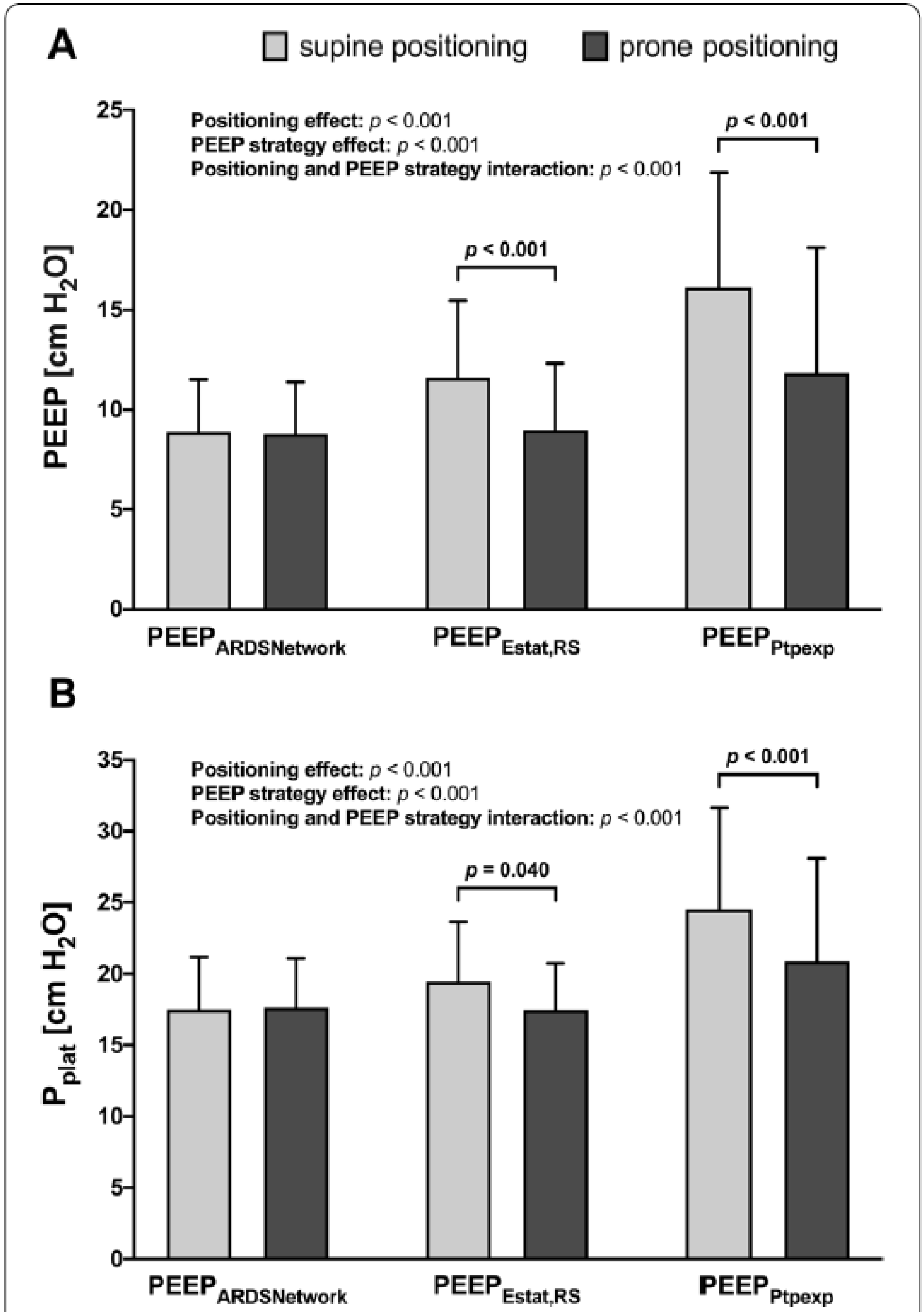
PEEP titration during prone positioning for acute respiratory distress syndrome

- **most** major trials have **titrated PEEP** according to severity of oxygenation impairment by using an arbitrary **low PEEP-FiO$_2$ table**
- **only** the **PROSEVA** trial used a PEEP-FiO$_2$ titration table for **all pts** *(identical to the low-PEEP strategy in the ALVEOLI trial)*
- the **optimum** approach to setting PEEP remains **undefined**
- we **believe** that the optimum approach involves **titrating PEEP** to **minimize** mechanical **lung injury**
- need to **adjust** PEEP after **each position change** to optimize mechanics for lung injury prevention

Effects of different positive end-expiratory pressure titration strategies during prone positioning in patients with acute respiratory distress syndrome: a prospective interventional study

Boesing et al. Critical Care. 2022;26:82.

- Medical Faculty Mannheim July 2019 to February 2021
- 40 consecutive pts with moderate to severe ARDS **PaO2/FiO_2 < 150 mmHg**
- evaluated during **supine** and **prone** positioning
- **three** different **titration strategies** of PEEP:
  - A) ARDS Network recommendations (**$PEEP_{ARDSNetwork}$**)
  - B) the lowest static elastance of the respiratory system (**$PEEP_{Estat,RS}$**)
  - C) targeting a positive Ptpexp (**$PEEP_{Ptpexp}$**)
- **primary endpoint:** does **Ptpexp** differ according to **PEEP titration strategy** during **supine** and **prone** positioning?



A
supine positioning
prone positioning
Positioning effect: p < 0.001
PEEP strategy effect: p < 0.001
Positioning and PEEP strategy interaction: p < 0.001
p < 0.001
p < 0.001
PEEP [cm H2O]
0
5
10
15
20
25
PEEPARDSNetwork
PEEPEstat,RS
PEEPPtpexp
B
Positioning effect: p < 0.001
PEEP strategy effect: p < 0.001
Positioning and PEEP strategy interaction: p < 0.001
p < 0.001
p = 0.040
Pplat [cm H2O]
0
5
10
15
20
25
30
35
PEEPARDSNetwork
PEEPEstat,RS
PEEPPtpexp

Effects of different positive end-expiratory pressure titration strategies during prone positioning in patients with acute respiratory distress syndrome: a prospective interventional study

Boesing et al. Critical Care. 2022;26:82.

setting $\text{PEEP}_{\text{ARDSNetwork}}$:

- resulted in the **least invasive** ventilator settings (Pplat, PEEP, transpulmonary pressures, and mechanical power)
- provided **sufficient gas exchange** and **hemodynamics**

setting $\text{PEEP}_{\text{Ptpexp}}$:

- resulted in ventilator settings with the **highest airway pressures** applied and transferred the **most energy in the lung** in the supine as well as the prone position

PEEP in prone position

- PEEP **optimization** remains under **debate** in ARDS pts
- **PEEP strategy** in prone and supine is mostly the **same**
- in trials, **PEEP level** in prone was found **lower** than **expected**
- recent studies **suggest** that optimal PEEP was significantly **lower** in **PP** than that in supine position
- there is currently **no one** technique that is **recommended above** all others

setting

in prone

position?

ventilator settings in PP

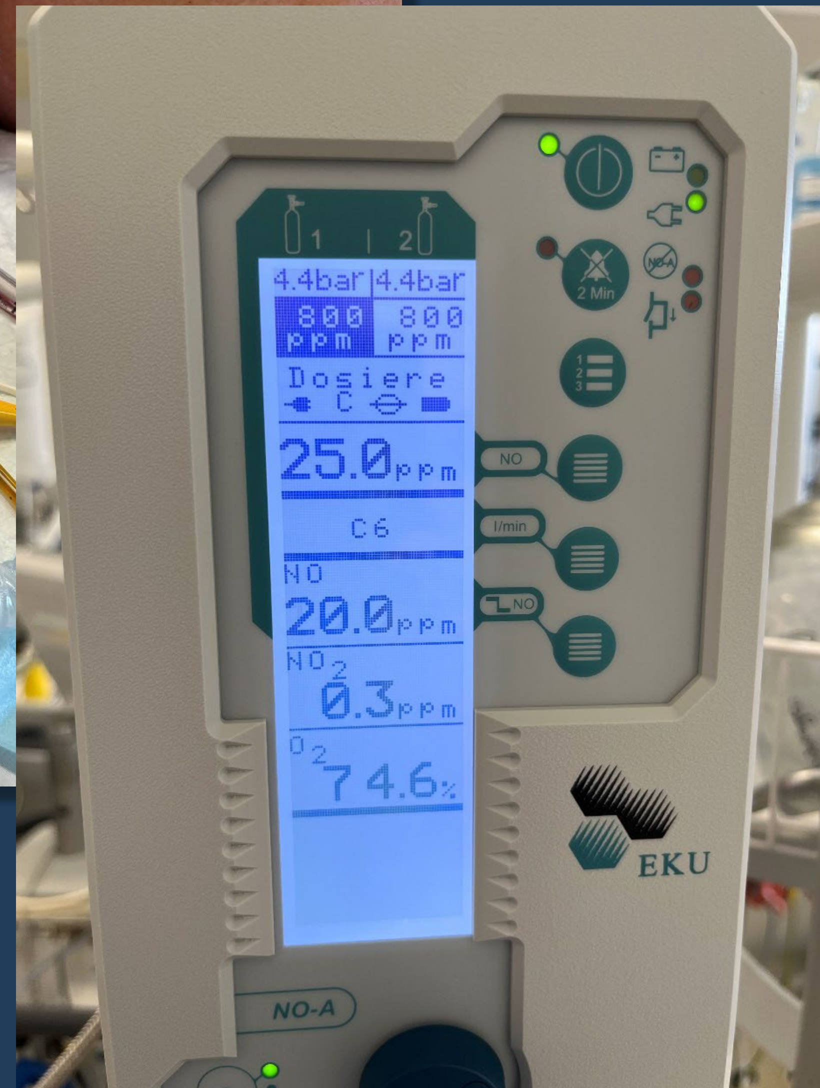
- lung **protective**
- **V_t** of **6 (4-8)** ml/kg predicted body weight (PBW)
- at least moderate **PEEP** levels (techniques?)
- **P_{plat}** < **30** cmH_2O
- **FiO_2** lowest as possible **(<0,60**)
- IRV (**I:E** ≥1:1)

other settings in PP

- complete **(180°)** vs incomplete **(135°)** prone position
- muscle **paralysis** is **not** mandatory for all patients!
- **enteral** nutrition is possible (minimum of 500 ml/day)
- **bronchoscopy** is **possible** *(and easy)*
- combination with **CRRT** is **possible** *(and easy)*
- combination with **NO** therapy is **possible** *(and easy)*
- combination with **ECMO** is **possible**


Dräger
prismaflex
1000ml
81
122/60
94
HF-box
LK Baden
Intensiv

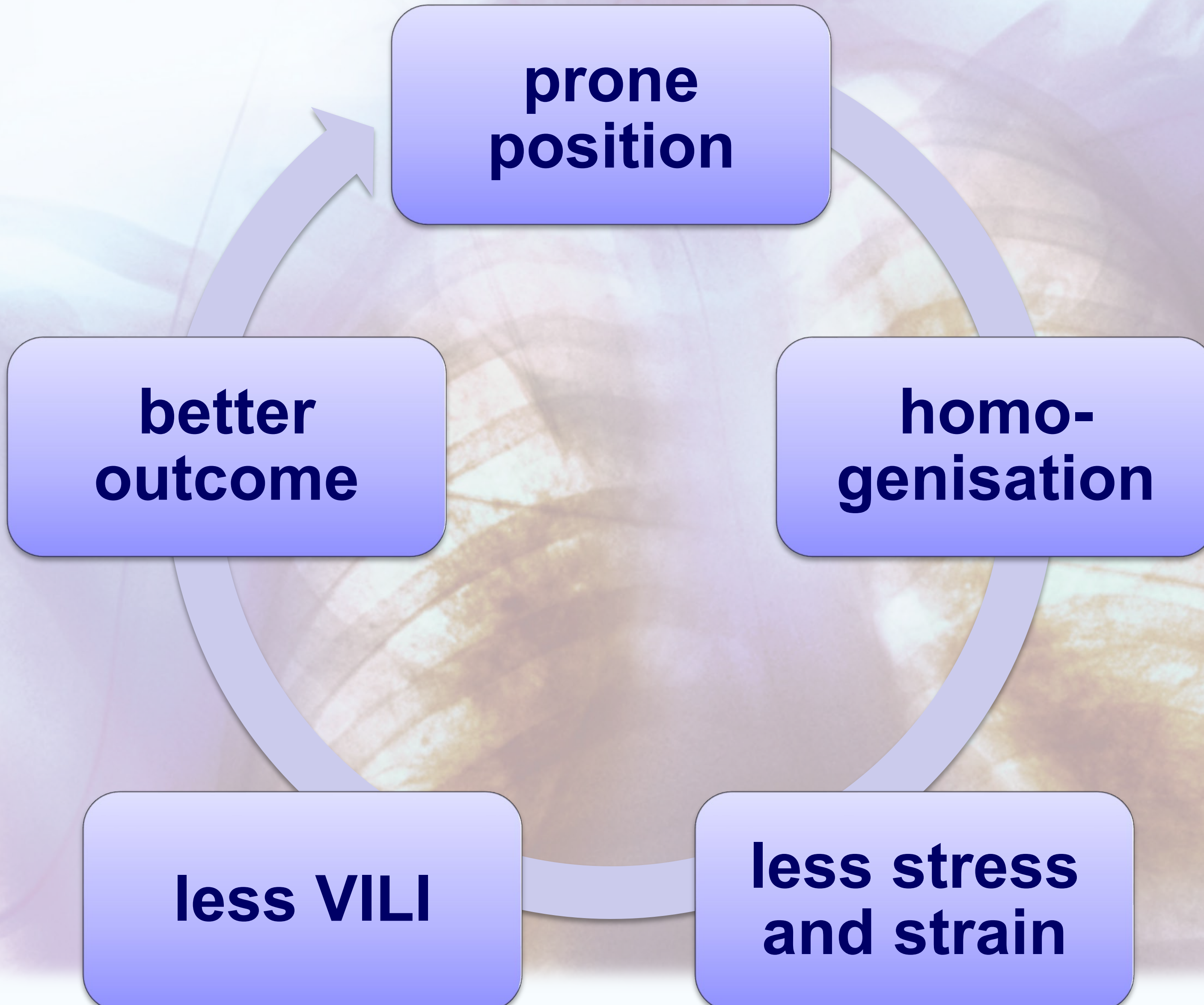

CUFF


1
2
4.4bar
4.4bar
800 ppm
800 ppm
Dosiere
C
25.0ppm
C6
NO
20.0ppm
NO2
0.3ppm
O2
74.6%
NO
l/min
NO
2 Min
NO-A
EKU
NO-A

facit

- ventilator settings is an **unanswered** issue
- use lung **protective** strategy in **both** positions
- the main **goal** of prone position is not only to improve oxygenation but - *maybe first of all* - to **reduce aggressiveness of ventilation** (FiO_2, PIP, PEEP, DP, …)
- **personalized** adjustments **required**

***prone** the patient is **most important** setting*


prone position
homo-genisation
less stress and strain
less VILI
better outcome


...děkuji Vám za pozornost