



Open-lung concept **con**

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**An Official American Thoracic Society/European Society of Intensive
Care Medicine/Society of Critical Care Medicine Clinical Practice
Guideline: Mechanical Ventilation in Adult Patients with Acute
Respiratory Distress Syndrome**



All patients with ARDS ($\text{PaO}_2/\text{FIO}_2 < 300$ mmHg):

- Vt 4–8 ml/kg PBW, plateau pressure < 30 cm H₂O – strong recommendation

The ARDSNet trial

Severe ARDS ($\text{PaO}_2/\text{FIO}_2 < 100$ mmHg)

- Prone Positioning for more than 12 hours per day - strong recommendation

PROSEVA trial

- ECMO - additional evidence is necessary to make a definitive recommendation

Moderate to severe ARDS ($\text{PaO}_2/\text{FIO}_2 < 200$ mmHg)

- HFOV - not be used routinely in patients with moderate or severe ARDS – strong recommendation

OSCILLATE and OSCAR trial

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Moderate to severe ARDS ($\text{PaO}_2/\text{FIO}_2 < 200$)

Higher vs Lower, PEEP?

We suggest that adult patients with moderate or severe ARDS receive higher rather than lower levels of PEEP

moderate confidence conditional recommendation

consider the risks and benefits for the individual patient of increasing PEEP when plateau pressure is greater than or equal to 30 cm H₂O

**Higher vs Lower Positive End-Expiratory Pressure
in Patients With Acute Lung Injury
and Acute Respiratory Distress Syndrome**

Systematic Review and Meta-analysis

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Moderate to severe ARDS ($\text{PaO}_2/\text{FIO}_2 < 200$)

Should Patients with ARDS Receive RMs? –

We suggest that adult patients with ARDS receive RMs

low–moderate confidence, conditional recommendation

cautious about RMs in patients with preexisting hypovolemia or shock

Metaanalysis of 6 RCTs including 1,423 patients

The type of RM varied widely among trials, and our primary analysis excluded five trials that used higher PEEP as a cointervention with RMs. In the only trial without cointervention, RMs were significantly associated with lower mortality. When considering all six RCTs, RMs were significantly associated with lower mortality (six studies, 1,423 patients; RR, 0.81; 95% CI, 0.69–0.95; moderate confidence).

Vyšší nebo nižší PEEP?

3 velké studie:

- ALVEOLI (NEJM 2004)
 - Lung Open Ventilation Study (LOVs) (JAMA 2008)
 - EXPRESS Study (JAMA 2008)
-
- + metaanalýza (JAMA 2010)

Higher vs Lower Positive End-Expiratory Pressure in Patients With Acute Lung Injury and Acute Respiratory Distress Syndrome

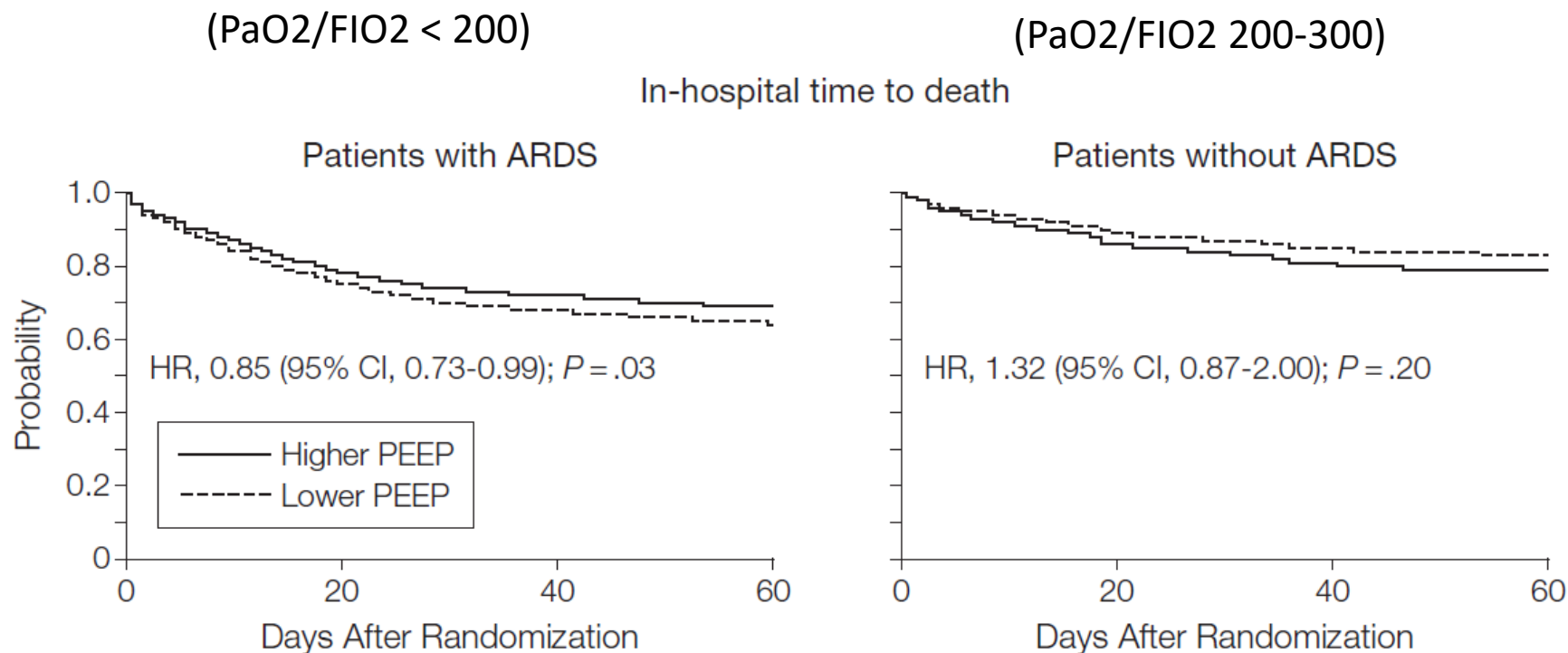
Systematic Review and Meta-analysis

2010

meta-analysis of individual-patient data

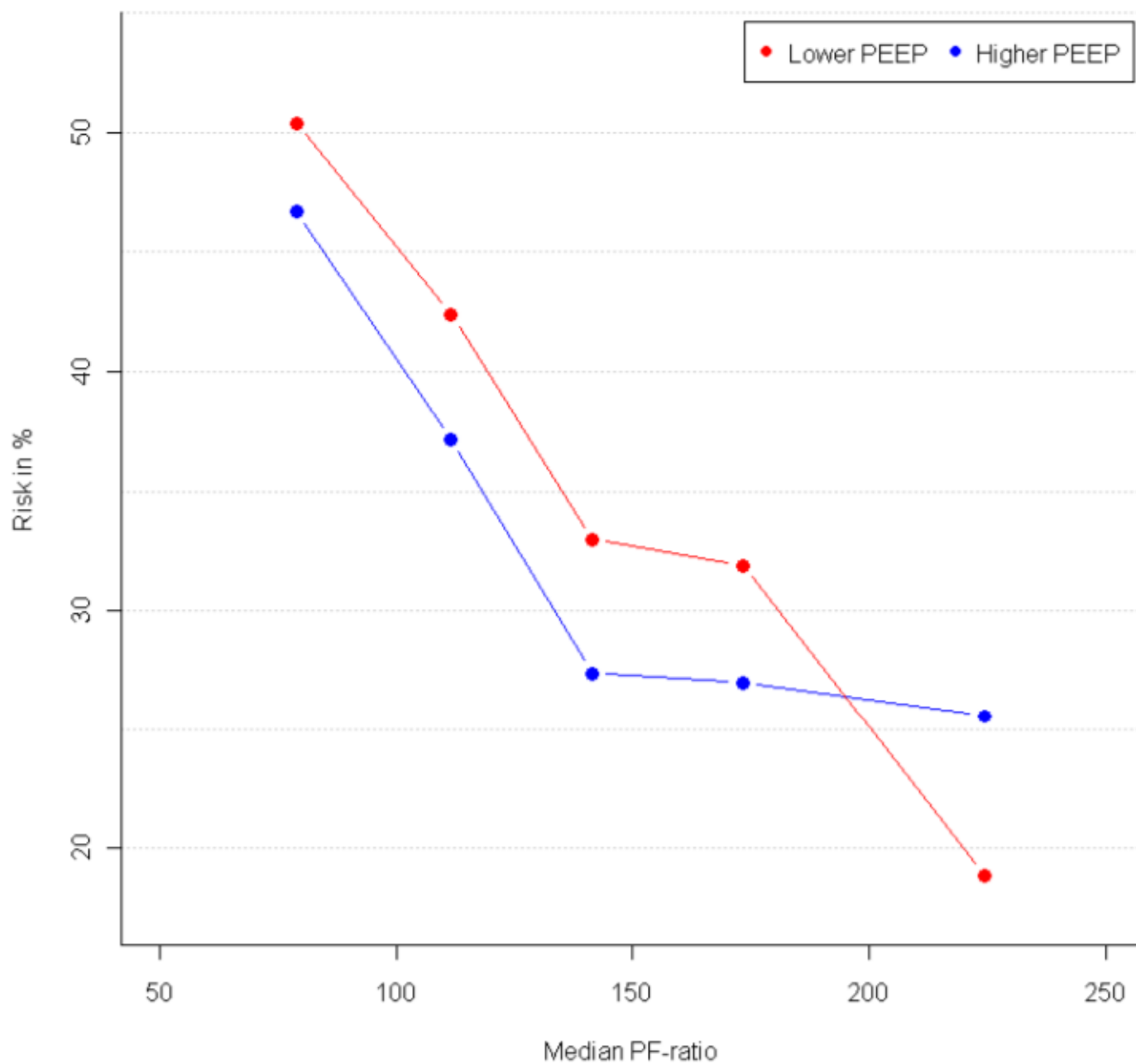
2299 pacientů (stará kritéria ARDS/ALI)

overall, no statistically significant difference in hospital mortality.



- Den 1 PEEP 15.3 vs 9 mbar
- In patients with ARDS, higher levels of PEEP were associated with a relative hospital mortality reduction of 10% (absolute difference, 4%; number needed to treat, 25).

PF-ratio Quintiles - Risks for Hospital Mortality



Recruitment manoeuvres for adults with acute respiratory distress syndrome receiving mechanical ventilation

Carol Hodgson^{1,2}, Ewan C Goligher³, Meredith E Young¹, Jennifer L Keating⁴, Anne E Holland⁵, Lorena Romero⁶, Scott J Bradley², David Tuxen⁷

10 RCTs, 1658 participants, published in 2016

Low-quality evidence suggests that recruitment manoeuvres improve ICU survival but not 28-day or hospital survival.

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Moderate to severe ARDS ($\text{PaO}_2/\text{FIO}_2 < 200$)

Should Patients with ARDS Receive RMs?

Two ongoing RCTs may provide additional insights into the efficacy of RMs in the routine management of patients with ARDS and may impact our confidence in the estimates of effect

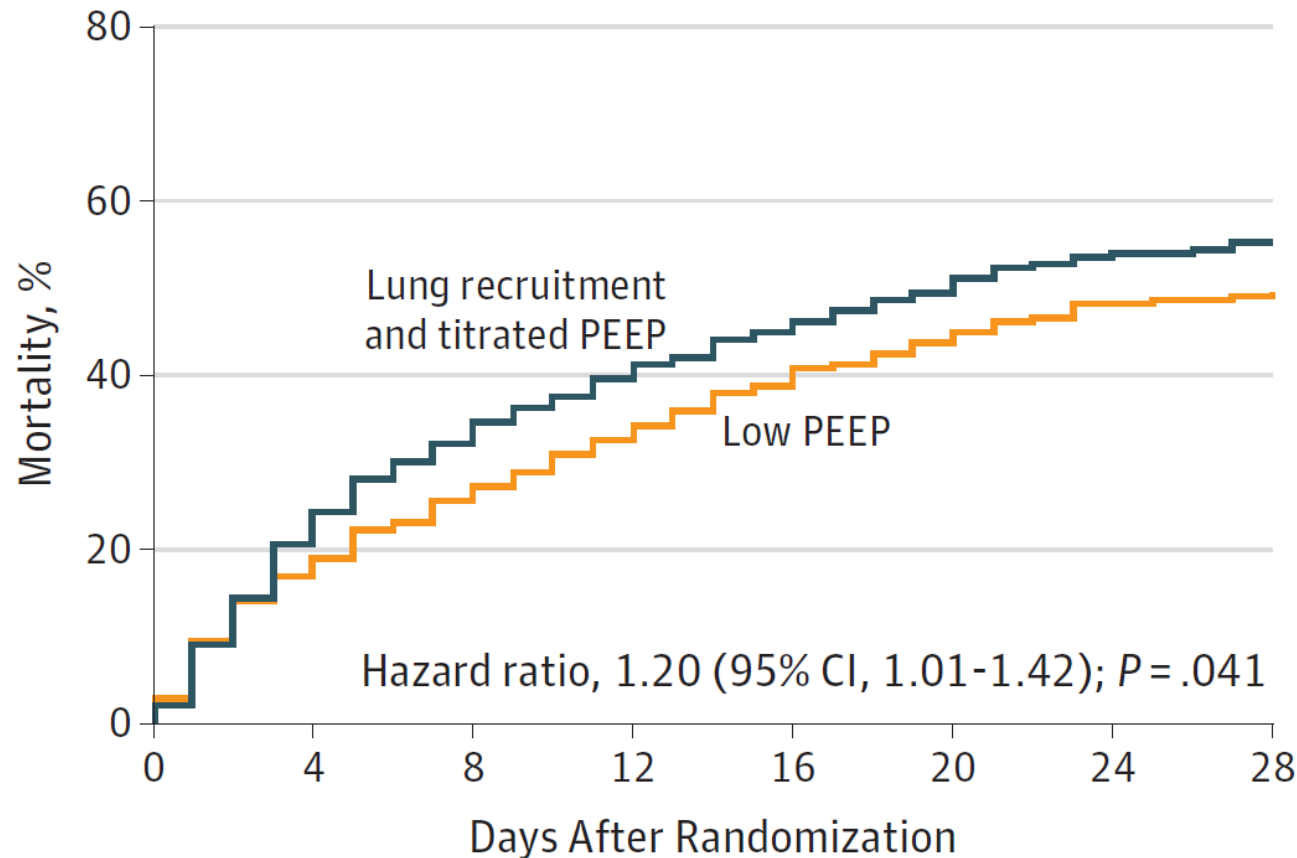
[ART](#) [Alveolar Recruitment for Acute Respiratory Distress Syndrome Trial], and
[PHARLAP](#) [Permissive Hypercapnia, Alveolar Recruitment and Low Airway
Pressure]

1010 pacienți

Higher vs Lower Positive End-Expiratory Pressure in Patients With Acute Lung Injury and Acute Respiratory Distress Syndrome

Systematic Review and Meta-analysis

ART trial (Alveolar Recruitment for ARDS Trial)
JAMA, September 2017

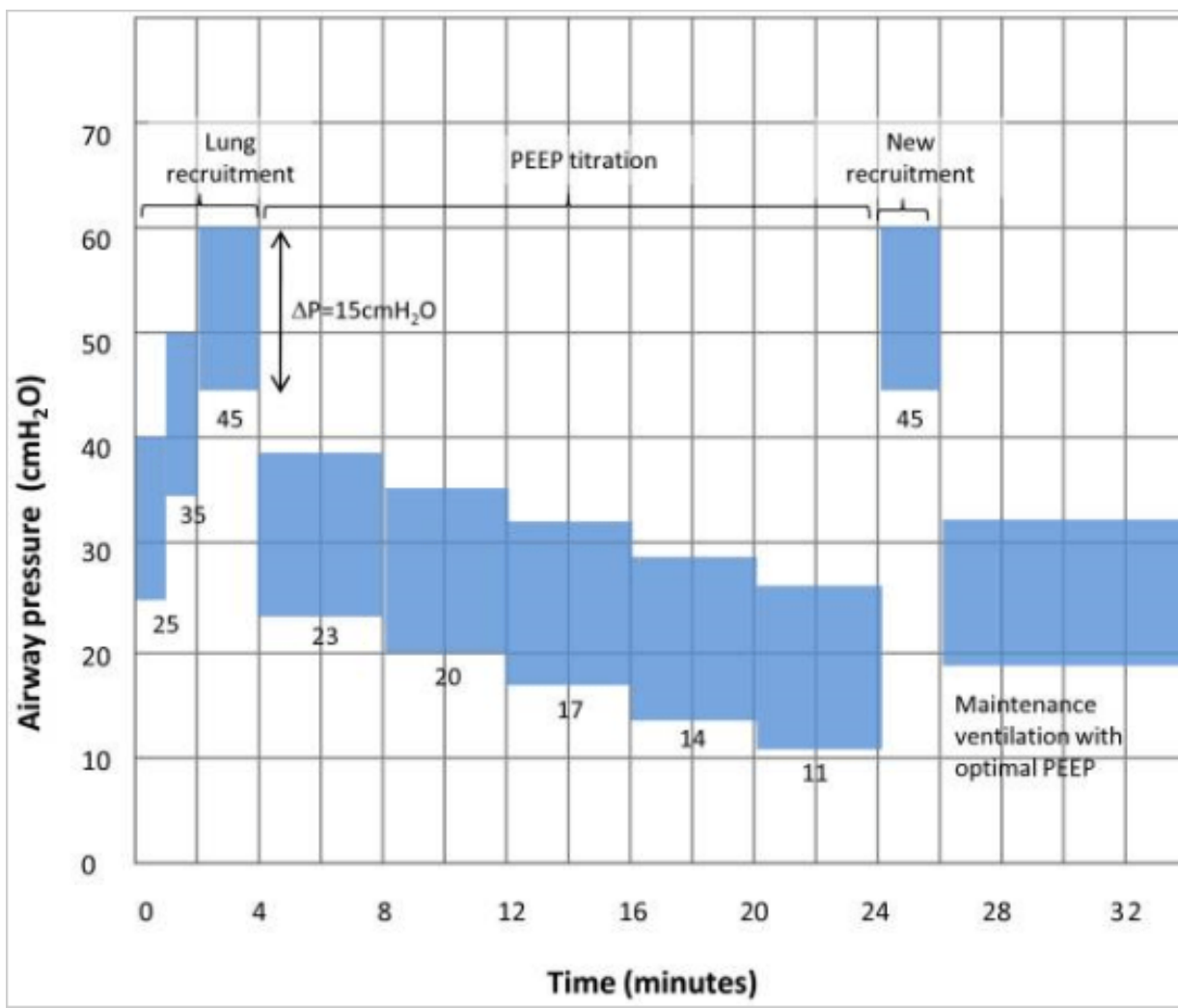


120 ICUs z 9 zemí , 2011 - 2017

1010 pacientů

středně těžké až těžké ARDS ($\text{PaO}_2/\text{FIO}_2 < 200$), < 72 h

PEEP nastaven dle nejlepší poddajnosti (+2 mbar)



- upravený protokol pro 3xKPR
 - vrcholové tlaky sníženy z 60 na 50 mbar a zkráceny intervaly
- u 16% musel být recruitment zastaven hl. pro hypotenzi a pokles SpO2
- PEEP 1.h 16.4 vs 13
- intervenční skupina měla vyšší 28-d mortalitu 55.3% vs 49.3% ($p = .041$)
- A 6-m mortalitu 65.3% vs 59.9% ($p = .04$)
- intervenční skupina měla více PNO (3.2% vs 1.2%) a barotraumatu (5.6% vs 1.6%)

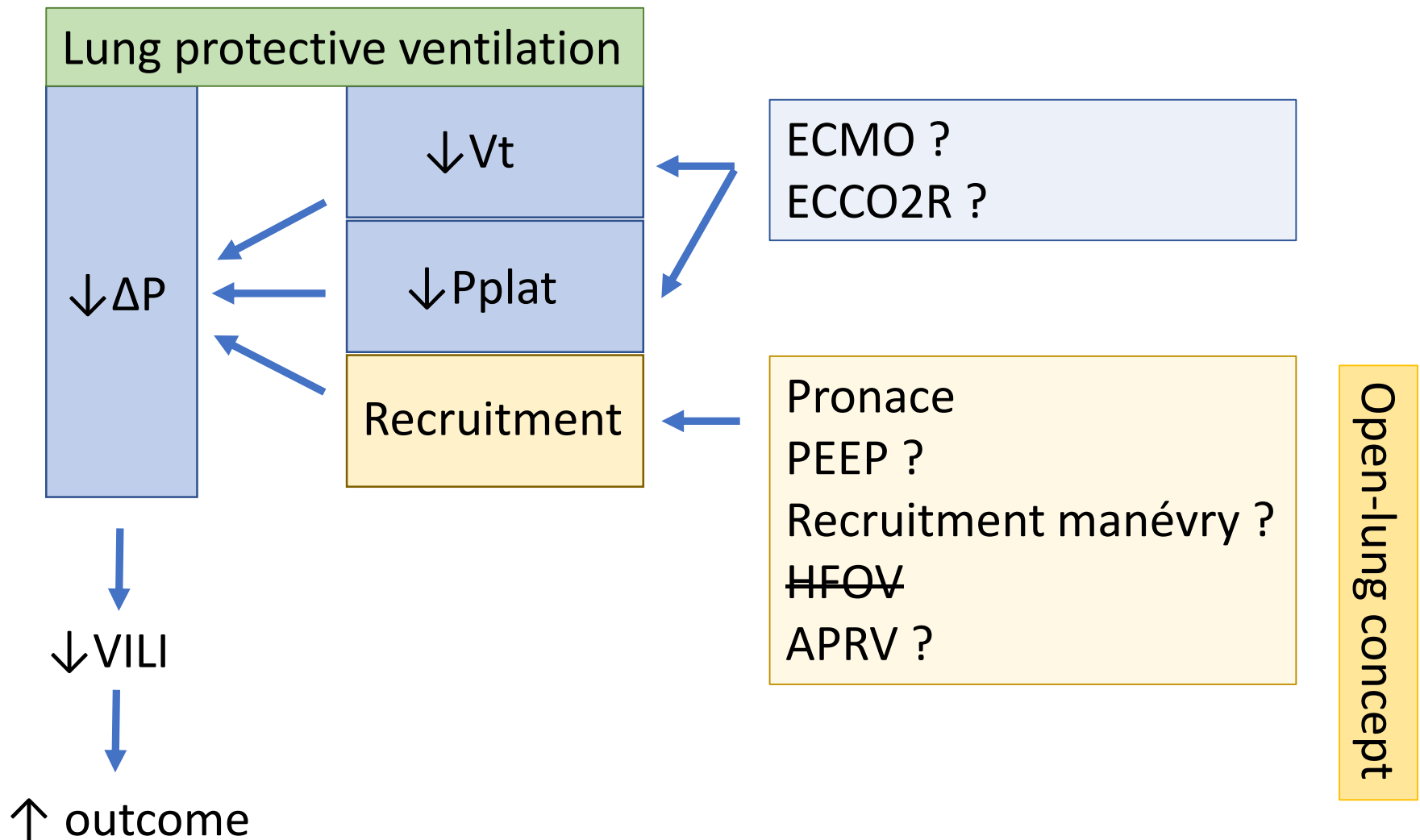
Hlavní kritika:

Dominantě zastoupena Jižní Amerika (hl. Brazílie)

Vyšší mortalita v obou větvích než v obdobných studiích

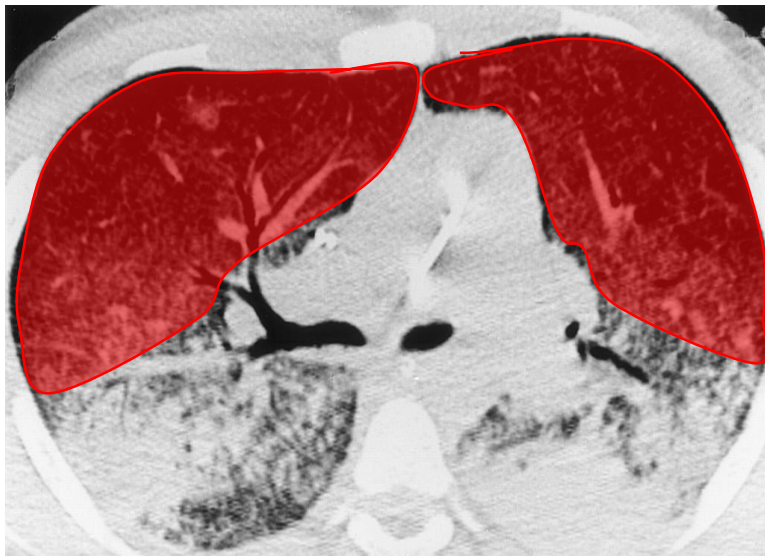
Pouze 10% pronace

PEEP v kontrolní skupině byl o trochu vyšší (cca 3 mbar) než v obdobných studiích

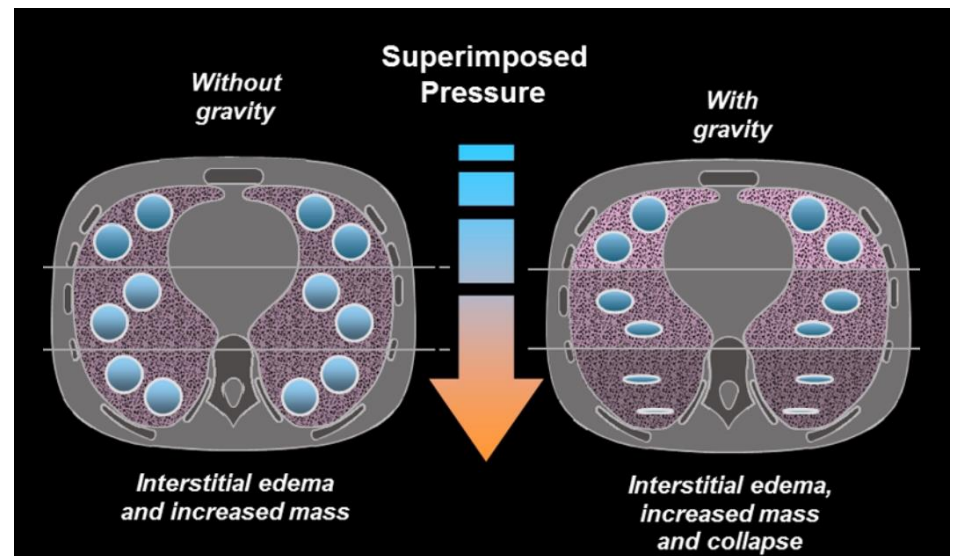


"Původní modely" ARDS

Baby Lung Model



Sponge Model



Recruitment + OLC je logickou úvahou

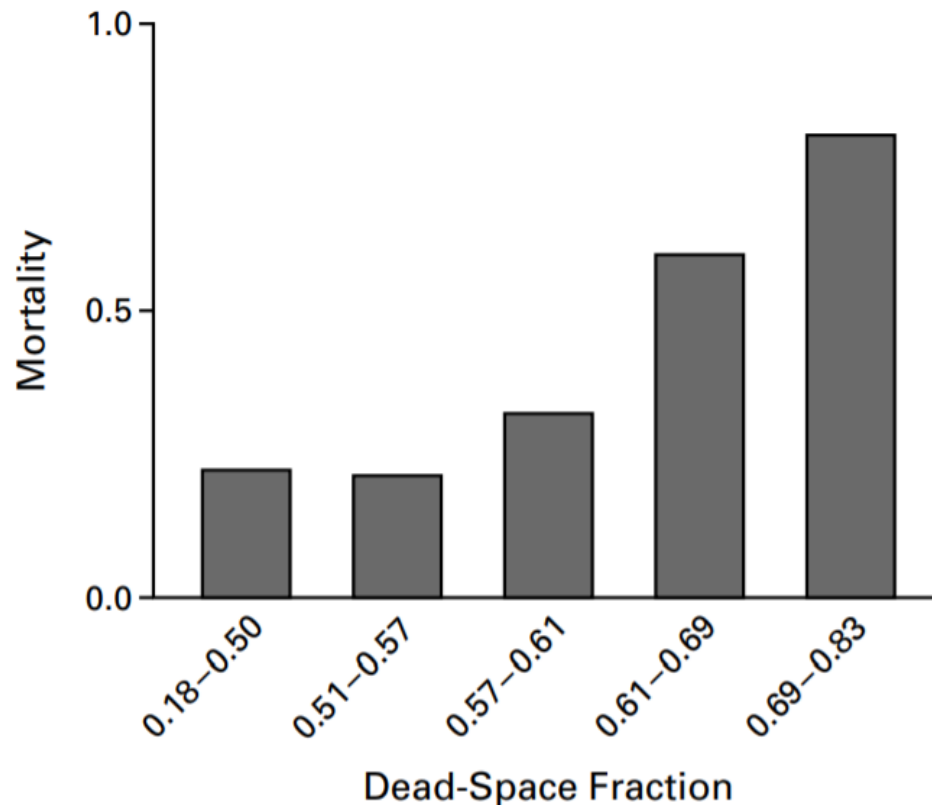
Je náš mentální model ARDS správný?

PULMONARY DEAD-SPACE FRACTION AS A RISK FACTOR FOR DEATH
IN THE ACUTE RESPIRATORY DISTRESS SYNDROME

2002

THOMAS J. NUCKTON, M.D., JAMES A. ALONSO, R.R.T., RICHARD H. KALLET, R.R.T., M.S., BRIAN M. DANIEL, R.R.T.,
JEAN-FRANÇOIS PITTET, M.D., MARK D. EISNER, M.D., M.P.H., AND MICHAEL A. MATTHAY, M.D.

$$\text{Dead - Space fraction} = \frac{p_a\text{CO}_2 - P\text{ECO}_2}{p_a\text{CO}_2}$$



Possible mechanisms include
injury of pulmonary capillaries
by thrombotic and
inflammatory mechanisms

=> impaired elimination of CO₂

Critical Care Perspective

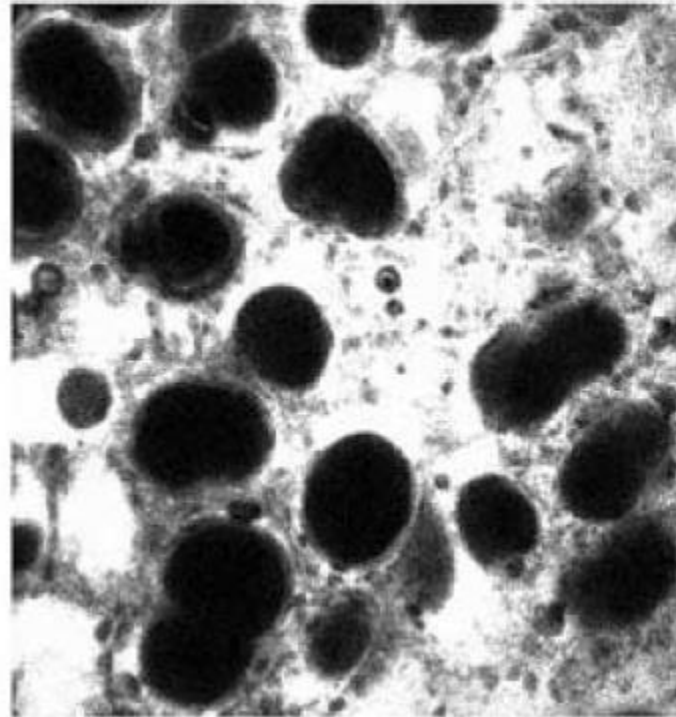
Perspective on Lung Injury and Recruitment

A Skeptical Look at the Opening and Collapse Story

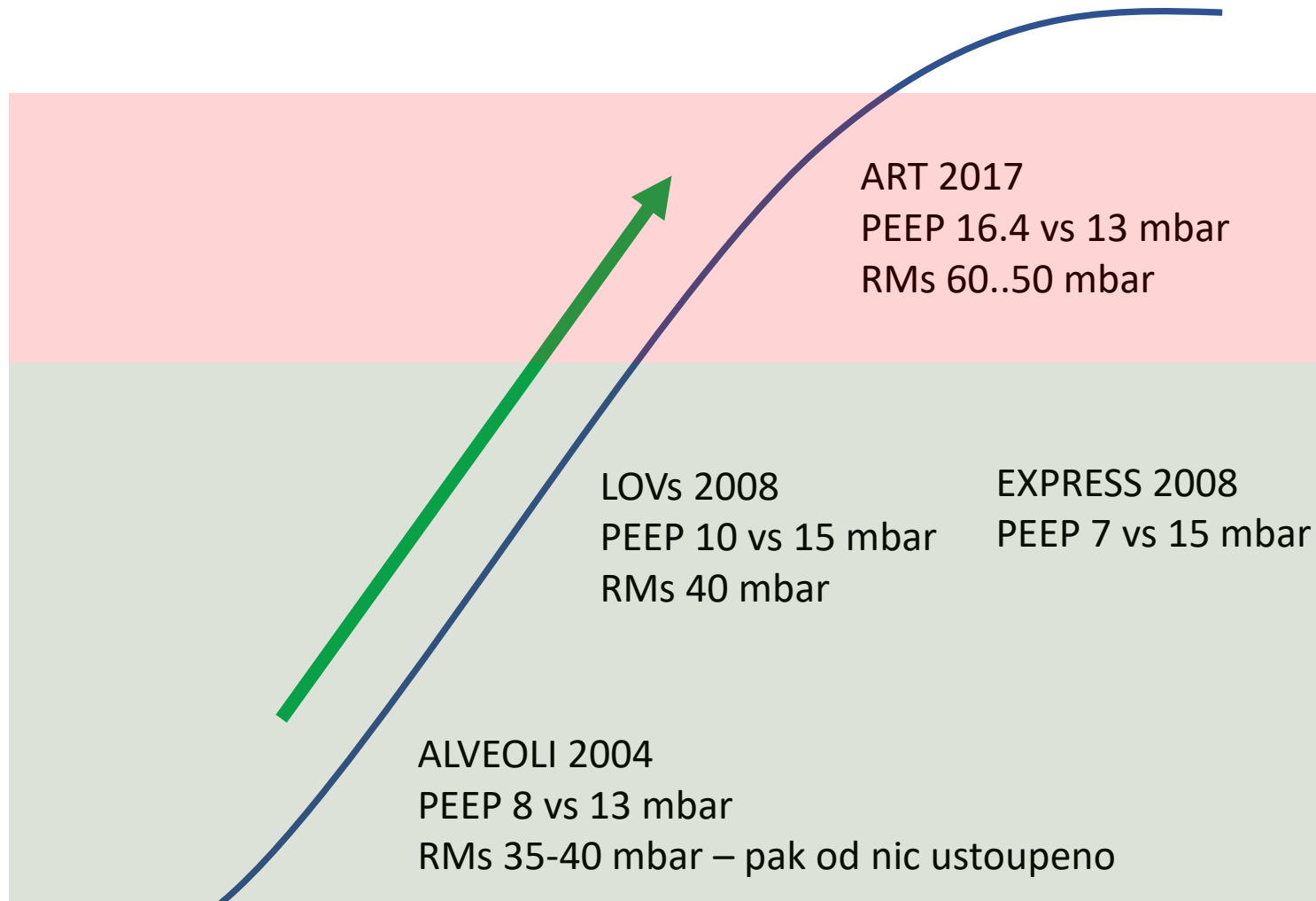
Rolf D. Hubmayr

Mayo Clinic, Rochester, Minnesota

Alveoly jsou vyplněny tekutinou spíše než zkolabované...



Vyšší tlaky vedou k hyperinflaci částečně vzdušných oblastí ...



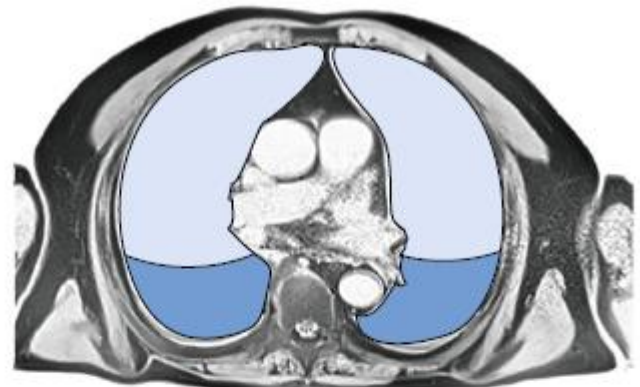
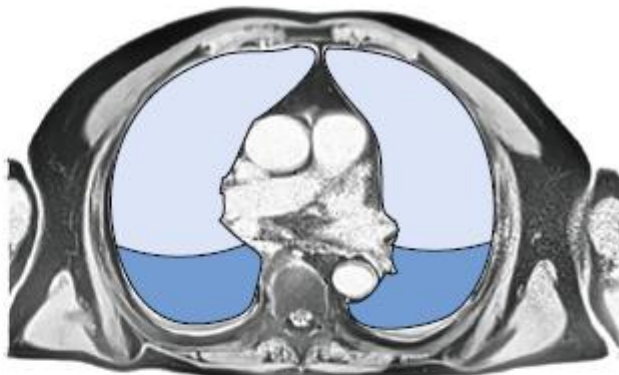
↑ mortalita

↓ mortalita

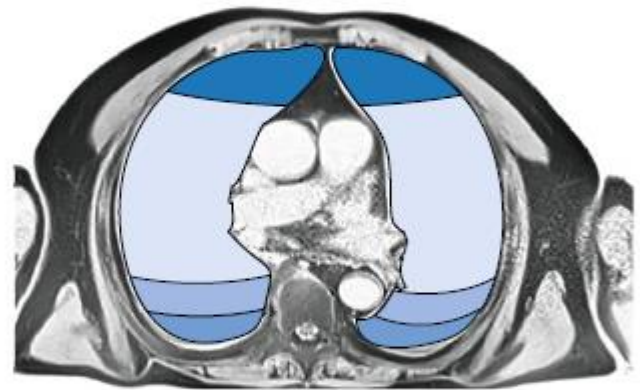
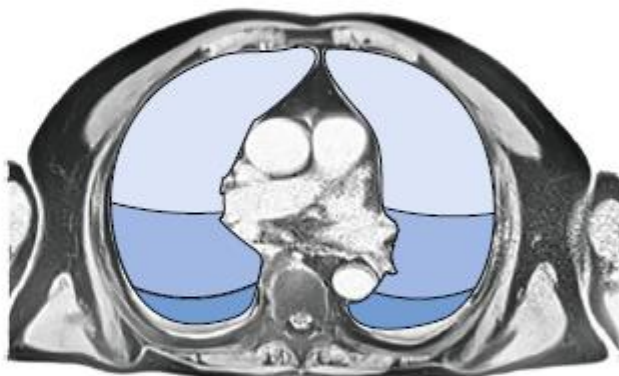
EXPIRATION

INSPIRATION

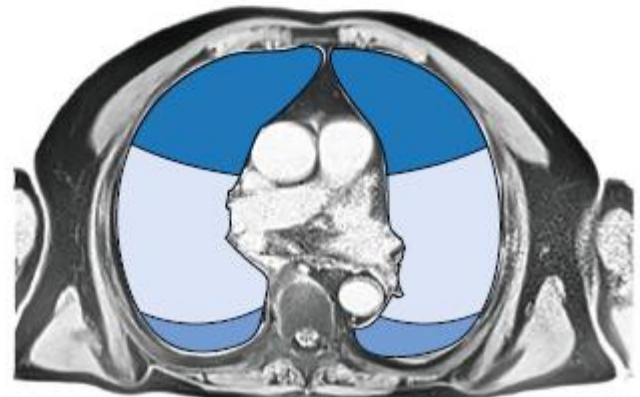
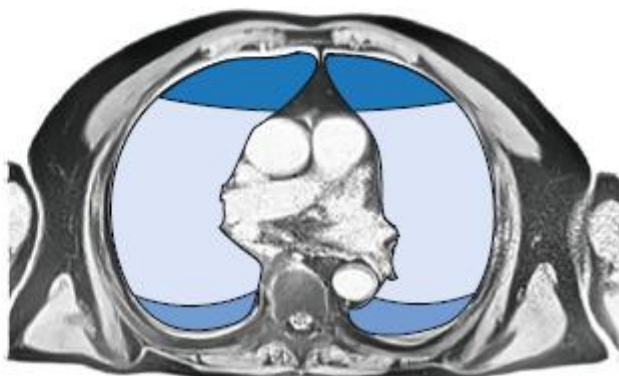
LOW V_T
LOW P_{Plat}
LOW PEEP
LOW ΔP



LOW V_T
HIGH P_{Plat}
MODERATE PEEP
LOW-MODERATE ΔP



LOW V_T
HIGH P_{Plat}
HIGH PEEP
HIGH OR LOW ΔP

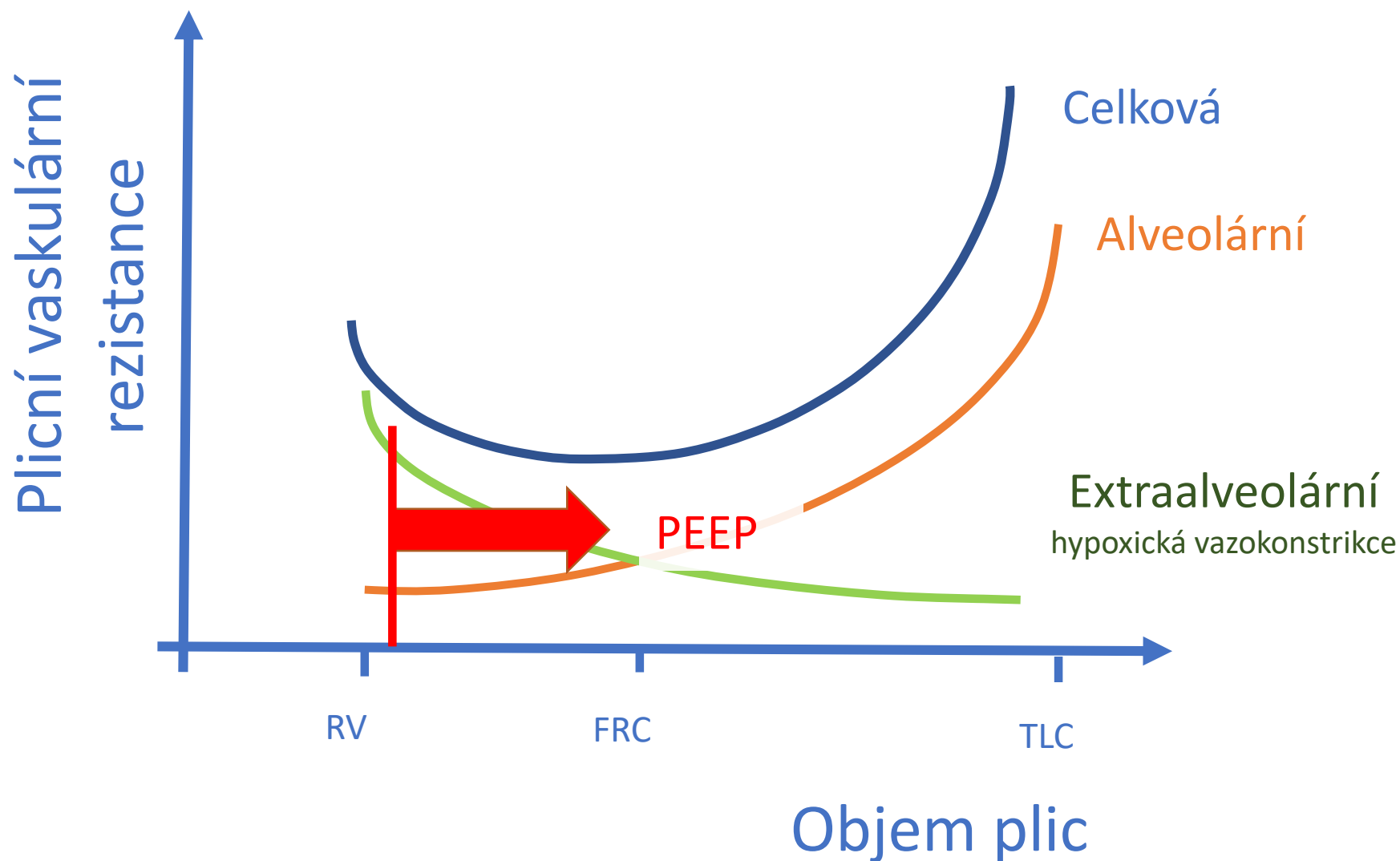


Některé práce naznačují že
hyperinflace je může být horší než atelektáza

Nízký oproti vysokému PEEP:
minim. ovlivňuje lymfatickou drenáž plic
a zlepšuje funkci pravé komory

- Low PEEP minimally impairs lymphatic drainage
- Low PEEP improves right ventricular function
- atelectatic lung regions exhibit reduced lung inflammation if kept at rest.
- CT scan studies have shown that high PEEP levels (> 15 cmH₂O) are needed to keep the lungs fully open and are always associated with increased overdistension and hemodynamic impairment.

Plicní objemy při UPV a PVR



Open up the lung and keep the lung open
(Lachman 1992)

vs.

Close down the lungs and keep them resting to minimize
ventilator-induced lung injury
(Pelosi 2018)

Permissive atelectasis

Permisivní atelektáza

- 1/ minimální PEEP k zajištění permisivní hypoxemie
- 2/ minimální ΔP (V_t a P_{plat}) + minimální dechová frekvence (permisivní hyperkapnie)

Děkuji za pozornost!