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UPV u ARDS
Recruitment, PEEP

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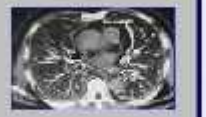
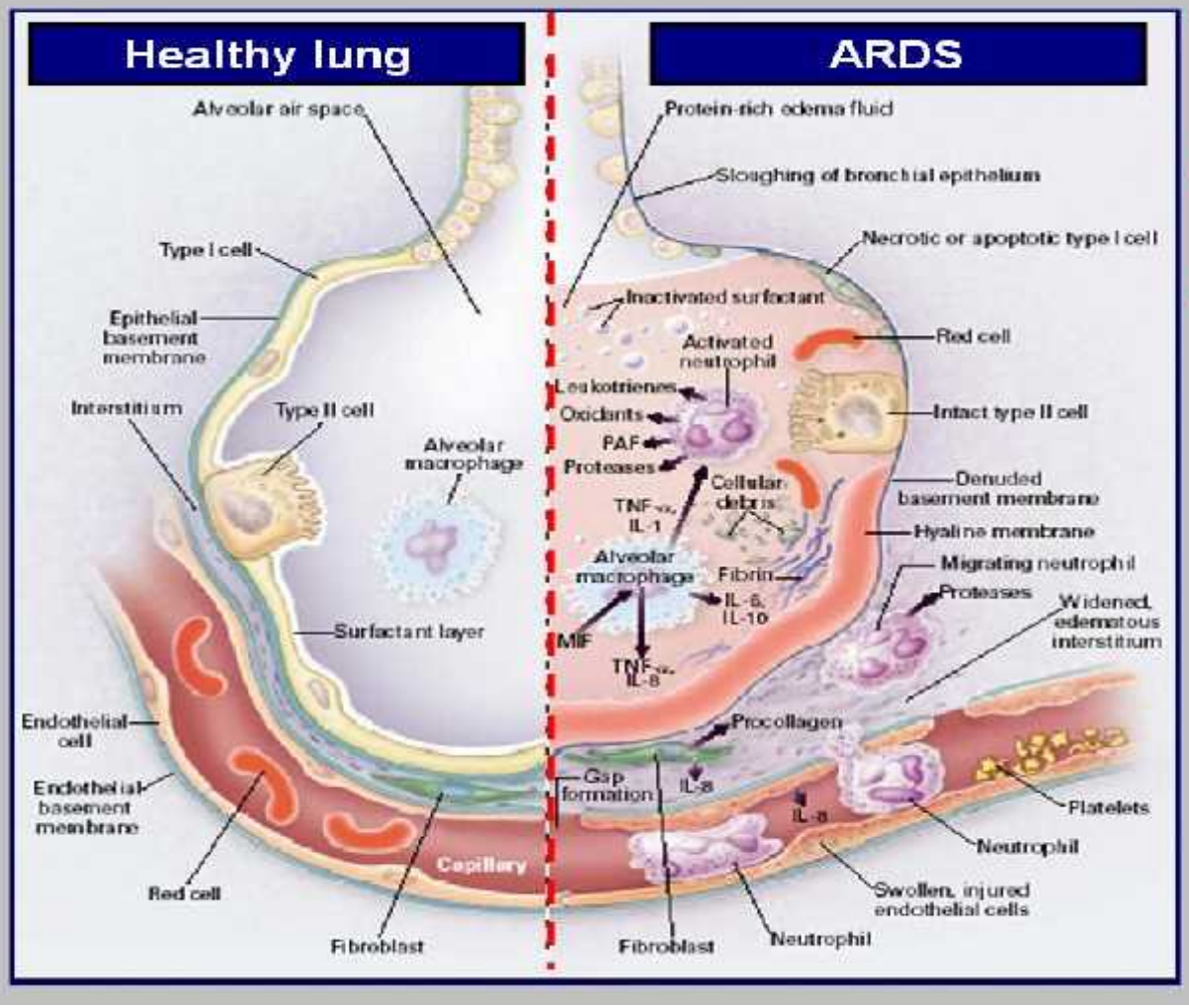
Fyziologický / patologický





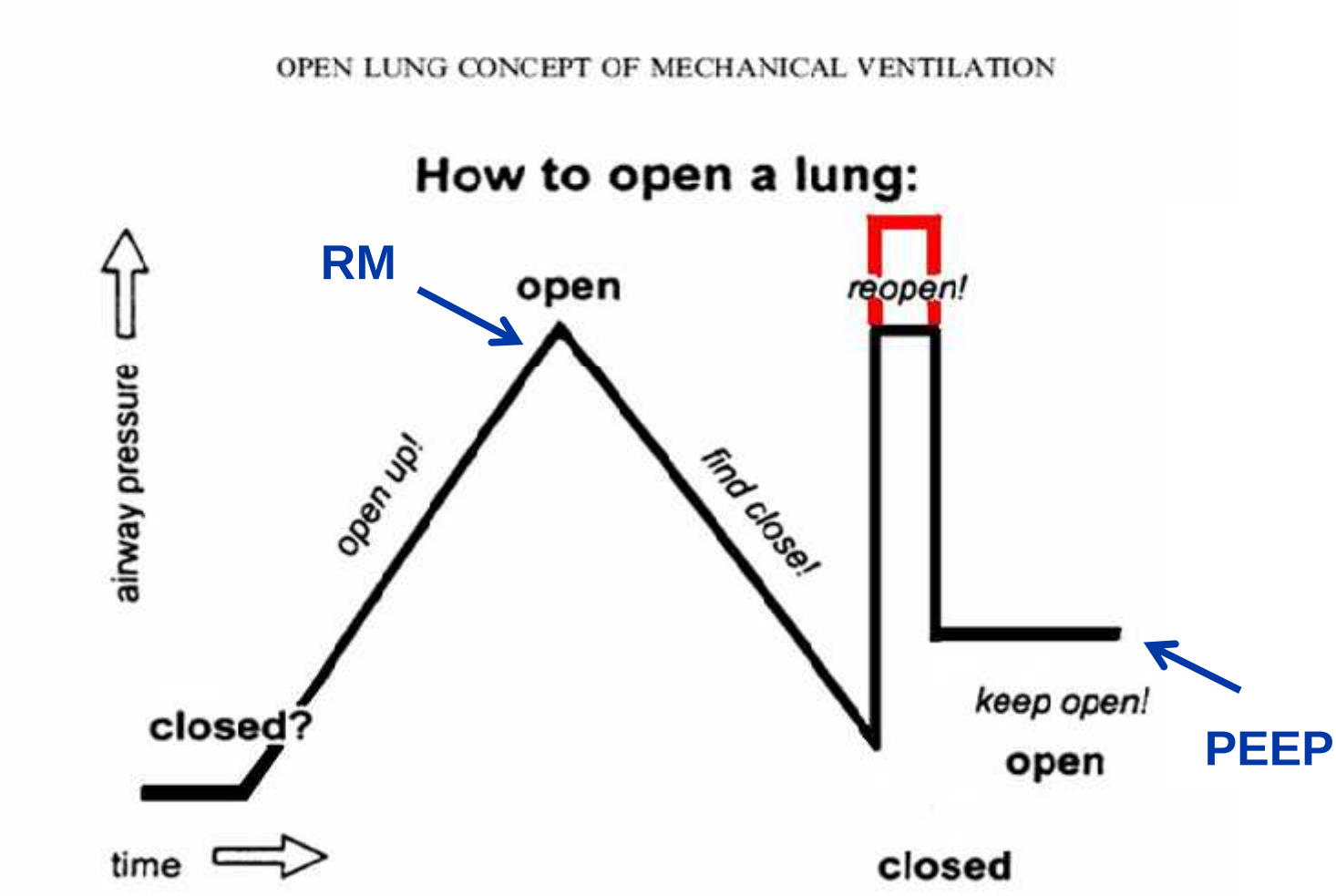
ADRS nová definice

ARDS - Berlínská definice 2011			
stupně ARDS	**mírné**	**střední**	**těžké**
nástup	**akutní začátek do 1 týdne od klinického insultu / prvních příznaků zhoršení**		
hypoxémie	**paO_2/FiO_2 201-300 + PEEP ≥ 5**	**paO_2/FiO_2 ≤ 200 + PEEP ≥ 5**	**paO_2/FiO_2 ≤ 100 + PEEP ≥ 10**
etiologie edému	**respirační selhání není plně vysvětlitelné srdečním selháním nebo tekutinovým přetížením**		
radiologický nález	**bilaterální opacity**	**bilaterální opacity**	**bilaterální opacity minimálně v 3 kvadrantech**
přidružený patologický nález	**x**	**x**	**V_{Ecorr} > 10L/min nebo C_{RS} < 40 ml/cmH_2O**

V_{Ecorr} korigovaná minutová ventilace V_E x $pCO_2/40$, C_{RS} kompliance plic

Ranieri M. 2011 ESICM

Open up the lung and keep the lung open

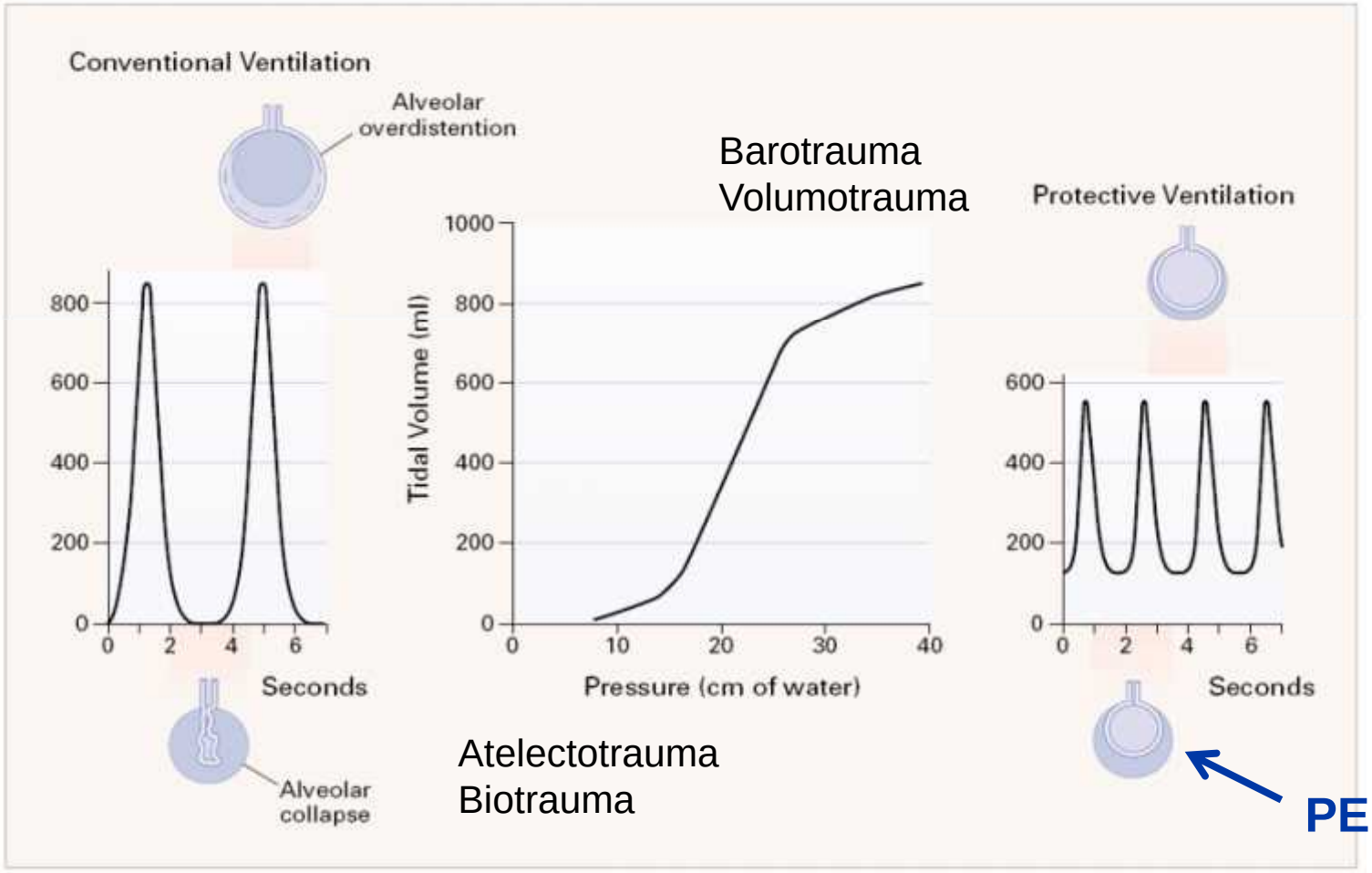


Lachmann B, ICM, 1992

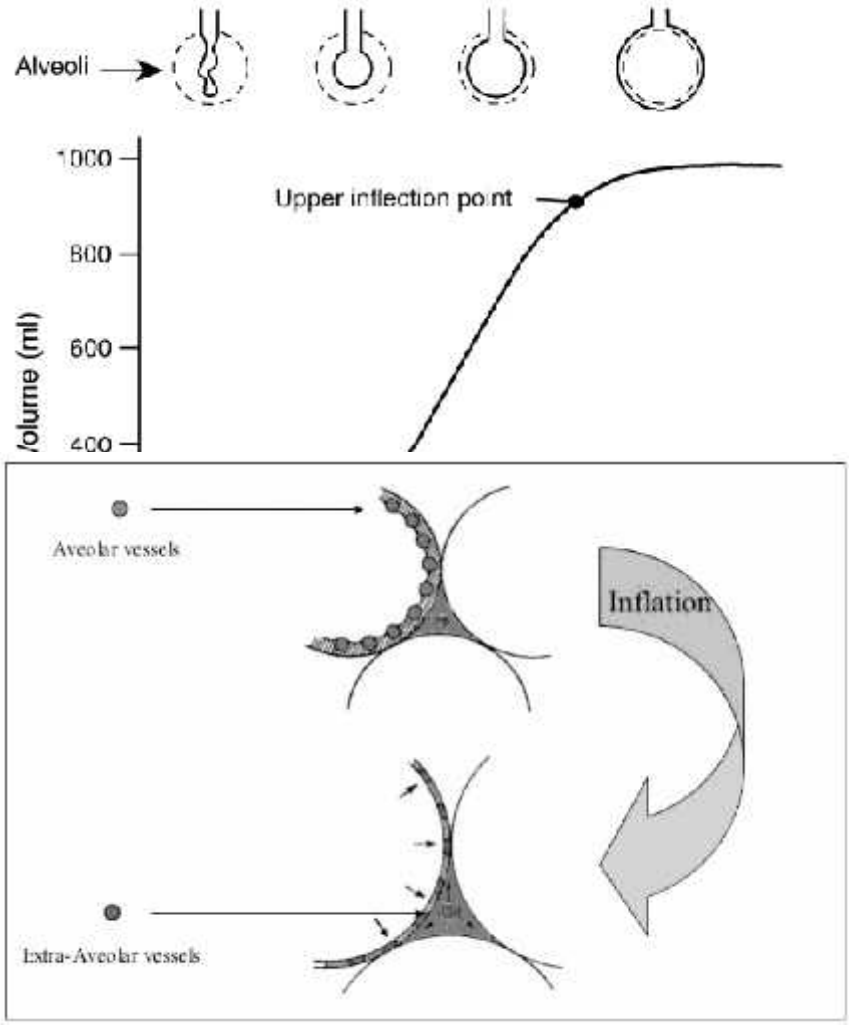
Protektivní ventilace, PEEP

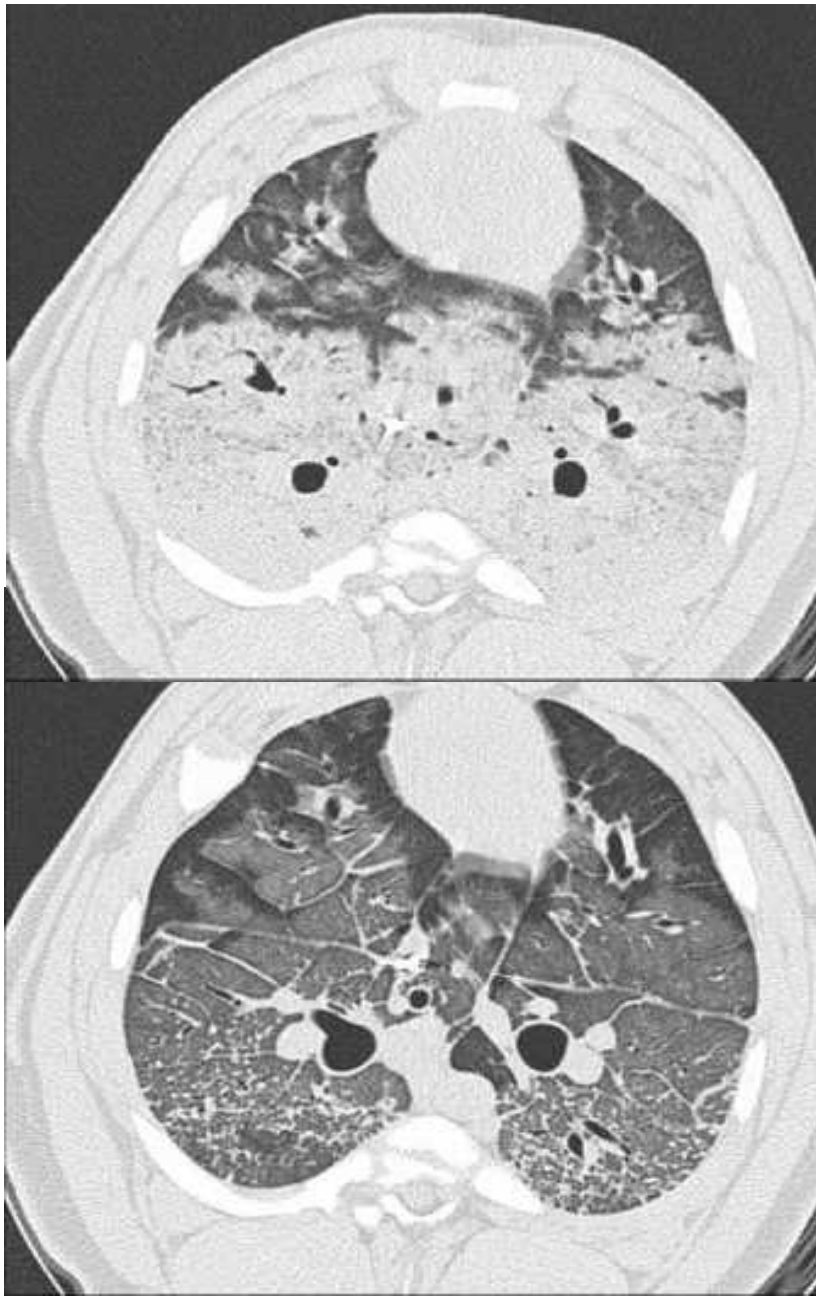
10 ml/kg, nízká DF

6 ml/kg, PEEP, vyšší DF

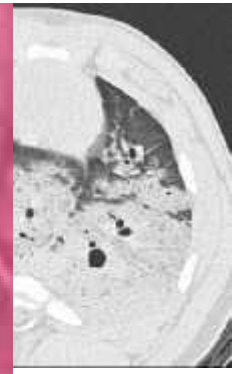


PEEP / RM

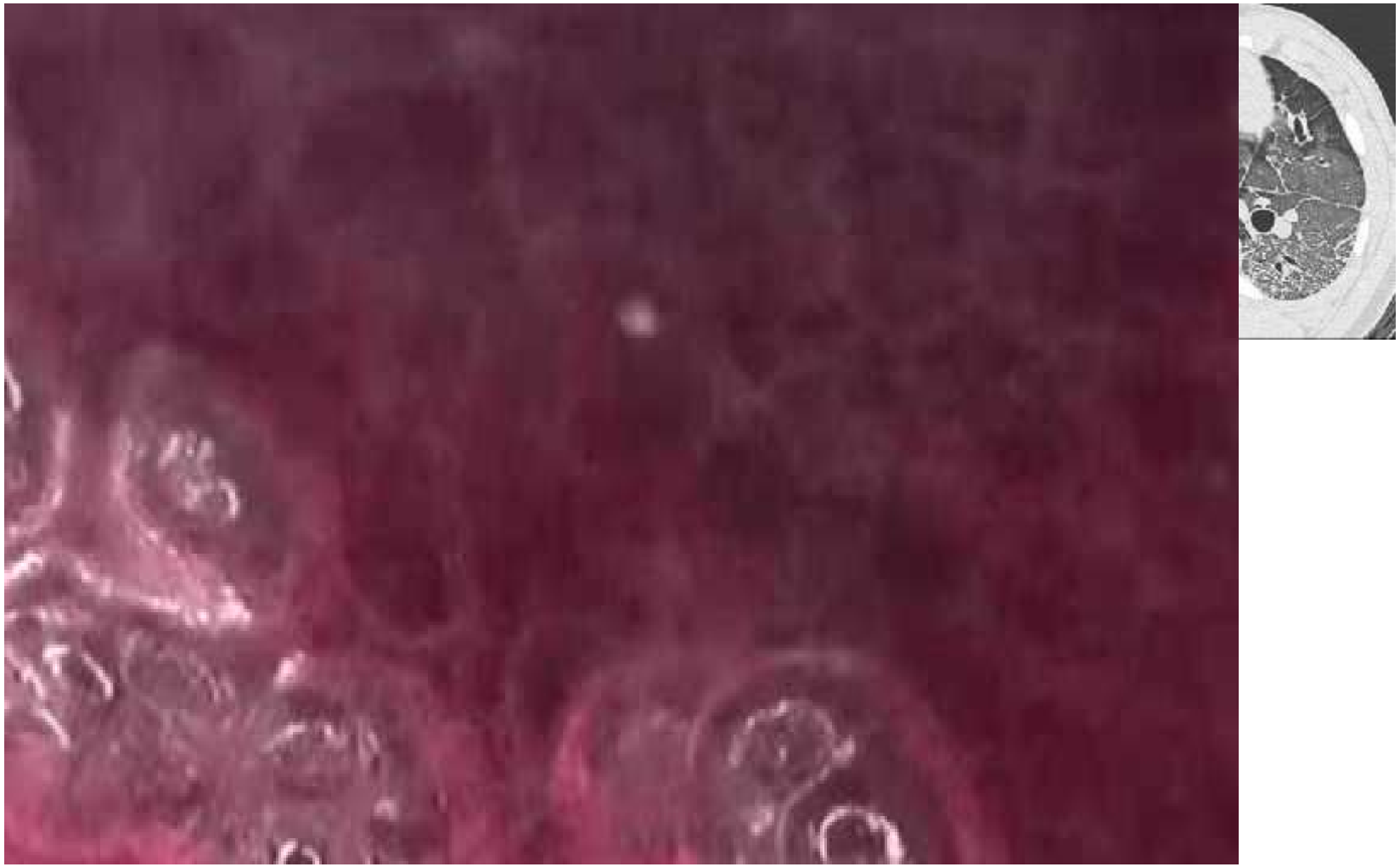

Alveoli
1000
800
600
400
Upper inflection point
Alveolar vessels
Inflation
Extra-Alveolar vessels



Použití PEEPu



Použití PEEPu / PCV-RM



Efekt PEEPu na mortalitu ARDS?

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

Systematic Review and Meta-analysis

Characteristic	ALVEOLI,[3] 2004	LOVS,[9] 2008	EXPRESS,[10] 2008
Inclusion criteria	Acute lung injury with $Pao_2:Fio_2$ ≤300[a]	Acute lung injury with $Pao_2:Fio_2$ ≤250[a]	Acute lung injury with $Pao_2:Fio_2$ ≤300[a]
Recruitment period	1999-2002	2000-2006	2002-2005
Recruiting hospitals (country)	23 (United States)	30 (Canada, Australia, Saudi Arabia)	37 (France)
Patients randomized to higher vs lower PEEP	278 vs 273	478 vs 509[b]	385 vs 383[c]
Validity			
Concealed allocation	Yes	Yes	Yes
Follow-up for primary outcome, %	100	100	100
Blinded data analysis	Yes	Yes	Yes
Stopped early	Stopped for perceived futility	No	Stopped for perceived futility
Experimental intervention	Higher PEEP according to Fio_2 chart, recruitment maneuvers for first 30 patients	Higher PEEP according to Fio_2 chart, required plateau pressures ≤40 cm H_2O, recruitment maneuvers	PEEP as high as possible without increasing the maximum inspiratory plateau pressure >28-30 cm H_2O
Control intervention	Conventional PEEP according to Fio_2 chart, required plateau pressures ≤30 cm H_2O, no recruitment maneuvers	Conventional PEEP according to Fio_2 chart, required plateau pressures ≤30 cm H_2O, no recruitment maneuvers	Conventional PEEP (5-9 cm H_2O) to meet oxygenation goals

Briel, JAMA, 2010

Efekt PEEPu na mortalitu ARDS? EXPRESS trial

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Positive End-Expiratory Pressure Setting in Adults With Acute Lung Injury and Acute Respiratory Distress Syndrome
A Randomized Controlled Trial

PEEP 5-9cmH20 X max. s cílem <Pplat. 28-30, SpO2 88-95%

Vt 6ml/kg, Ppl.>32 Vt 4ml/kg, df < 35/min pH 7.3-7.4

RM povolen ale NEDOPORUČEN

Table 3. Respiratory Variables During the First 7 Days of Treatment[a]

Variable	Day 1			Day 3			Day 7		
	Minimal Distension	Increased Recruitment	*P* Value	Minimal Distension	Increased Recruitment	*P* Value	Minimal Distension	Increased Recruitment	*P* Value
Tidal volume, mL/kg of predicted body weight	6.1 (0.4)	6.1 (0.3)	.57	6.2 (0.6)	6.2 (0.5)	.83	6.4 (0.9)	6.8 (1.3)	.001
No. of patients	372	378		322	332		210	192	
Plateau pressure, cm H_2O	21.1 (4.7)	27.5 (2.4)	<.001	20.7 (5.0)	26.5 (4.2)	<.001	21.1 (5.6)	24.3 (5.8)	<.001
No. of patients	365	378		314	329		173	163	
PEEP, cm H_2O	7.1 (1.8)	14.6 (3.2)	<.001	6.7 (1.8)	13.4 (4.7)	<.001	6.2 (2.1)	8.9 (5.1)	<.001
No. of patients	372	380		333	351		264	252	
Total PEEP, cm H_2O[b]	8.4 (1.9)	15.8 (2.9)	<.001	8.1 (2.0)	15.1 (4.3)	<.001	8.0 (2.5)	12.0 (5.4)	<.001
No. of patients	336	348		274	284		154	138	
Pao_2/Fio_2	150 (69)	218 (97)	<.001	175 (81)	245 (98)	<.001	184 (79)	206 (85)	.003
No. of patients	371	378		331	350		262	247	

Mercat, JAMA,2008

Efekt PEEPu na mortalitu ARDS? EXPRESS trial

Positive End-Expiratory Pressure Setting in Adults With Acute Lung Injury and Acute Respiratory Distress Syndrome
A Randomized Controlled Trial

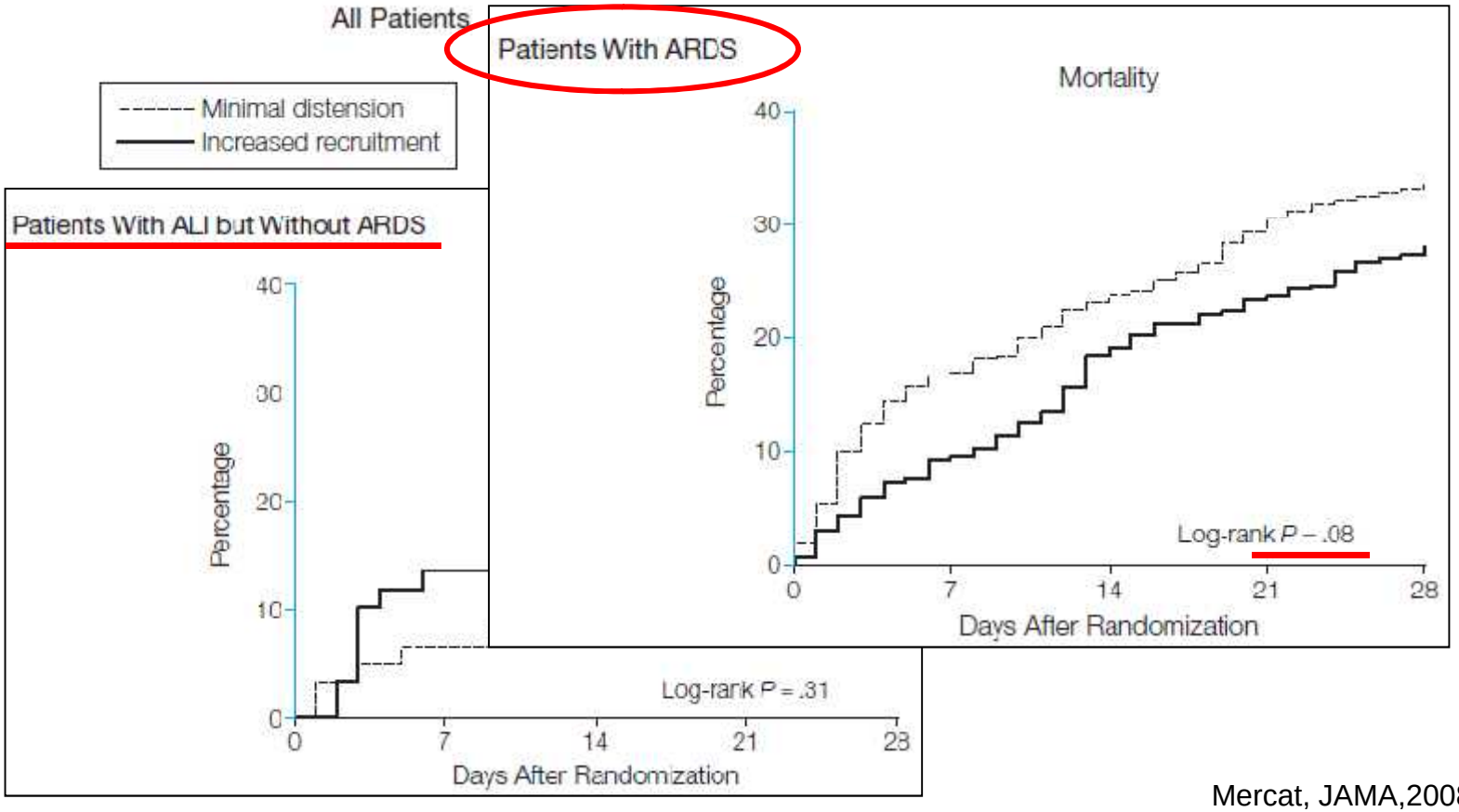
Table 5. Cointerventions and Adjunctive Therapies

Intervention	No. (%)[a] Minimal Distension (n=382)	No. (%)[a] Increased Recruitment (n=385)	*P* Value
During the first 72 h			
Fluid loading	255 (66.8)	290 (75.3)	.01
Volume of fluids, median (IQR), L[b]	0.5 (0-1.5)	1.0 (0.1-2.2)	<.001
During the first 7 d			
Epinephrine or norepinephrine	286 (74.9)	289 (75.1)	.95
Corticosteroids	198 (51.8)	199 (51.7)	.97
Neuromuscular blockade	209 (54.7)	204 (53)	.63
Recruitment maneuvers	49 (12.8)	27 (7.0)	.007
Adjunctive therapies during the first 7 d			
Prone position	72 (18.8)	34 (8.8)	<.001
Inhaled nitric oxide	98 (25.7)	57 (14.8)	<.001
Almitrine bismesylate	25 (6.5)	14 (3.6)	.07
Any therapy	132 (34.6)	72 (18.7)	<.001
Mortality in patients who received rescue therapy	62 (47.0)	37 (51.4)	.55

Mercat, JAMA,2008

Efekt PEEPu na mortalitu ARDS?
EXPRESS trial

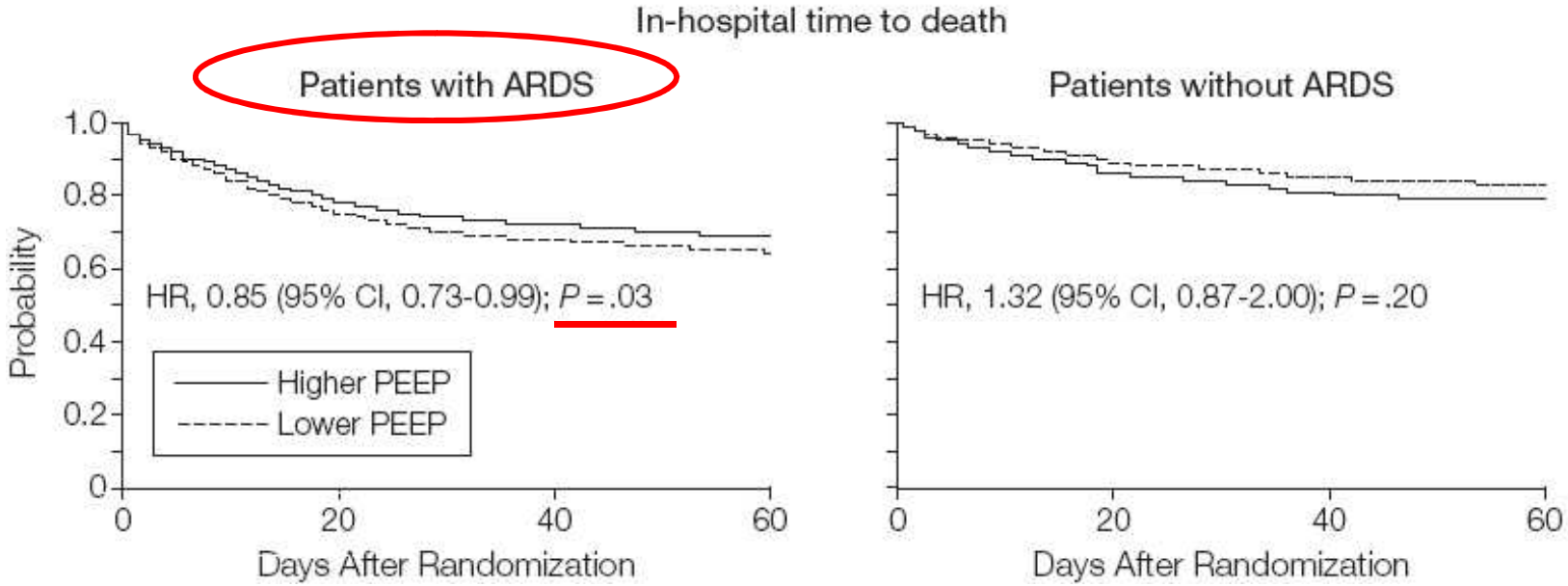
Positive End-Expiratory Pressure Setting in Adults With Acute Lung Injury and Acute Respiratory Distress Syndrome
A Randomized Controlled Trial



Mercat, JAMA,2008

Efekt PEEP u na mortalitu ARDS?

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



Briel, JAMA, 2010

Recruitment maneuver (RM)

- různé typy plicního poškození
  - u sekundárních / extra pulmonálních forem ARDS
- různá tíže plicního postižení i různá fáze
- transpulmonální tlak dosažený během RM
- **typ recruitment manévru SI / PCV - RM**
- nastavení PEEPu po provedeném RM
- diference v poloze pacienta (pronace)
- diference v intravazální náplni i vasoaktivních látkách, které ovlivňují CO i plicní vask. rezistenci

Pelosi et al. Critical Care 2010

Primární / sekundární ARDS

Primární = direct (pulmonary) lung injury

- **damaged alveolar epithelium, alveolar filling by edema, fibrin, and neutrophilic aggregates**

Sekundární = indirect (extrapulmonary) lung injury

- **inflammatory mediators released from extrapulmonary foci into the systemic circulation, microvessel congestion and interstitial edema with relative sparing of intra-alveolar spaces**

„RM more effective to open atelectatic lung regions in indirect compared to direct lung injury“

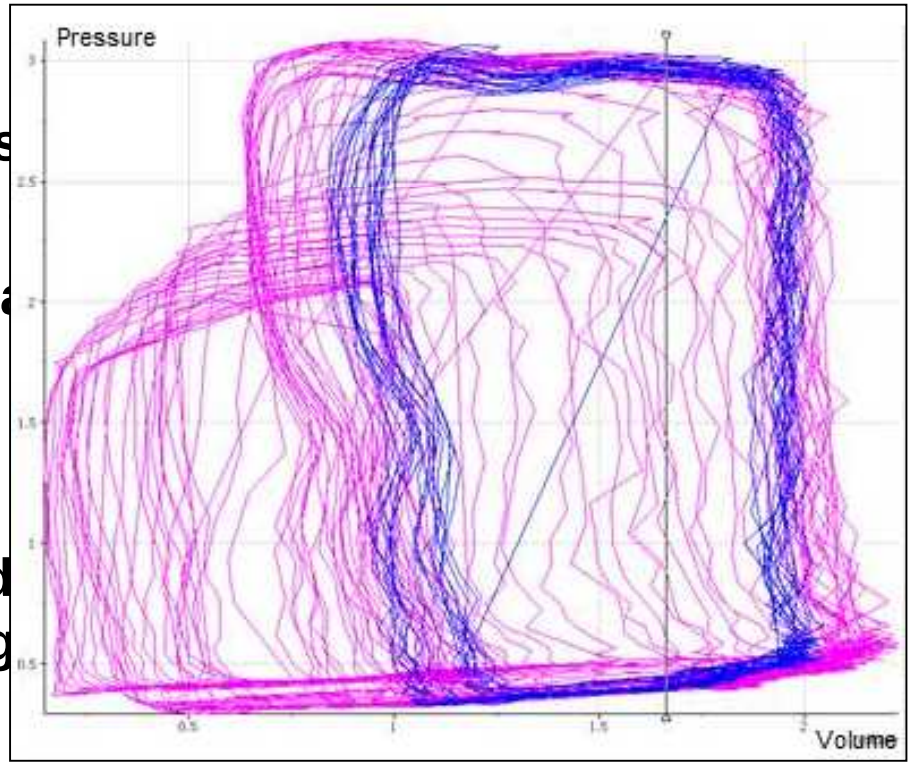
Riva, CCM2009

Typy RM - SI

Sustained Inflation technique

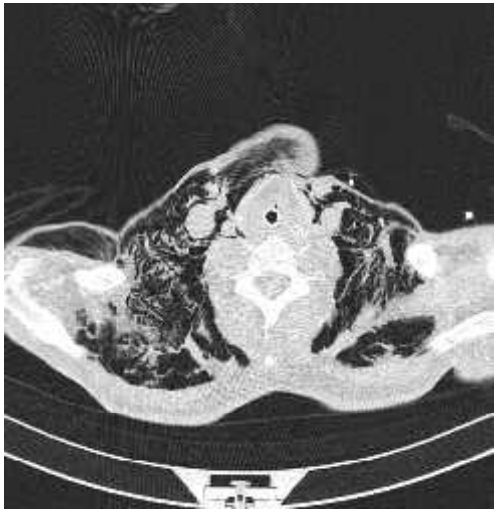
(40 cmH2O to 40/60 sec, 45/45)

- **reducing lung atelectas respiratory mechanics**
- **preventing endotrachea derecruitment**
- **RM may be ineffective, circulatory impairment baro/volutrauma , a red or even worsened oxyg**



Pelosi, Critical Care, 2010

ARDS – barotrauma





Typy RM - varianty

1) **incrementally increased PEEP limiting the maximum inspiratory pressure**

Rzezinski, *Respir Physiol Neurobiol* 2009

2) **PCV applied with escalating PEEP and constant driving pressure**

Villagrá, Am J RespirCrit Care Med 2002

3) **SRM - staircase RM** progressive increase in PEEP (up to 40 cm H2O / higher pr. 55 cm H2O)

Hudgson, CC 2011

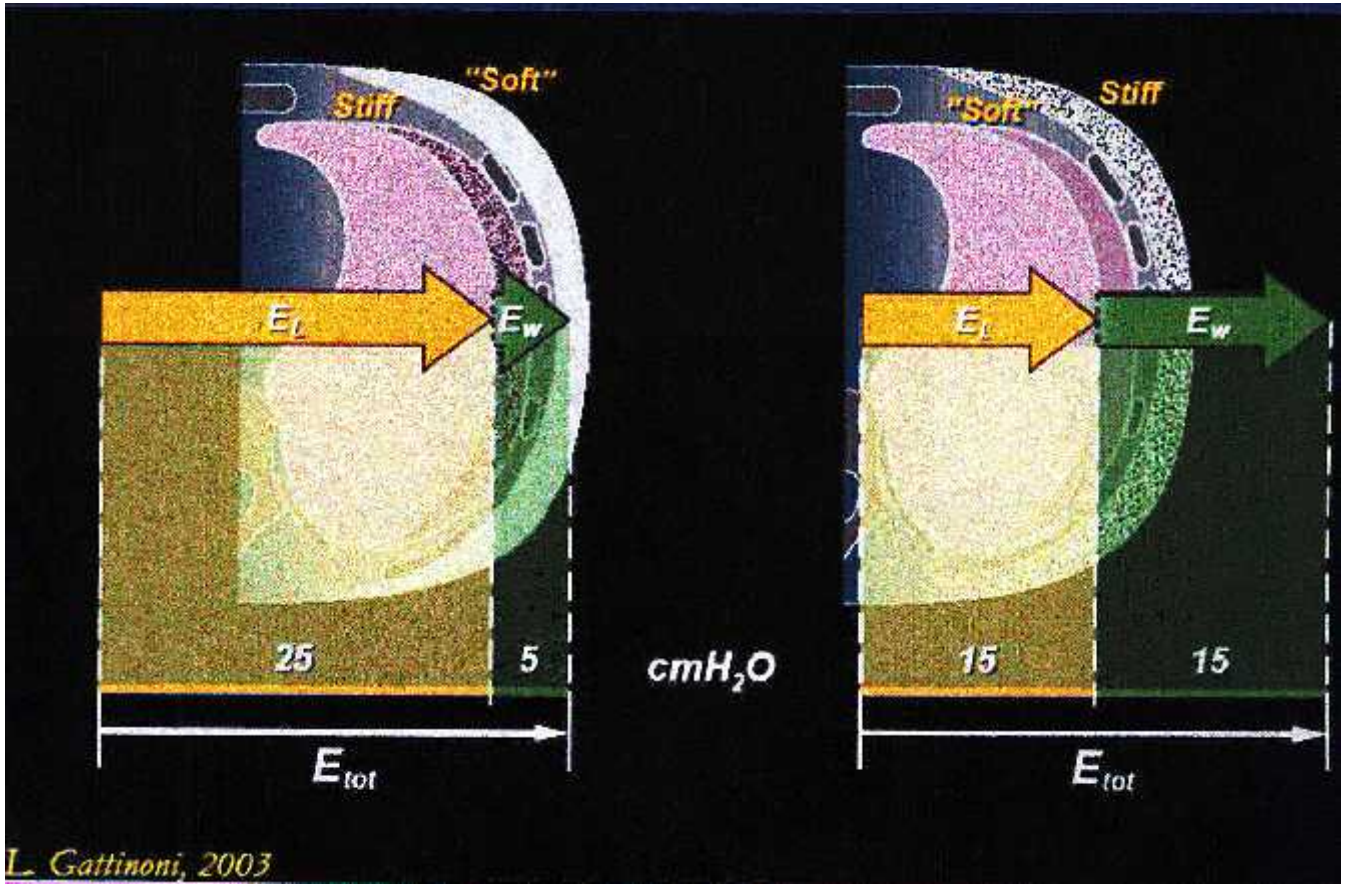
4) **intermittent sighs to reach a specific plateau pressure in volume or pressure control mode** Steimback, IMC,2009, Badet, Respiratory Care, 2009

5) **(RAMP) long slow increase in inspiratory pressure up to 40 cmH2O = PV tool** Riva, Crit Care Med 2009

6) **PCV RM - eSigh: 10 cmH2O above LIP, 15 min** Constantin, CC 2008

7) **PCV RM - PEEP 25 / Phigh 40, 30 min** Borges, AJRCCM,2006

Inspirační P / transpulmonální P



Staircase RM

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A randomised controlled trial of an open lung strategy with staircase recruitment, titrated PEEP and targeted low airway pressures in patients with acute respiratory distress syndrome

Carol L Hodgson[1,2*], David V Tuxen[1], Andrew R Davies[1,2], Michael J Bailey[1,2], Alisa M Higgins[2], Anne E Holland

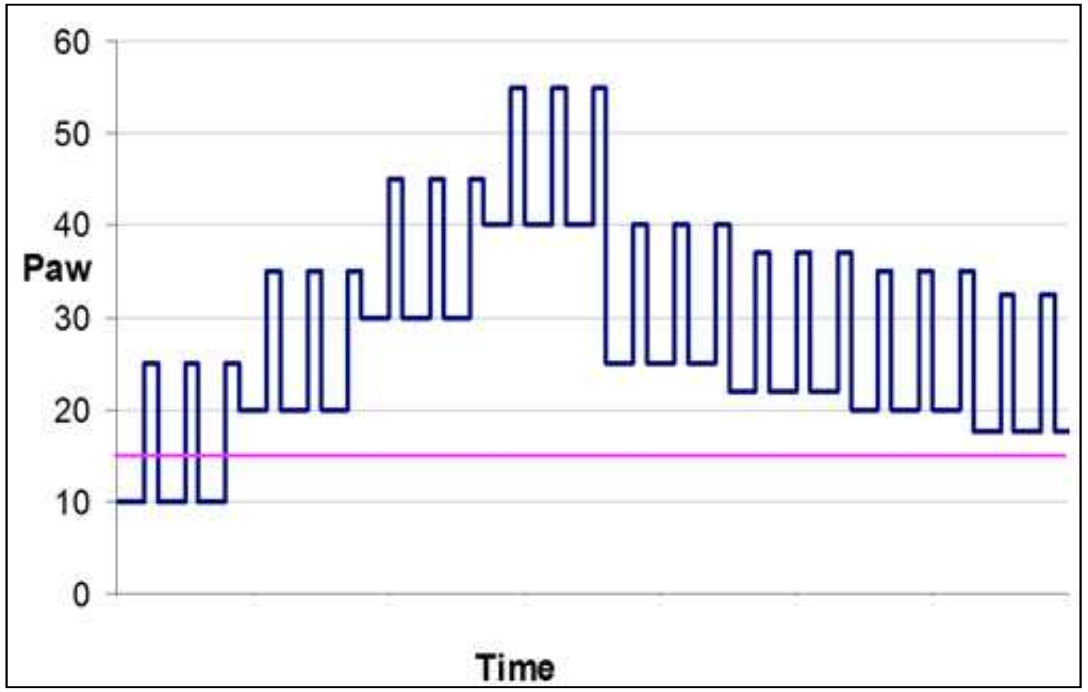
SRM:

PEEP 20 (2min)+15 PC
30 (2min) before
40 cmH20 (2min)
to check HD tolerance

PEEP reductions to 25
down in 2.5
every 3 min
derecruitment when
SaO2 decreases by 1-2%

Incr. PEEP to 40 for 1min
and return 2,5 above

20 pts:
10 **PHARLAP SRM daily**
10 ARDS protocol
(Pplat<30, 6ml/kg)



Hudgson, CC 2011

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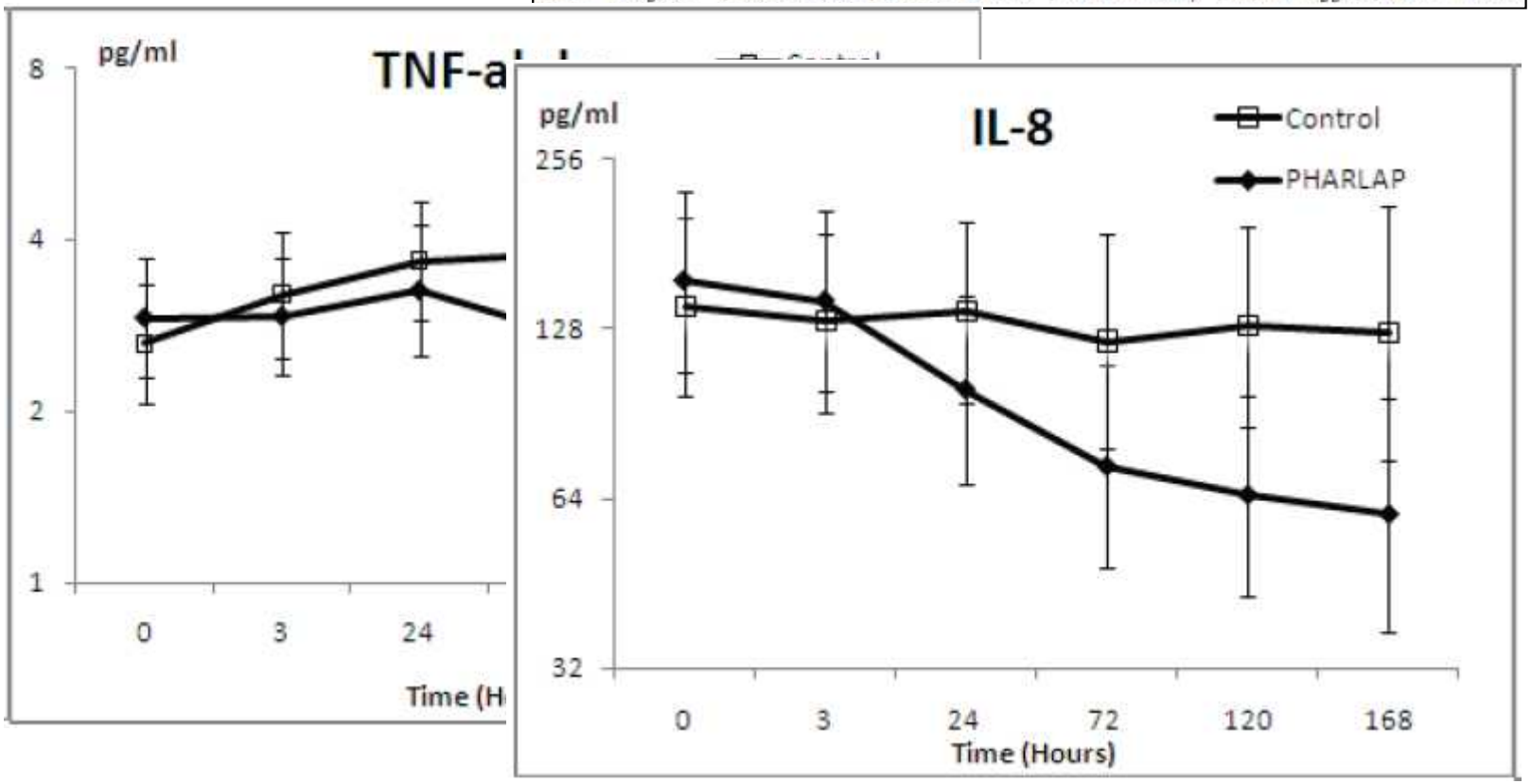

Hudgson, CC 2011

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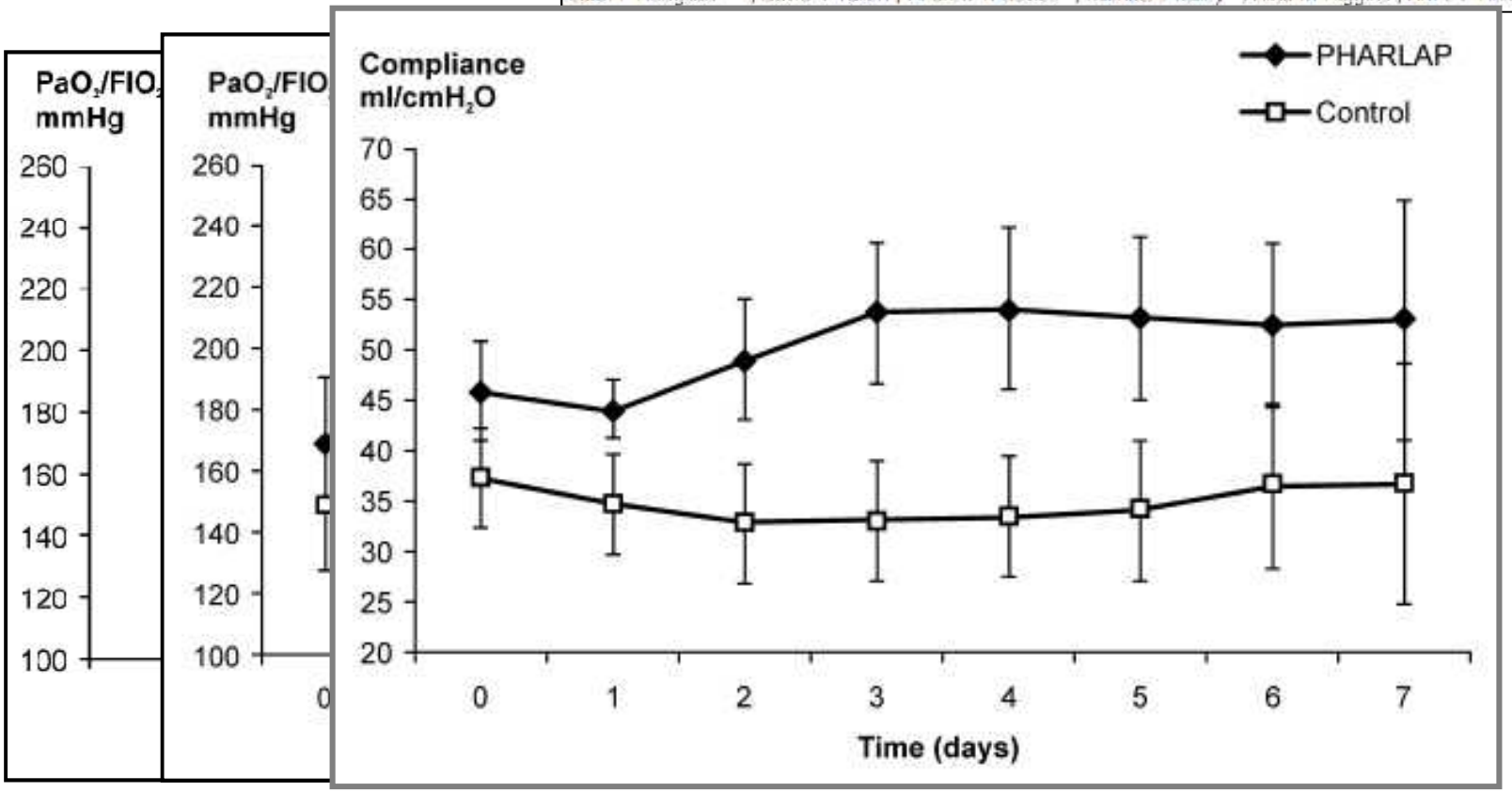

Hudgson, CC 2011

Staircase RM

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Table 4 Outcomes

	PHARLAP	Control	*P*
Hospital mortality, number	3	2	0.61
LOV, hours	180 (87 to 298)	341 (131 to 351)	0.13
ICU LOS, days	9.9 (5.6 to 14.8)	16.0 (8.1 to 19.3)	0.19
Hospital LOS, days	17.9 (13.7 to 34.5)	24.7 (20.5 to 39.8)	0.16
Barotrauma, number	0	0	
Rescue therapies, number of patients	0	2	0.46
SOFA score (Day 7)	8.6 ± 0.3	8.4 ± 0.6	0.27

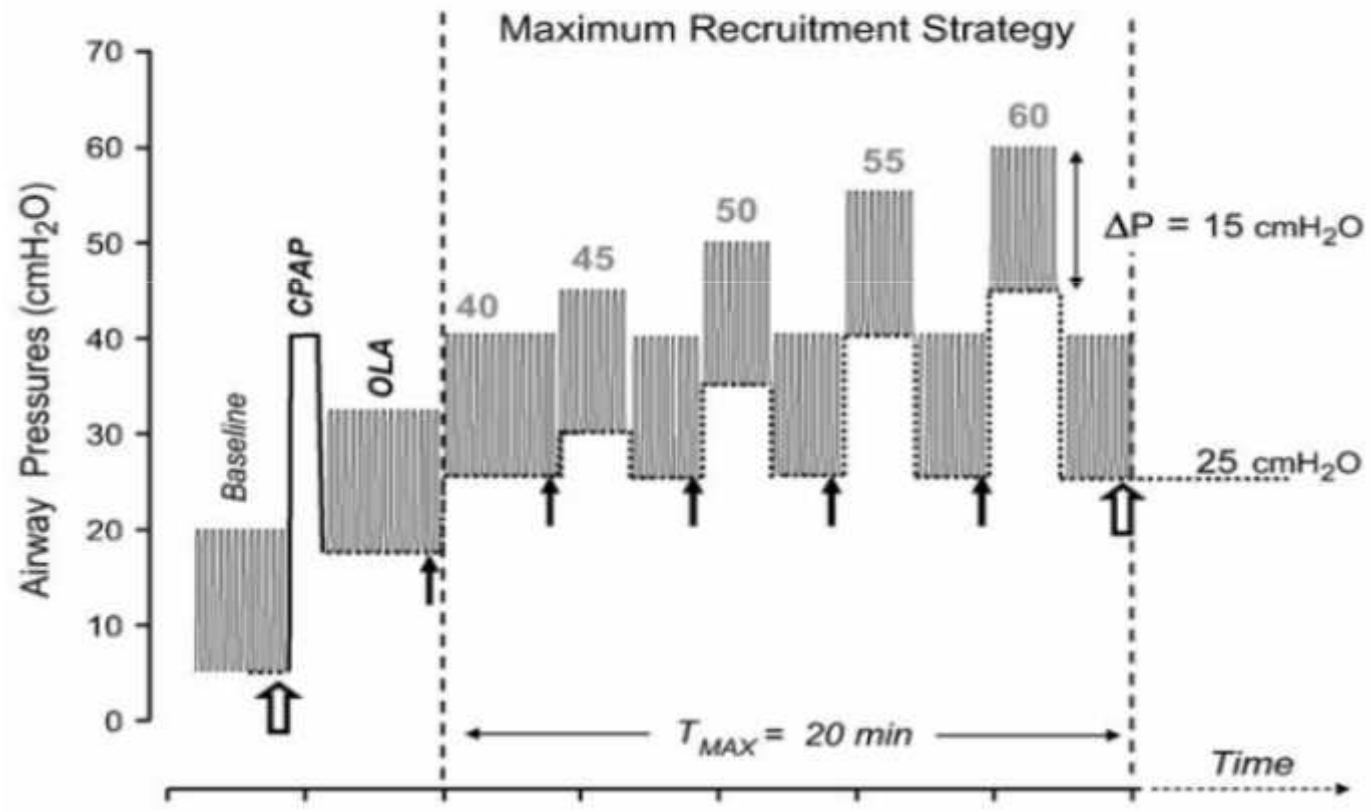
LOV, length of ventilation; ICU LOS, intensive care length of stay; LOS, length of stay;

Hudgson, CC 2011

PCV RM

Reversibility of Lung Collapse and Hypoxemia in Early Acute Respiratory Distress Syndrome

João B. Borges, Valdelis N. Okamoto, Gustavo F. J. Matos, Maria P. R. Caramez, Paula R. Arantes,



SI RM 40/40, set PEEP LIP 19, Press + 5, paO2 + pCO2>400 mmHg, df 10/min

Borges, AJRCCM, 2006

PCV RM

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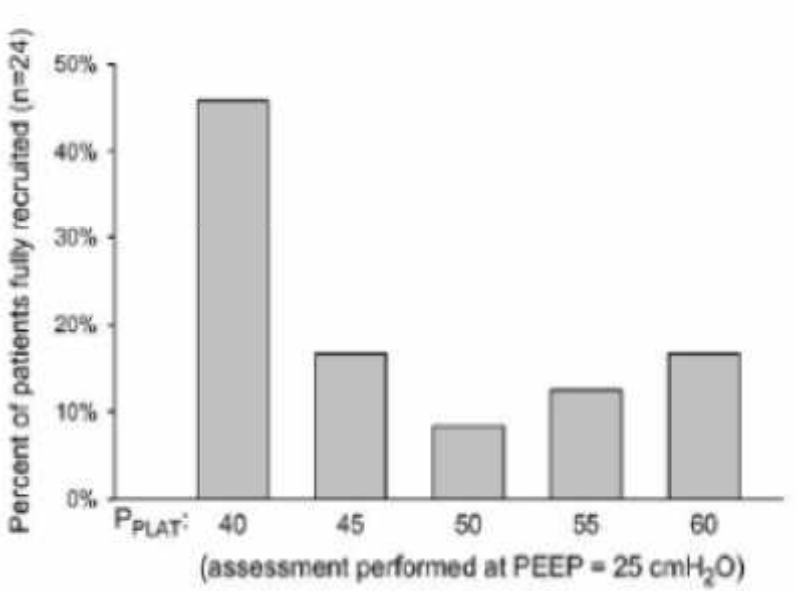
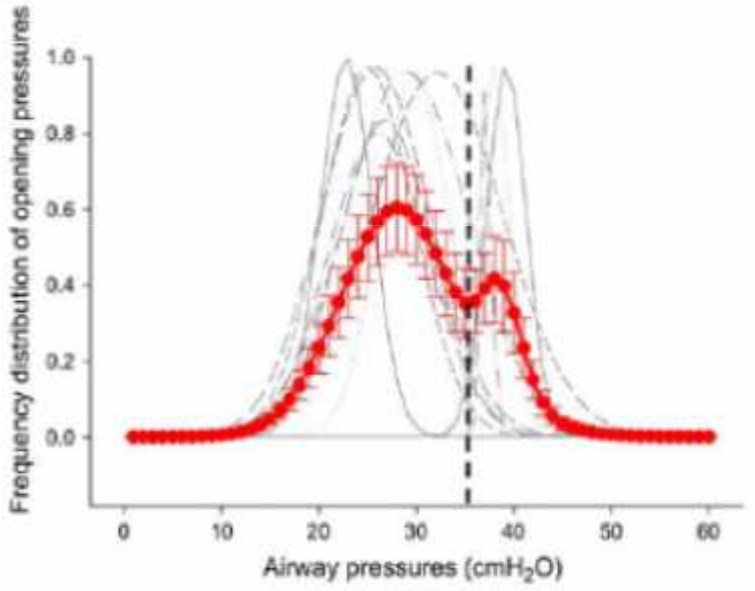


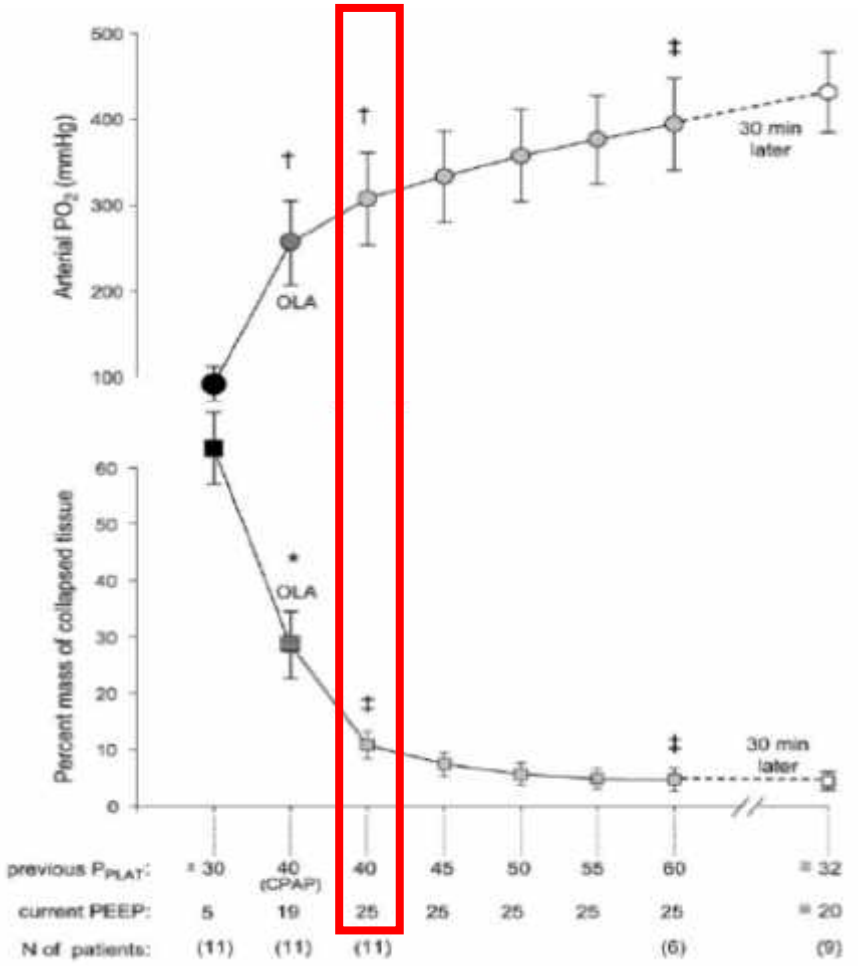


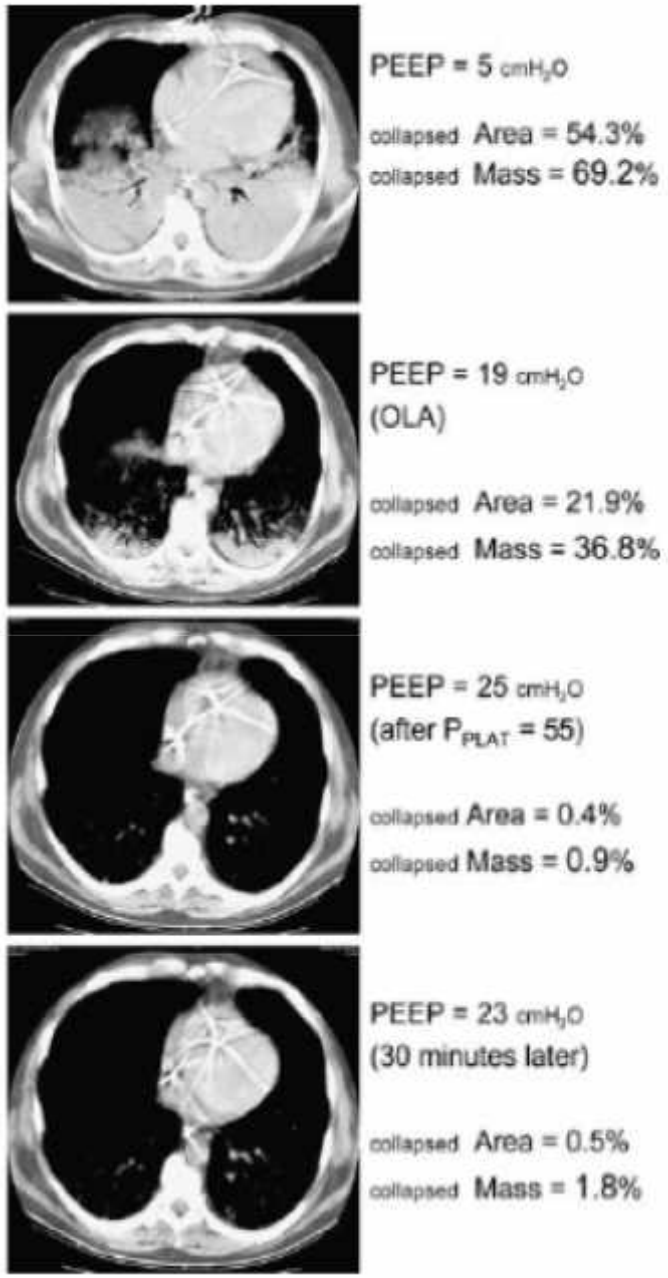
SI RM 40/40, set PEEP LIP 19, Press + 5, paO2 + pCO2>400 mmHg, df 10/min

RM nedosáhli 2/26, žádné barotrauma během

Borges, AJRCCM, 2006

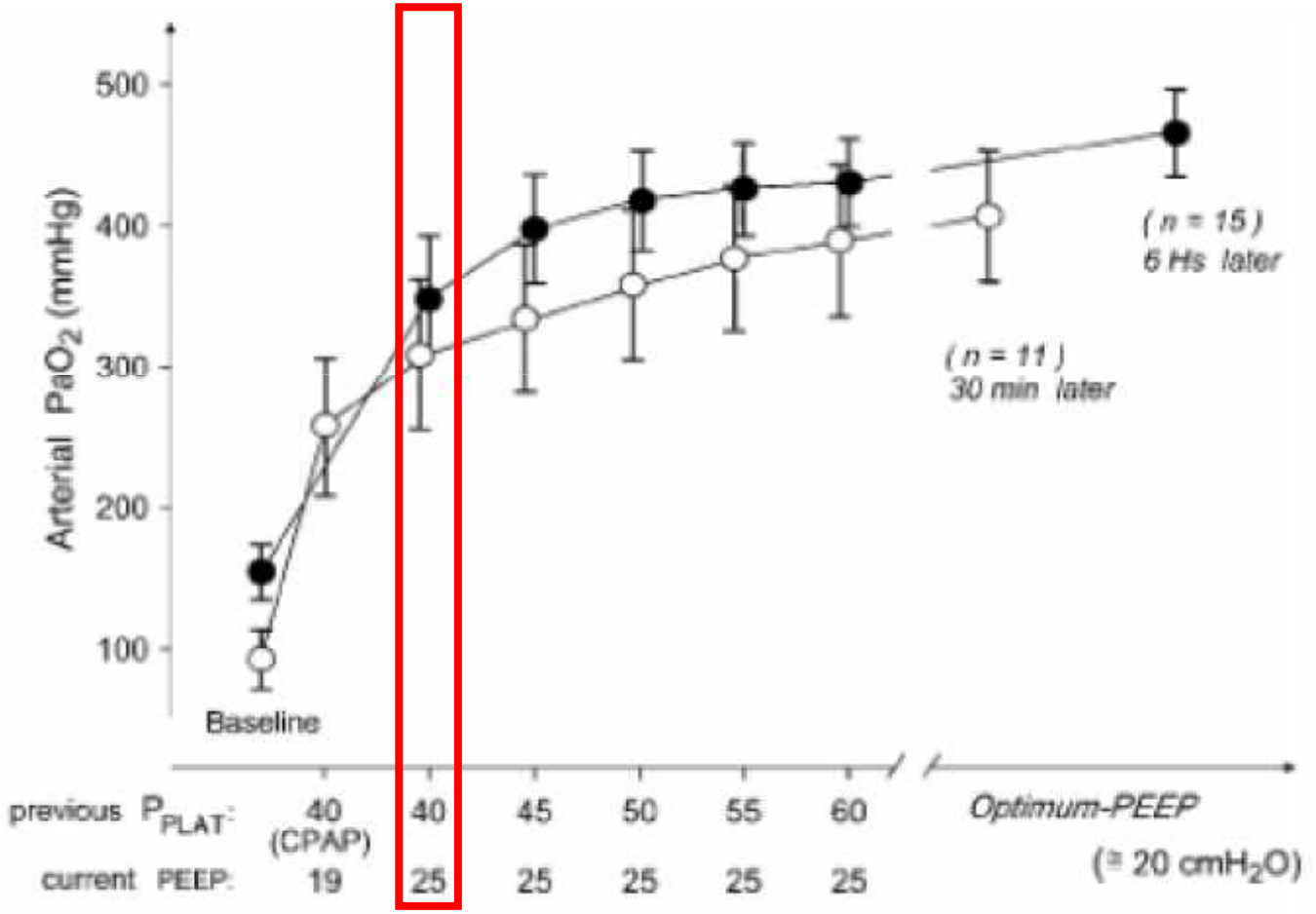
PCV RM





Borges, AJRCCM, 2006

PCV RM 25/40 – 30min/6h?



Borges, AJRCCM, 2006

SI RM versus PCV RM

Different patterns of lung recruitment maneuvers in primary acute respiratory distress syndrome: effects on oxygenation and central hemodynamics

M. IANNUZZI, A. DESIO, E. DE ROBERTIS, O. MAZZA, G. SERVILLO, R. TUFANO

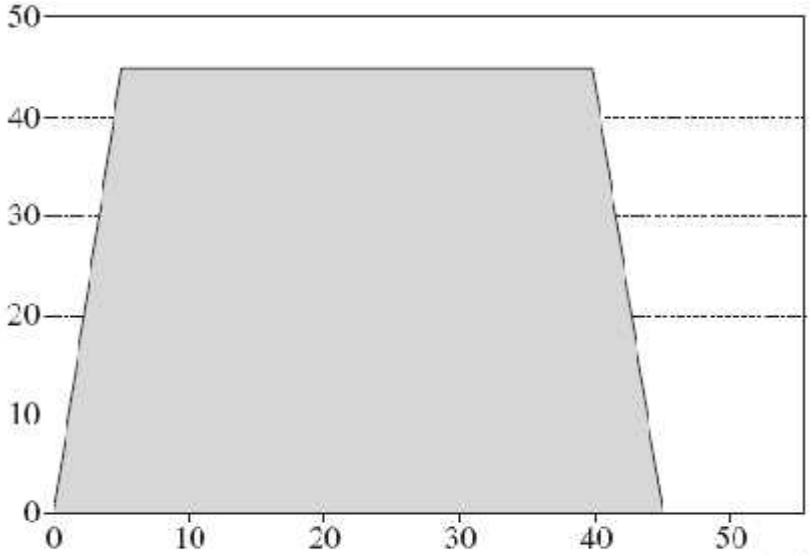


Figure 1. Pressure time product of sustained inflation (SI) recruitment maneuver. X axis: time (seconds); Y axis: airway

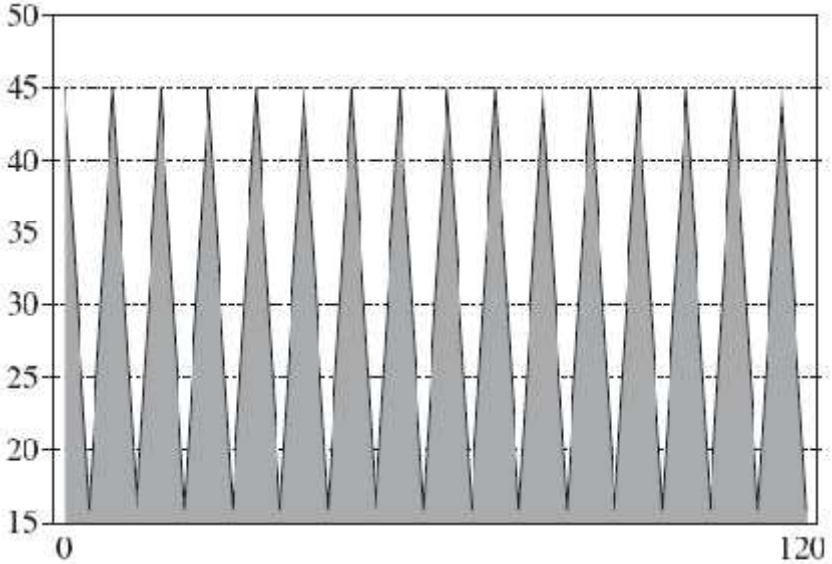


Figure 2.—Pressure-time product of pressure controlled ventilation (PCV) recruitment maneuver. X axis: time (seconds); Y axis: airway pressure (cmH_2O).

SI RM : 45cm H2O na 40 sec.

Pressure time product SI i PVC=1800

PCV RM: PEEP 16, PIP 45, I:E 1:2, df 8/min

Iannuzzi, Minerva anestesiologica,2010

SI RM versus PCV RM
hemodynamika

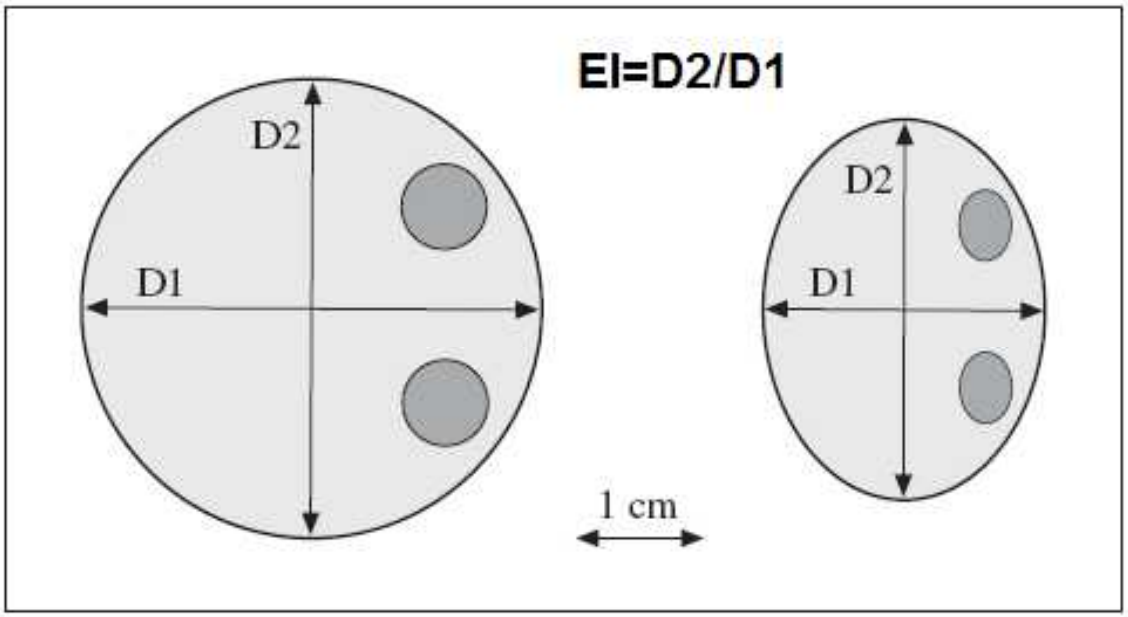


TABLE II.—*H*

Author	Post-PCV RM
PaO_2 (mmHg)	157.6± 61.5*
P/F (mmHg)	238.8±86.5*
$PaCO_2$ (mmH	55.0±3.4
C_{RS}	62.0±12.5*
Qs/Qt (%)	
C.I. (L/min)	3.4±0.8
PAOP (mmHg	19.7±2.0*
MPAP (mmHg	30.2±3.5*
PVRI (dyne · s	247.0±15.2
RVSWI (g · m/	5.7±0.9*
CVP (mmHg)	19.7±2
Sys/Dia (mmH	106.5±13.1; 55.7±10.3
HR (bpm)	84.5±13.1

TABLE III.—*Echocardiographic evaluations before and after recruitment maneuvers (RM).*

	Pre-SI RM	Post-SI RM	Pre-PCV	Post-PCV RM
LVEDA	19.0 (14.2 to 25.6)	7.4 (2.6-10.5)*	18.7 (13.2 to 24.2)	11.7 (7.5 to 19.2)
LVESA	9.2 (5.2 to 16.1)	5.4 (2.2 to 7.4)*	9.4 (5.5 to 13.3)	7.1 (3.2 to 15.4)
EI	1.15± 0.10	1.44±0.26*	1.18±0.20	1.21± 0.10

*P<0.05. LVEDA: left ventricular end diastolic area; LVESA: left ventricular end systolic area; EI: eccentricity index.

Iannuzzi, Minerva anestesiologica,2010

SIGH?

KARIM
1.LF UK A VFN V PRAZE

Comparison of Optimal Positive End-Expiratory Pressure and Recruitment Maneuvers During Lung-Protective Mechanical Ventilation in Patients With Acute Lung Injury/ Acute Respiratory Distress Syndrome

Michel Badet MD, Frédérique Bayle MD, Jean-Christophe Richard MD PhD, and Claude Guérin MD PhD

- **12 pacientů , časné ALI/ARDS**
- **SI RM 40 cm H2O for 30 s**
- **PEEP 24 cm H2O, regrese PEEP skokově 4 cm H2O každých 10 min, FiO2 0,8, paO2**
- **“optimal” PEEP - PEEP před poklesem PaO2 > 20% (12)**

Následně VCV 6mL/kg, optimal PEEP, Pplateau < 30 cm H2O, DF dle etCO2 tak aby pH > 7.33 (350ml, df 25, Tinsp. 0,8)

3 strategie: 1hod

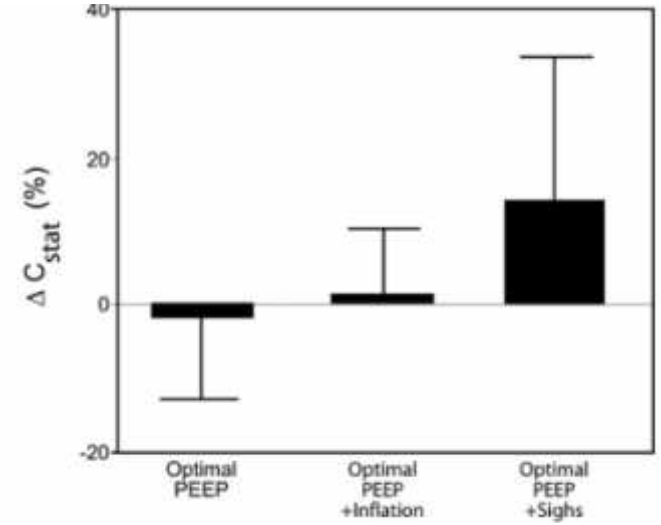
1) **optimal PEEP (x maximal. O2 transport)**
2) **optimal PEEP plus jednou SI RM (40 cm H2O/30 s)**
3) **optimal PEEP plus SIGH (Vt 12ml/, Pplateau < 40 cm H2O) každých 25 dechů (Vt 666ml)**

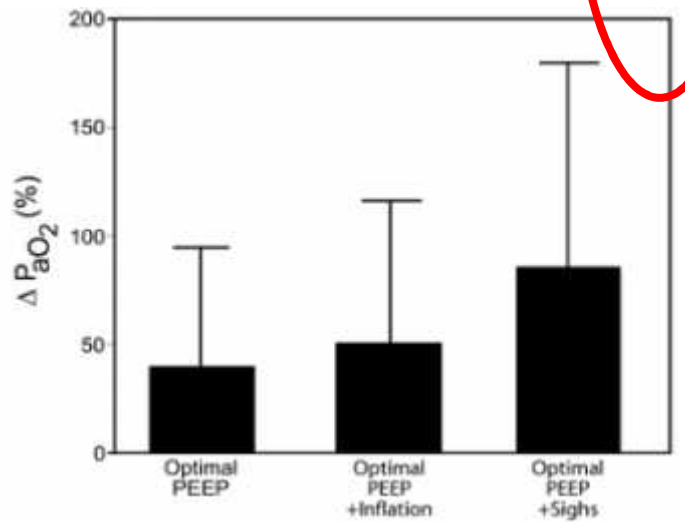
Badet, Respiratory Care, 2009

SIGH, intermitentní

Table 2. Respiratory Mechanics, Hemodynamics, and Arterial Blood Gas Values With 3 PEEP Strategies

	Optimal PEEP Only (mean ± SD)		Optimal PEEP With a Sustained Inflation (mean ± SD)		Optimal PEEP With Sighs (mean ± SD)	
	Baseline	60 min	Baseline	60 min	Baseline	60 min
PEEP (cm H_2O)	9 ± 5	12 ± 4	9 ± 5	12 ± 4	9 ± 5	12 ± 4
Total PEEP (cm H_2O)	10 ± 4	13 ± 4	11 ± 4	13 ± 4	11 ± 4	14 ± 4
P_{plat} (cm H_2O)	20 ± 4	24 ± 5	20 ± 5	23 ± 5	21 ± 5	23 ± 5
C_{stat} (mL/cm H_2O)	37 ± 11	36 ± 10	38 ± 12	39 ± 13	37 ± 12	41 ± 13*
Mean systemic arterial pressure (mm Hg)	78 ± 8	78 ± 7	77 ± 8	75 ± 8	78 ± 9	81 ± 10
P_{aO_2} (mm Hg)	111 ± 55	140 ± 53	114 ± 49	160 ± 63	110 ± 46	182 ± 66†
P_{aCO_2} (mm Hg)	40 ± 8	41 ± 8	41 ± 8	40 ± 8	41 ± 8	40 ± 10
pH	7.39 ± 0.05	7.39 ± 0.05	7.39 ± 0.04	7.39 ± 0.04	7.39 ± 0.04	7.40 ± 0.04



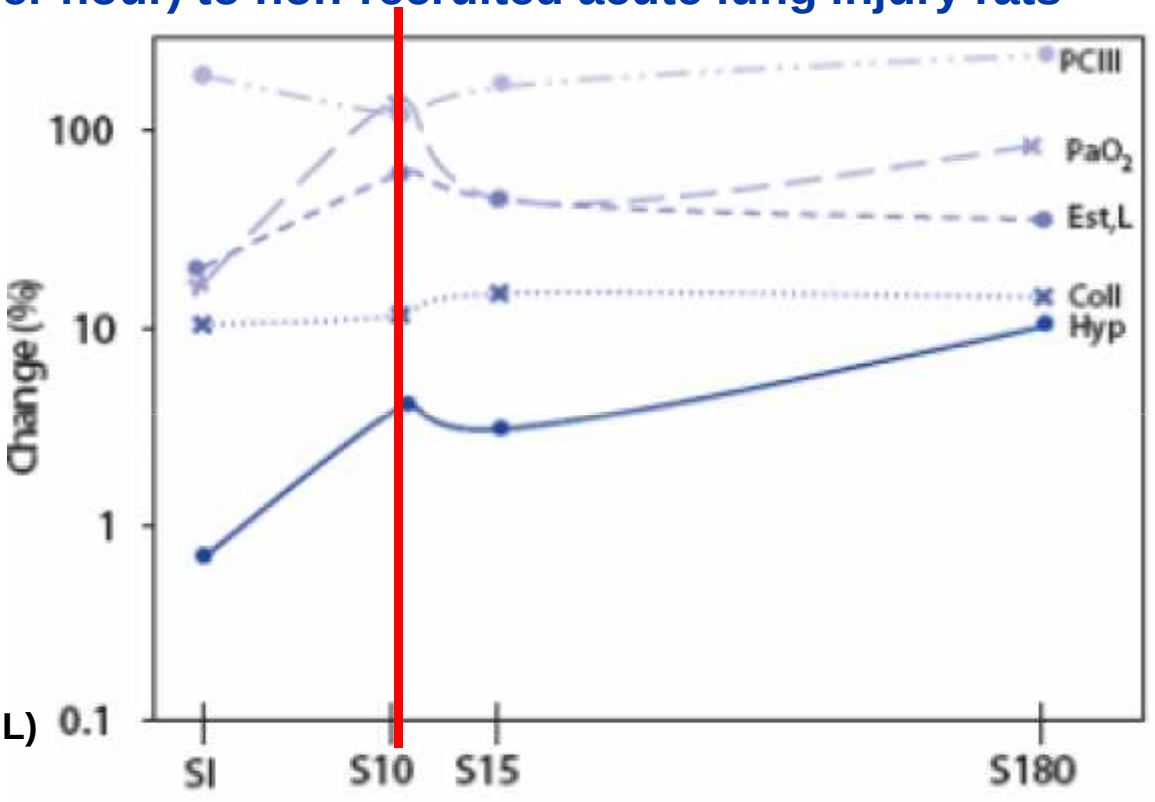


Badet, Respiratory Care, 2009

Sigh at different frequencies

(10, 15 and 180 per hour) to non-recruited acute lung injury rats

Pplat = 40 cmH2O



static lung lastance (Est,L)

oxygenation (PaO2)

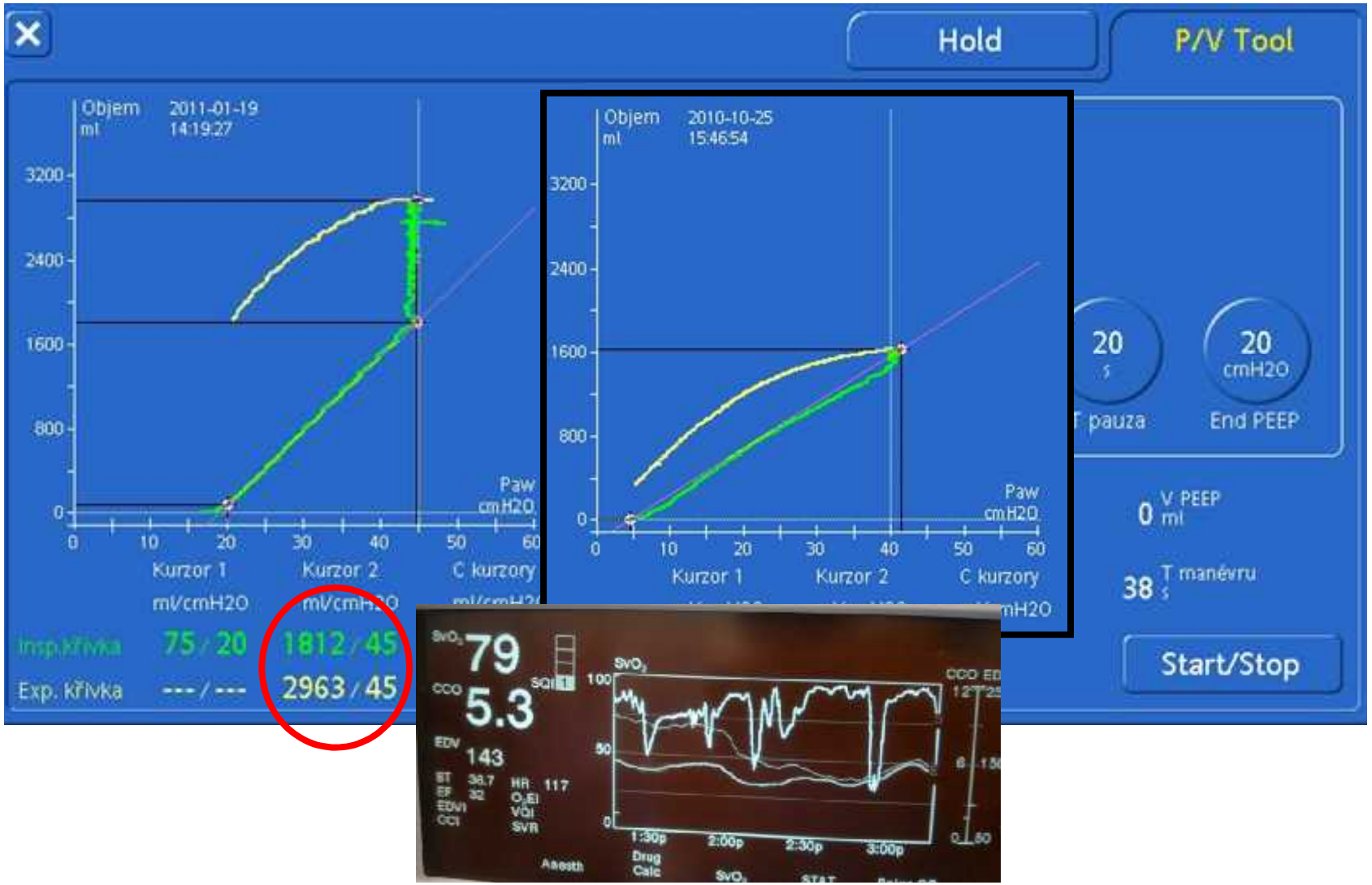
fractional area of alveolar collapse (Coll)

hyperinfl ation (Hyp),

mRNA expression of type III procollagen (PCIII)

Steimback *et al*.: Eff ects of frequency and inspiratory plateau pressure during recruitment manoeuvres on lung and distal organs in acute lung injury. *Intensive Care Med* 2009

PV tool

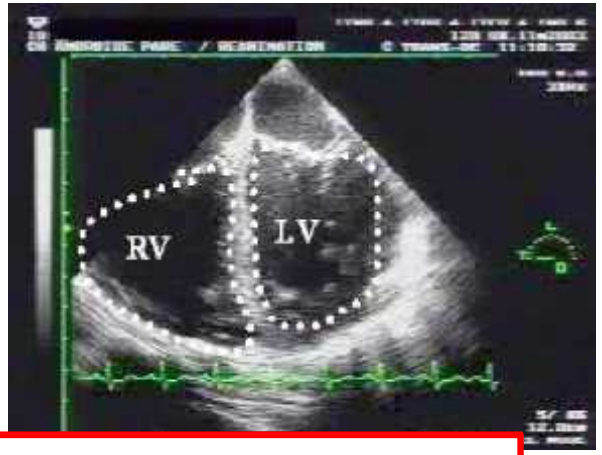

Hold
P/V Tool
Objem
ml
2011-01-19
14:19:27
3200
2400
1600
800
0
Paw
cmH2O
0
10
20
30
40
50
60
Kurzor 1
Kurzor 2
C kurzory
ml/cmH2O
Insp.křivka
75 / 20
1812 / 45
Exp. křivka
--- / ---
2963 / 45
Objem
ml
2010-10-25
15:46:54
20
s
T pauza
20
cmH2O
End PEEP
0
V PEEP
ml
38
T manévru
s
Start/Stop
SvO2
79
CCO
5.3
EDV
143
HR
117
100
50
0
1:30p
2:00p
2:30p
3:00p
Anesth
Drug Calc

A co na to PK?

The Right Ventricle During the Acute Respiratory Distress Syndrome Revisited by Echocardiography

Is there a safe plateau pressure in ARDS? The right heart only knows

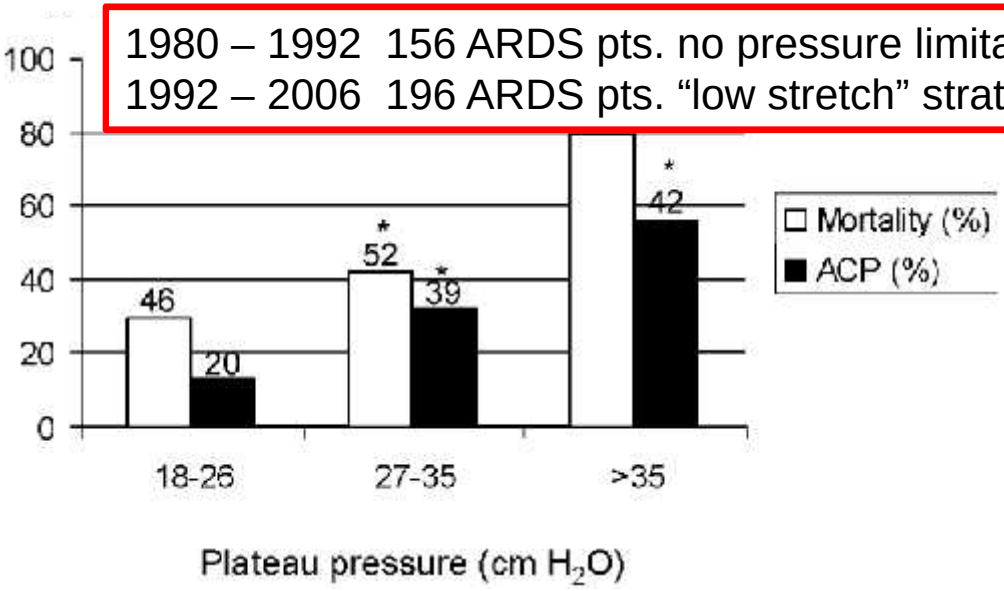
François Jardin
Antoine Vieillard-Baron

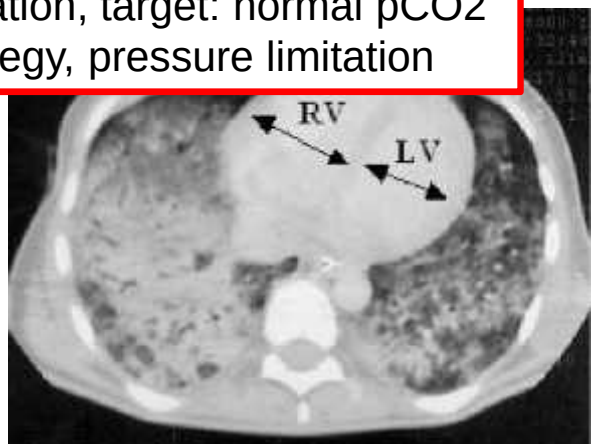


- Akutní cor pulmonale (ACP)
  PK/LK>0.6 + septální dyskineza
- PK>LK 100% úmrtí
- **Signifikantní redukce mortality při**

Pplat<27cm H2O

1980 – 1992 156 ARDS pts. no pressure limitation, target: normal pCO2
1992 – 2006 196 ARDS pts. "low stretch" strategy, pressure limitation



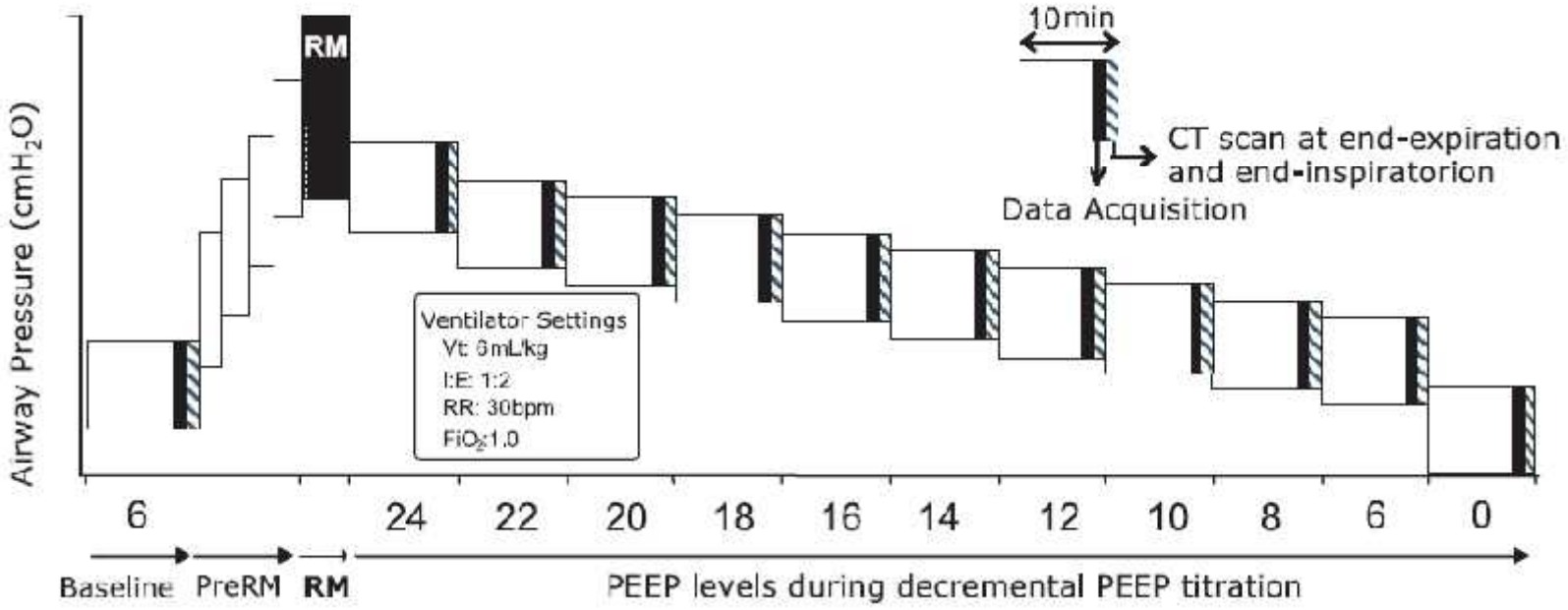


Jardin ICM, 2007

Titrace PEEPu po RM pomocí Cdyn

Use of dynamic compliance for open lung positive end-expiratory pressure titration in an experimental study

Fernando Suarez-Sipmann, MD; Stephan H. Böhm, MD; Gerardo Tusman, MD; Tanja Pesch;



Prasečí model, laváž FR á 5min až paO2/FiO2<100, RM 30/60 1:1 2min
PEEP 24, regrese á 10min o -2cmH2O

Suarez-Sipmann,CCM, 2007

Titrace PEEPu po RM pomocí Cdyn

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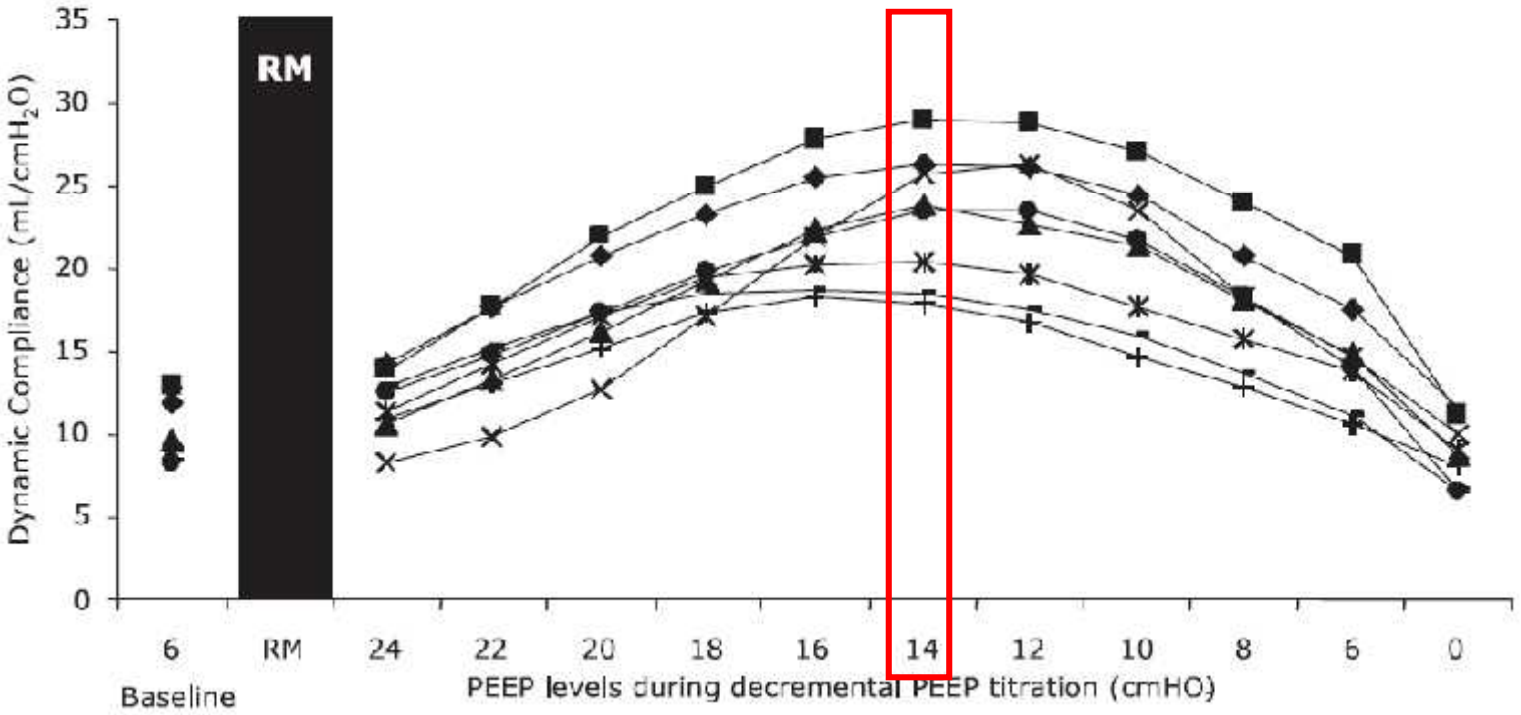
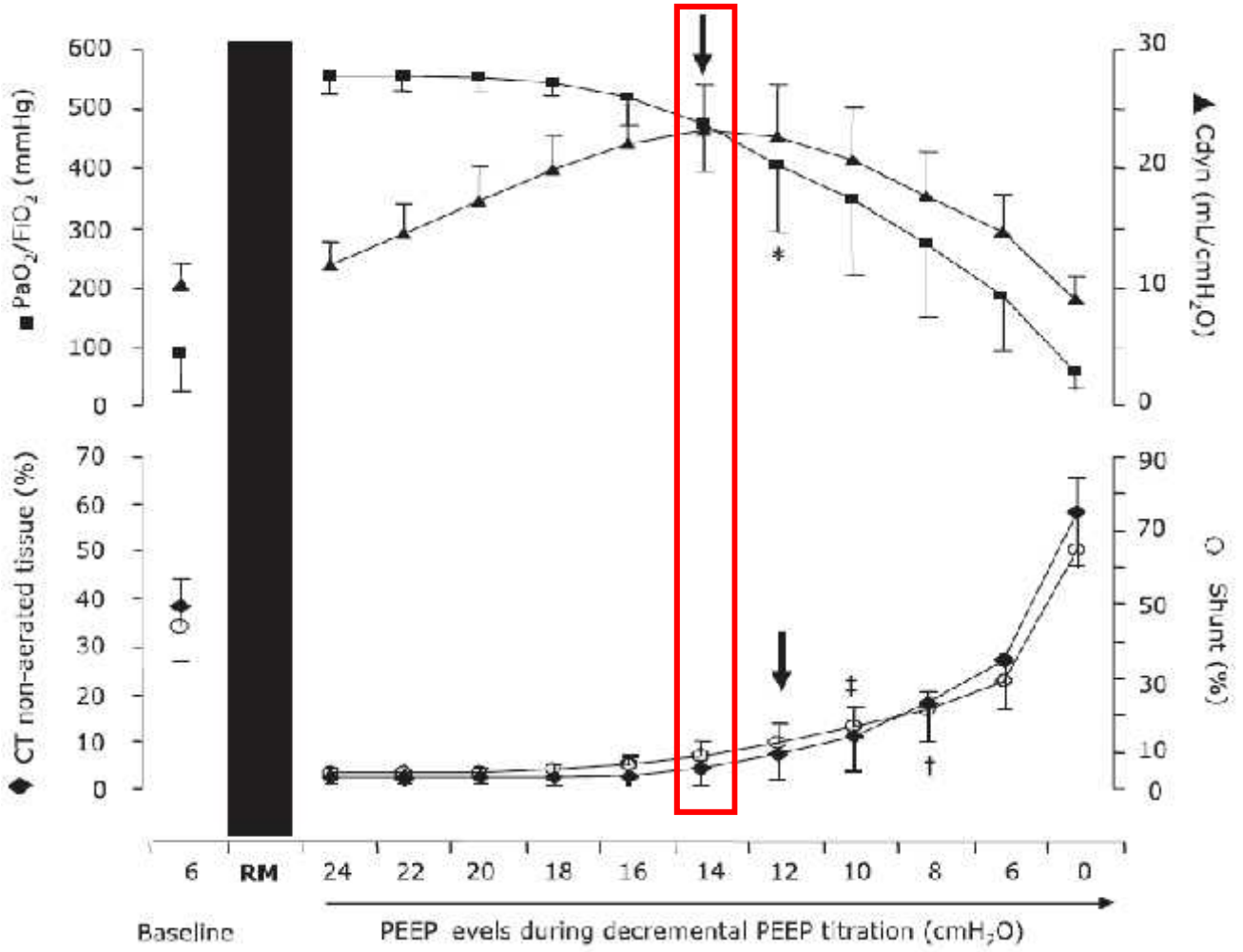


Suarez-Sipmann,CCM, 2007

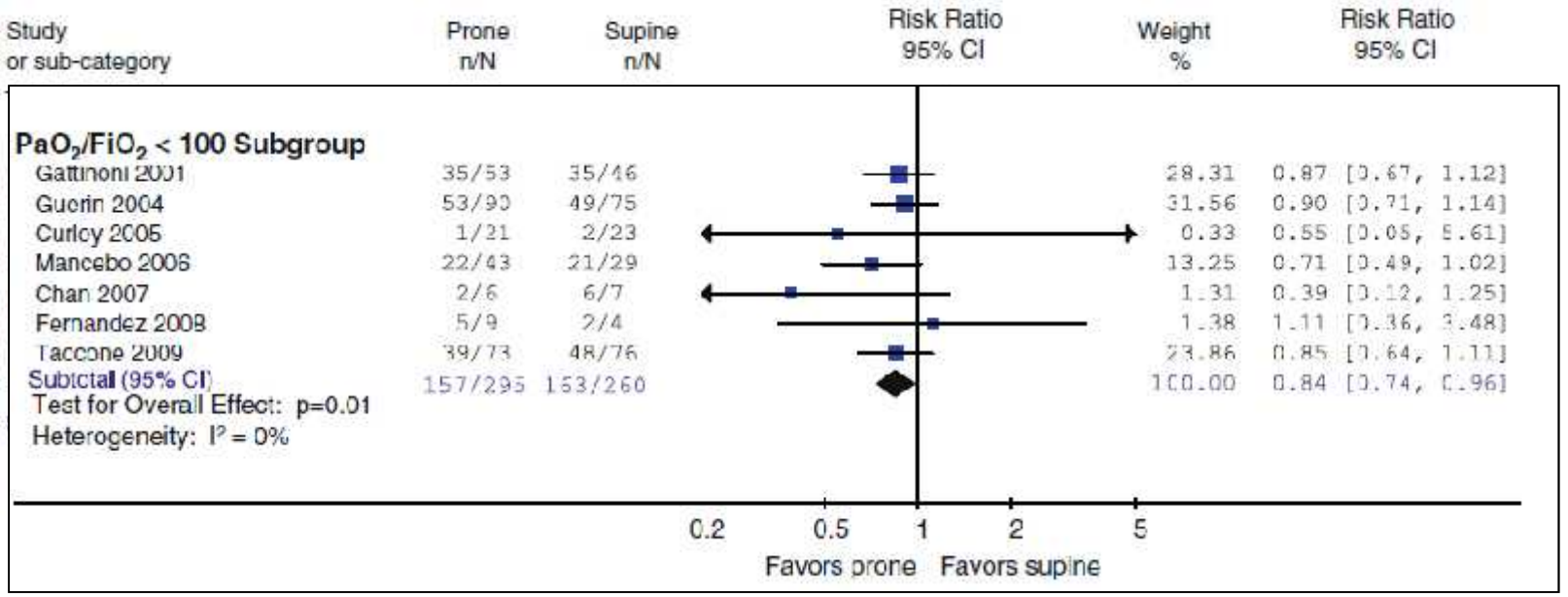
Titrace PEEPu po RM pomocí Cdyn



Suarez-Sipmann,CCM, 2007

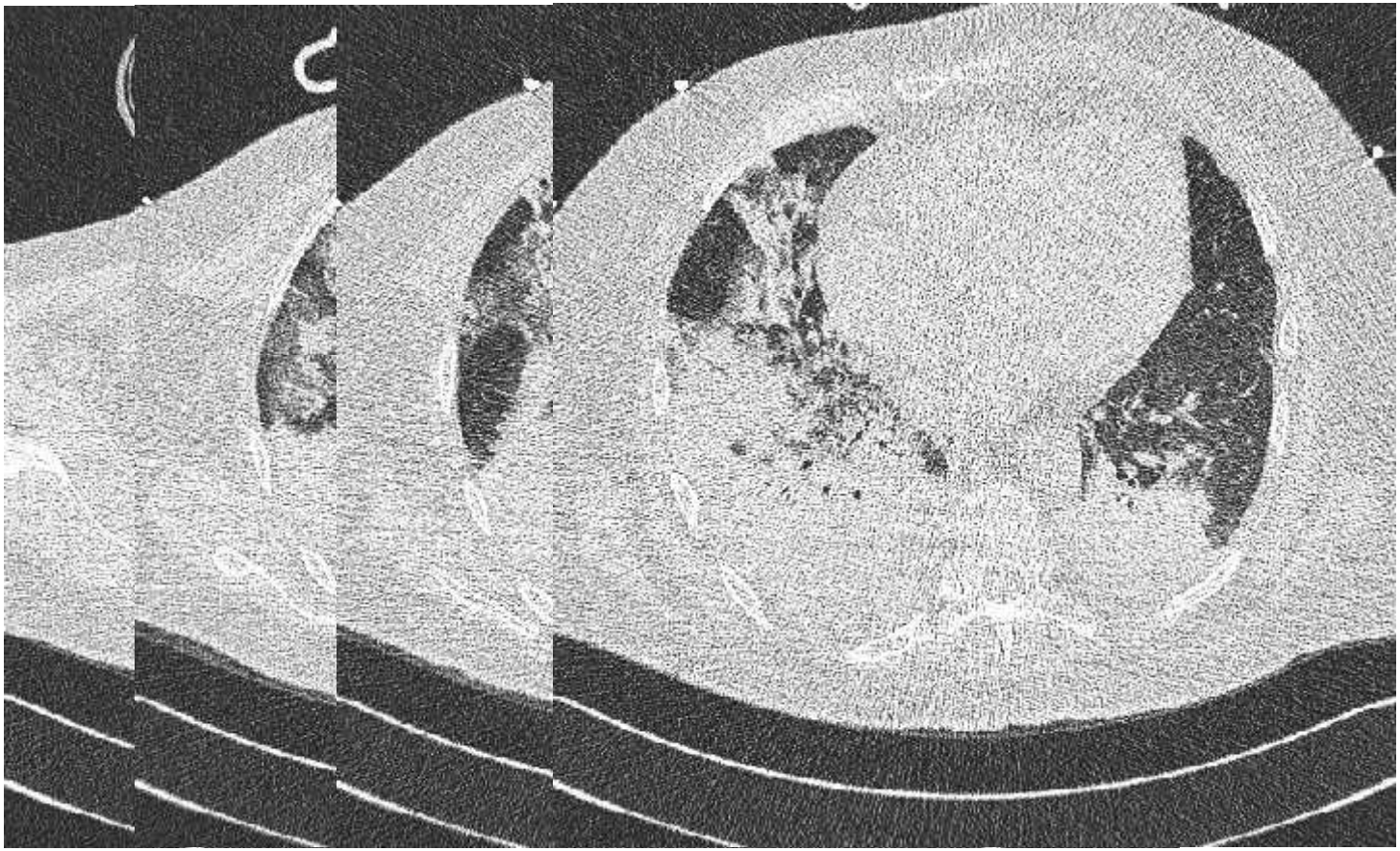
Efekt PRONACE na mortalitu ARDS?

Prone ventilation reduces mortality in patients with acute respiratory failure and severe hypoxemia: systematic review and meta-analysis

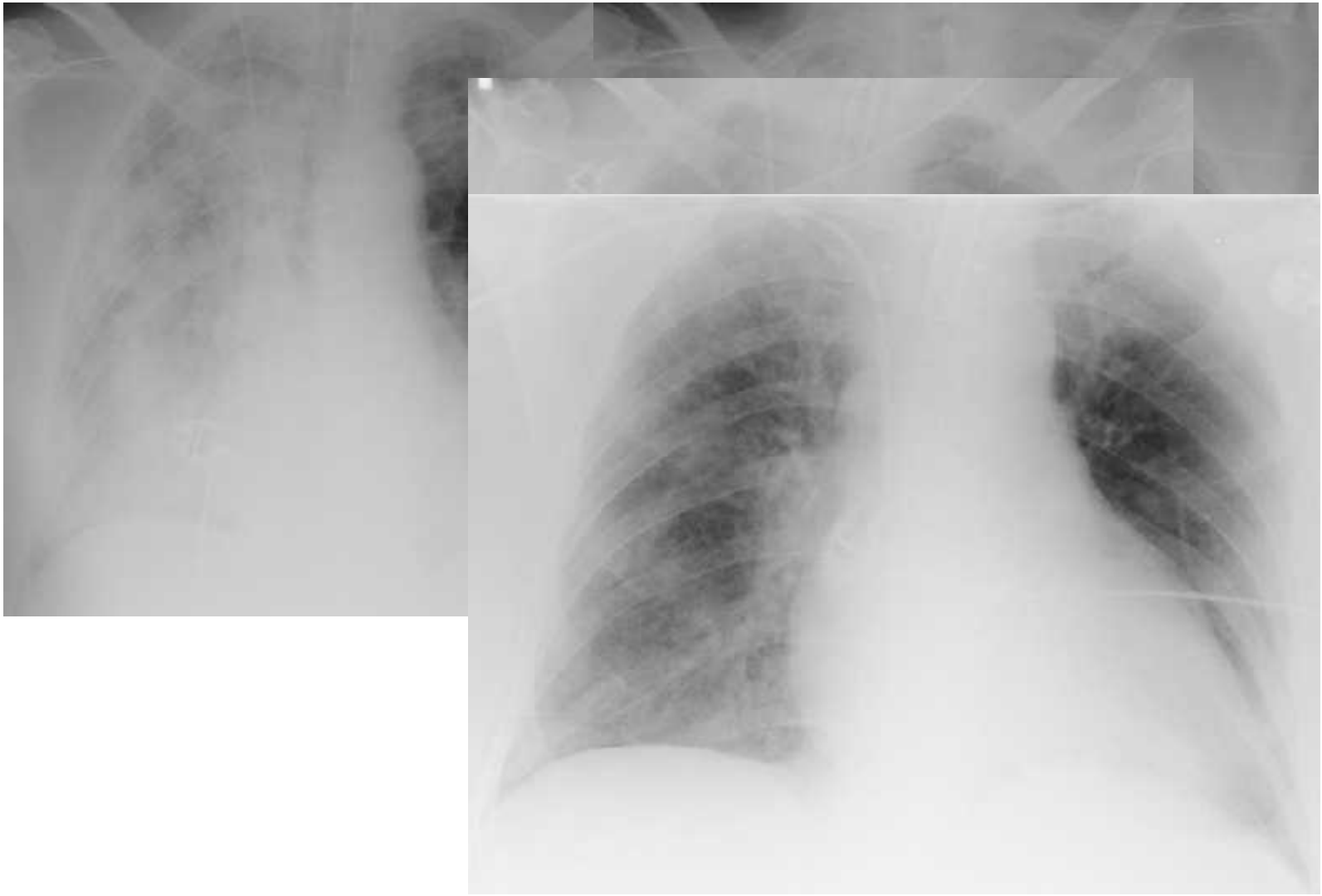


Sud, ICM,2010

Efekt SEMI - PRONACE



Efekt SEMI - PRONACE



Relaxace u ARDS

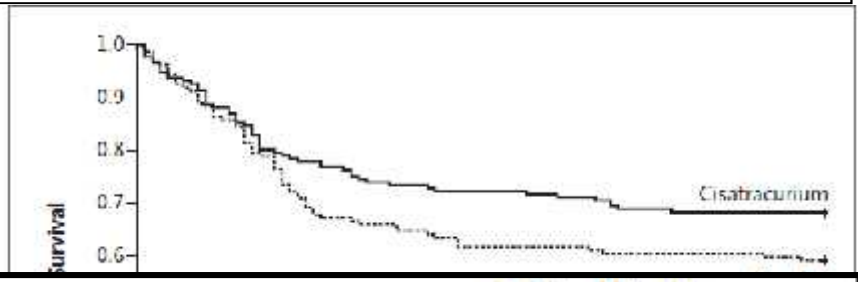
Neuromuscular Blockers in Early Acute Respiratory Distress Syndrome

Laurent Papazian, M.D., Ph.D., Jean-Marie Forel, M.D.

Multicentric, RCT, 20 ICUs

340 pts. With ARDS for max. 48h.

Cisatracurium vs. Placebo (178/162)



Outcome	Cisatracurium (N=177)	Placebo (N=162)	Relative Risk with Cisatracurium (95% CI)	P Value
Barotrauma — no. (% [95% CI])†	9 (5.1 [2.7–9.4])	19 (11.7 [7.6–17.6])	0.43 (0.20–0.93)	0.03
Pneumothorax — no. (% [95% CI])	7 (4.0 [2.0–8.0])	19 (11.7 [7.6–17.6])	0.34 (0.15–0.78)	0.01
Patients without ICU-acquired paresis¶				
By day 28 — no./total no. (% [95% CI])	68/96 (70.8 [61.1–79.0])	52/77 (67.5 [56.5–77.0])		0.64
By ICU discharge — no./total no. (% [95% CI])	72/112 (64.3 [55.1–72.6])	61/89 (68.5 [58.3–77.3])		0.51

(P = 0.08)

Figure 2. Probability of Survival through Day 90, According to Study Group.

rate of ICU-acquired paresis did not differ significantly between the two groups

Papazian, NEJM, 2010

Kontroverze

- nejsou „velké“ studie
- rozdílné kohorty, Berlínská definice?
- rozdílné provedení RM, nastavení PEEPu
- opakování RM?
- weaning …. mortalitní efekt?

- ošetření derecruitmentu

(nebulizace, rozpojení, odsávání)

„malý RM“ = inspirační hold PEEP>10, >14 RM?

Závěr:

- **PEEP není RM**
- **Recrutabilita? PV tool**
- **RM by měl být součástí protektivní ventilace u ARDS - následně titrace optimálního PEEPu**
- **PK a její přetížení**
- **Pronační poloha**
- **Relaxace v prvních 48h?**
- **PCV RM možná nejvýhodnější / PV tool**

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Děkuji za pozornost

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Workshop ventilace u ARDS

VETRAM - Ventilační TRénink na Animálním Modelu

Praktický kurz ventilace, se speciálním zaměřením na model a management ARDS

30.11.2012

www.karim-vfn.cz