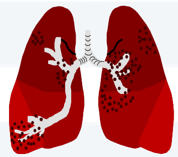
CONSORCI
HOSPITAL GENERAL
UNIVERSITARI
VALÈNCIA



Analyzing
Lung protective ventilation

F Javier Belda MD, PhD

Sº de Anestesiología y Reanimación

Hospital Clinico Universitario

Valencia (Spain)

SARTD-CHGUV Sesión de Formación Continuada

Valencia 14 de Enero de 2014

ALI/ARDS

Report of the American-European consensus conference on ARDS: Intensive Care Med 1994; 20:225–232

Acute Respiratory Distress Syndrome. The Berlin Definition JAMA 2012; 307:2526-33

Table 3. The Berlin Definition of Acute Respiratory Distress Syndrome

	Acute Respiratory Distress Syndrome
Timing	Within 1 week of a known clinical insult or new or worsening respiratory symptoms
Chest imaging[a]	Bilateral opacities—not fully explained by effusions, lobar/lung collapse, or nodules
Origin of edema	Respiratory failure not fully explained by cardiac failure or fluid overload Need objective assessment (eg, echocardiography) to exclude hydrostatic edema if no risk factor present
Oxygenation[b]	
Mild	200 mm Hg < PaO_2/FiO_2 ≤ 300 mm Hg with PEEP or CPAP ≥5 cm H_2O[c]
Moderate	100 mm Hg < PaO_2/FiO_2 ≤ 200 mm Hg with PEEP ≥5 cm H_2O
Severe	PaO_2/FiO_2 ≤ 100 mm Hg with PEEP ≥5 cm H_2O

ALI/ARDS

Report of the American-European consensus conference on ARDS:
Intensive Care Med 1994; 20:225–232
Acute Respiratory Distress Syndrome. The Berlin Definition
JAMA 2012; 307:2526-33

Table 5. Predictive Validity of ARDS Definitions in the Physiologic Database

	Modified AECC Definition[a]		Berlin Definition ARDS[a]		
	ALI Non-ARDS	ARDS	Mild	Moderate	Severe
No. (%) [95% CI] of patients	66 (25) [19-30]	203 (75) [70-80]	66 (25) [20-30]	161 (59) [54-66]	42 (16) [11-21]
Mortality, No. (%) [95% CI][b]	13 (20) [11-31]	84 (43) [36-50]	13 (20) [11-31]	62 (41) [33-49]	22 (52) [36-68]
Ventilator-free days					
Median (IQR)	8.5 (0-23.5)	0 (0-16.0)	8.5 (0-23.5)	0 (0-16.5)	0 (0-6.5)
Missing, No.	10	26	10	25	1
Duration of mechanical ventilation in survivors, median (IQR), d	6.0 (3.3-20.8)	13.0 (5.0-25.5)	6.0 (3.3-20.8)	12.0 (5.0-19.3)	19.0 (9.0-48.0)
Lung weight, mg[c]					
Mean (SD)	1371 (360.4)	1602 (508.1)	1371 (360.4)	1556 (469.7)	1828 (630.2)
Missing, No.	16	48	16	32	16
Shunt, mean (SD), %[c,d]	21 (21)	32 (13)	21 (12)	29 (11)	40 (16)

SARTD-CHGUV Sesión de Formación Continuada
Valencia 14 de Enero de 2014

An Early PEEP/FI_{O_2} Trial Identifies Different Degrees of Lung Injury in Patients with Acute Respiratory Distress Syndrome

Jesús Villar[1], Lina Pérez-Méndez[1,2], José López[3], Javier Belda[4], Jesús Blanco[5], Iñaki Saralegui[6], Fernando Suárez-Sipmann[7], Julia López[8], Santiago Lubillo[1,9], and Robert M. Kacmarek[10], on behalf of the HELP Network*

Am J Respir Crit Care Med 2007:176:795–804,

AMERICAN JOURNAL OF Respiratory and Critical Care Medicine

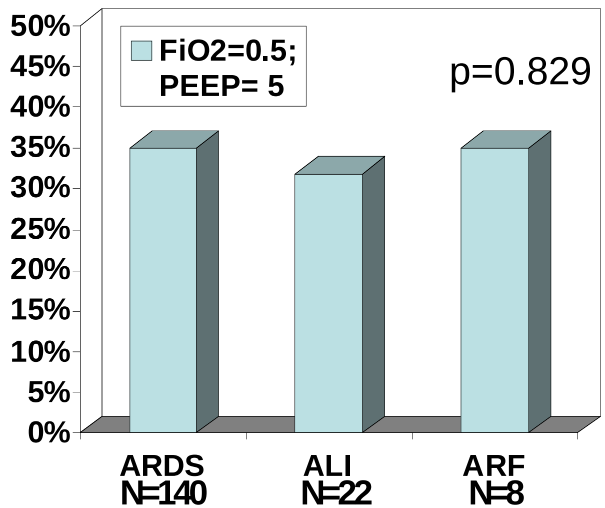
Design: Multicentric, prospective, randomized, intervention

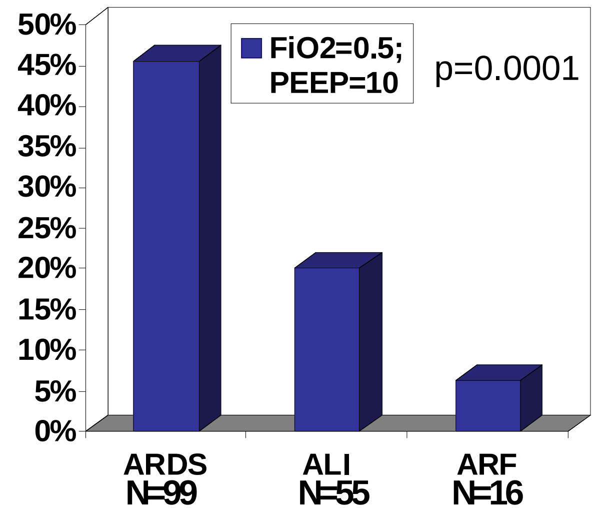
Methods: 170 patients AECC criteria for ALI / ARDS
BGA day 0 and 24 h after standard settings

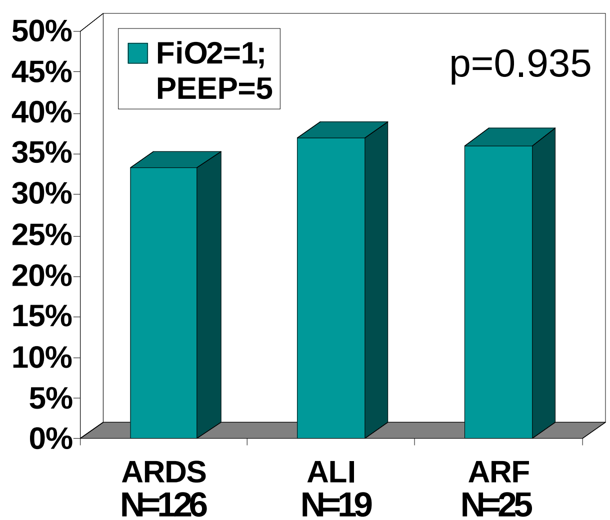
Settings: VT: 7 ml/kg and FR for PCO_2:35-50 mmHg
+ PEEP and FIO_2 sequentially adjusted:

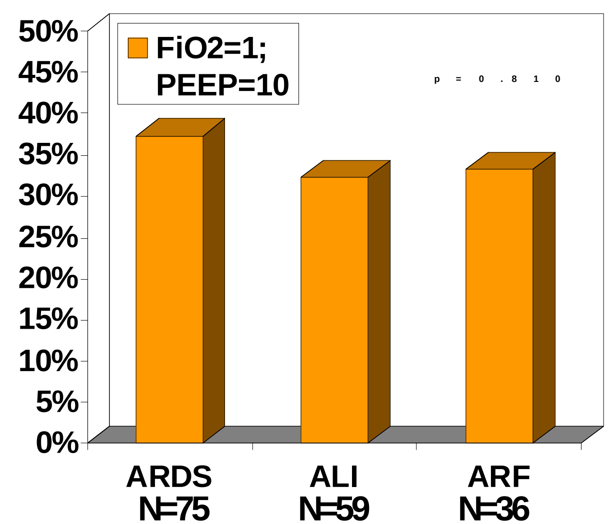
PEEP 5 cmH_2O and FIO_2 0.5
PEEP 5 cmH_2O and FIO_2 1.0
PEEP 10 cmH_2O and FIO_2 0.5
PEEP 10 cmH_2O and FIO_2 1.0

Mortality at 28 days









Intensive Care Med (2013) 39:583–592
DOI 10.1007/s00134-012-2803-x

ORIGINAL

Jesús Villar
Lina Pérez-Méndez
Jesús Blanco
José Manuel Añón
Lluís Blanch
Javier Belda
Antonio Santos-Bouza
Rosa Lidia Fernández
Robert M. Kacmarek
Spanish Initiative for Epidemiology, Stratification, and Therapies for ARDS (SIESTA) Network

A universal definition of ARDS: the PaO_2/FiO_2 ratio under a standard ventilatory setting—a prospective, multicenter validation study

Derivation cohort ($n = 170$)	Validation cohort ($n = 282$)

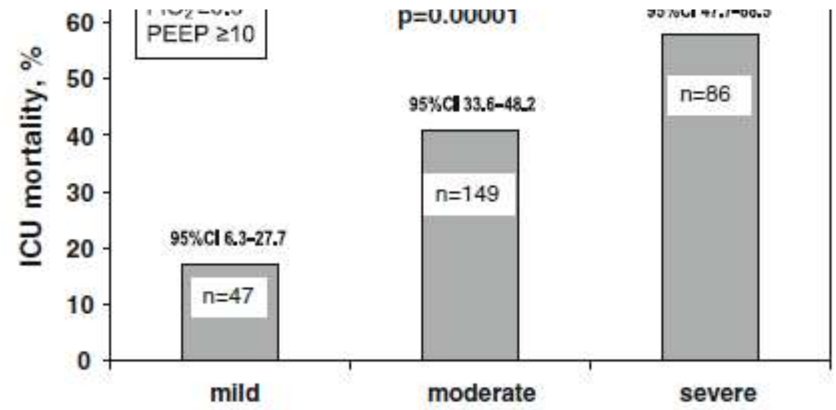


Fig. 3 Classification of 282 patients from the validation cohort into

SARTD-CHGUV Sesión de Formación Continuada
Valencia 14 de Enero de 2014

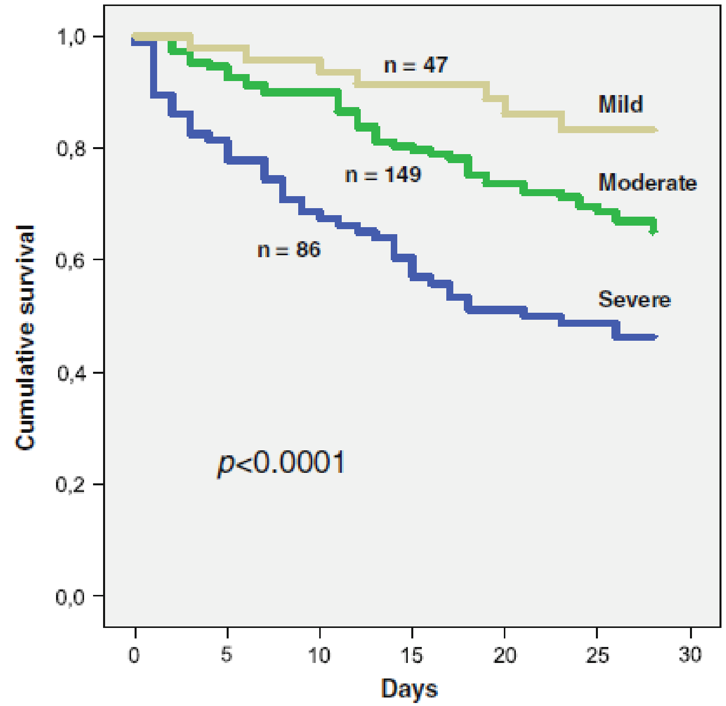
Intensive Care Med (2013) 39:583–592
DOI 10.1007/s00134-012-2803-x

ORIGINAL

Jesús Villar
Lina Pérez-Méndez
Jesús Blanco
José Manuel Añón
Lluís Blanch
Javier Belda
Antonio Santos-Bouza
Rosa Lidia Fernández
Robert M. Kacmarek
Spanish Initiative for Epidemiology, Stratification, and Therapies for ARDS (SIESTA) Network

A universal definition of ARDS: the PaO_2/FiO_2 ratio under a standard ventilatory setting—a prospective, multicenter validation study

Derivation cohort (n = 170)	Validation cohort (n = 282)



P/F at 24 h
FiO_2 50%
PEEP 10

Consensus Conference on VALI in ARDS

Am J Respir Crit Care Med 1998;157:1332-47

AMERICAN JOURNAL OF
Respiratory and
Critical Care Medicine

Factors responsible for VALI

1- High lung volume
associated with elevated transpulmonary pressure and alveolar overdistention

2- Repeated alveolar collapse and reopening
due to low end-expiratory volume

Factors that contribute to, or aggravate injury:

- preexisting lung damage and/or inflammation
- high inspired oxygen concentration
- the level of blood flow
- the local and systemic release of inflammatory mediators

Consensus Conference on VALI in ARDS

Am J Respir Crit Care Med 1998;157:1332-47

AMERICAN JOURNAL OF
Respiratory and
Critical Care Medicine

Factors responsible for VALI

1- High lung volume
associated with elevated transpulmonary pressure and alveolar overdistention (EIP$_{TP}$: stress)

2- Repeated alveolar collapse and reopening
due to low end-expiratory volume (VT/EELV: strain)

Protective Strategy:
Low VT
+PEEP

Factors that contribute to, or aggravate injury:

- preexisting lung damage and/or inflammation
- high inspired oxygen concentration
- the level of blood flow
- the local and systemic release of inflammatory mediators

EBM: Ventilation with lower tidal volumes versus traditional tidal volumes in adults for ALI/ARDS

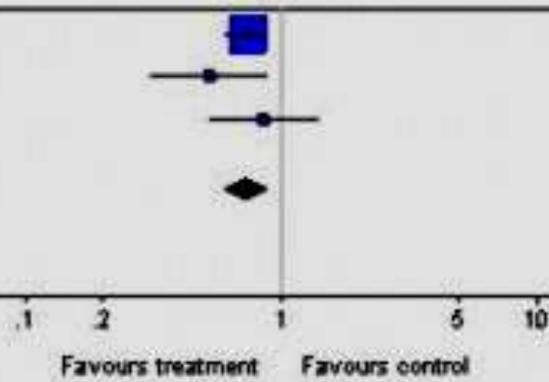
Cochrane database 2004, 2007 and 2013 (February).
5 Randomized trials: 1297 patients

High VT (control) 10-15 ml/Kg: 9.5 ml/Kg
Paw: 31-37
Mortality at day 28: 40%

Low VT (LPV) ≤ 7 ml/kg: 5.2 ml/kg
Paw: 22-30
Mortality at day 28: 30%   RR: 0.74 (diff: -10%)

Study	Protective n/N	Conventional n/N	Weight (%)	Relative Risk (Fixed) 95% CI
ARDS Network 2000	112 / 432	150 / 429	78.8	0.74 [0.60, 0.91]
Amato 1998	11 / 29	17 / 24	9.7	0.54 [0.31, 0.91]
Brochard 1998	19 / 58	22 / 58	11.5	0.86 [0.53, 1.42]
Total (95% CI)	142 / 519	189 / 511	100.0	0.74 [0.61, 0.88]

Test for heterogeneity chi-square=1.78 df=2 p=0.4106
Test for overall effect=-3.36 p=0.0008



The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 JULY 22, 2004 VOL. 351 NO. 4

Higher versus Lower Positive End-Expiratory Pressures in Patients with the Acute Respiratory Distress Syndrome

The National Heart, Lung, and Blood Institute ARDS Clinical Trials Network*

549 ARDS patients : VT 6 ml/Kg; Ppl< 30 cmH2O

Allowable combinations of PEEP and FiO_2†														
Lower-PEEP group														
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
Higher-PEEP group (before protocol changed to use higher levels of PEEP)														
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	

Low PEEP: 8.5 cmH2O Ppl: 24 Mortality: 24.9%

High PEEP:13.5 cmH2O Ppl: 26 Mortality: 27.5% ns

Rationale for the FiO_2-PEEP algorithm

"The lower-PEEP strategy represents a consensus of how the investigators and clinical colleagues balanced beneficial and adverse effects of PEEP in 1995."

"The higher-PEEP strategy was designed to use PEEP levels that were similar to those used in a previous trial."

Amato MBP, Barbas CSV, Medeiros DM, et al. Effect of a protective-ventilation strategy on mortality in the acute respiratory distress syndrome. N Engl J Med 1998;338:347-354

NEJM 2004

“To approximate more closely the separation in PEEP between study groups, we modified the higher-PEEP strategy by **eliminating the steps with a PEEP of <12 cmH2O** and requiring a minimum PEEP of 14 cmH2O for the first 48 hours”

Higher-PEEP group (before protocol changed to use higher levels of PEEP)						
FiO_2	0.3	0.3	0.3	0.3	0.3	0.4
PEEP	5	8	10	12	14	14
Higher-PEEP group (after protocol changed to use higher levels of PEEP)						
FiO_2	0.3	0.3	0.4	0.4	0.5	0.5
PEEP	12	14	14	16	16	18

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 JULY 22, 2004 VOL. 351 NO. 4

Higher versus Lower Positive End-Expiratory Pressures in Patients with the Acute Respiratory Distress Syndrome

The National Heart, Lung, and Blood Institute ARDS Clinical Trials Network*

549 ARDS patients : VT 6 ml/Kg; Ppl< 30 cmH_2O

Table 3. Respiratory Values during the First Seven Days of Treatment.*

Variable	Day 1		Day 3		Day 7	
	Lower-PEEP Group	Higher-PEEP Group	Lower-PEEP Group	Higher-PEEP Group	Lower-PEEP Group	Higher-PEEP Group
PaO_2/FiO_2	168±66	220±89‡	169±69	206±76‡	181±115	218±85†
No. of patients	230	244	159	152	87	91
Respiratory-system compliance	31±15	39±34‡	29±16	32±34	28±16	32±22

Ventilation Strategy Using Low Tidal Volumes, Recruitment Maneuvers, and High Positive End-Expiratory Pressure for Acute Lung Injury and Acute Respiratory Distress Syndrome

A Randomized Controlled Trial

JAMA 2008;299:637

Maureen O. Meade, MD, MSc
Deborah J. Cook, MD, MSc
Gordon H. Guyatt, MD, MSc
Arthur S. Slutsky, MD
Yaseen M. Arabi, MD
D. James Cooper, MD
Andrew R. Davies, MD
Lori E. Hand, RRT, CCRA
Qi Zhou, PhD
Lehana Thabane, PhD
Peggy Austin, CCRA
Stephen Lapinsky, MD
Alan Baxter, MD
James Russell, MD
Yoanna Skrobik, MD
Juan J. Ronco, MD
Thomas E. Stewart, MD
for the Lung Open Ventilation Study Investigators

Established low VT strategy

vs

"lung open ventilation" (LOV) strategy

(low VT, recruitment maneuvers, and high PEEP) in moderate and severe lung injury.

983 patients ARDS (P/F≤250) MV-VT: 6 ml/Kg

508 Conventional Table FiO_2-PEEP, Ppl<30

475 RM (40-40) High PEEP-ARDSnet, Ppl<30

Setting PEEP

Meade JAMA 2008

Goal: Oxigenation (PaO_2: 55-80 SpO_2: 88-95%)
Control group: Standard table
Lung open group: ARM 40-40 + PEEP 20cmH_2O
Then, FIO_2 and PEEP were reduced as table

Table 2. Allowable PEEP Ranges at Specified Levels of FIO_2[a]

	Fraction of Inspired Oxygen (FIO_2)							
	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
Control PEEP ranges, cm H_2O	5	5-8	8-10	10	10-14	14	14-18	18-24
Lung open ventilation PEEP ranges, cm H_2O								
Before protocol change	5-10	10-14	14-20	20	20	20	20	20-24
After protocol change	5-10	10-18	18-20	20	20	20-22	22	22-24

Setting PEEP

Meade JAMA 2008

Goal: Oxigenation (PaO_2: 55-80 SpO_2: 88-95%)
Control group: Standard table
Lung open group: ARM 40-40 + PEEP 20cmH_2O
Then, FIO_2 and PEEP were reduced as table

8 months after the launch of the trial, clinicians at participating hospitals were increasingly comfortable with higher levels of PEEP.. maximize this separation while staying within the bounds of clinical equipoise and usual clinical practice, we increased PEEP levels in the experimental strategy

Ventilation Strategy Using Low Tidal Volumes, Recruitment Maneuvers, and High Positive End-Expiratory Pressure for Acute Lung Injury and Acute Respiratory Distress Syndrome

A Randomized Controlled Trial

JAMA 2008;299:637

Maureen O. Meade, MD, MSc
Deborah J. Cook, MD, MSc
Gordon H. Guyatt, MD, MSc
Arthur S. Slutsky, MD
Yaseen M. Arabi, MD
D. James Cooper, MD
Andrew R. Davies, MD
Lori E. Hand, RRT, CCRA
Qi Zhou, PhD
Lehana Thabane, PhD
Peggy Austin, CCRA
Stephen Lapinsky, MD
Alan Baxter, MD
James Russell, MD
Yoanna Skrobik, MD
Juan J. Ronco, MD
Thomas E. Stewart, MD
for the Lung Open Ventilation Study Investigators

983 patients ARDS (P/F≤250)MV-VT: 6 ml/Kg

508 Conventional Table FiO_2-PEEP, Ppl<30

475 RM (40-40) High PEEP-ARDSnet, Ppl<30

Outcomes	No. (%) Lung Open Ventilation (n = 475)	No. (%) Control Ventilation (n = 508)	Relative Risk (95% Confidence Interval)	*P* Value
Death in hospital	173 (36.4)	205 (40.4)	0.90 (0.77-1.05)	.19
Death in intensive care unit	145 (30.5)	178 (35.0)	0.87 (0.73-1.04)	.13
Death during mechanical ventilation	136 (28.6)	168 (33.1)	0.87 (0.72-1.04)	.13
Death during first 28 d	135 (28.4)	164 (32.3)	0.88 (0.73-1.07)	.20
Barotrauma[b]	53 (11.2)	47 (9.1)	1.21 (0.83-1.75)	.33
Refractory hypoxemia	22 (4.6)	52 (10.2)	0.54 (0.34-0.86)	.01
Death with refractory hypoxemia	20 (4.2)	45 (8.9)	0.56 (0.34-0.93)	.03
Refractory acidosis	29 (6.1)	42 (8.3)	0.81 (0.51-1.31)	.39
Death with refractory acidosis	27 (5.7)	38 (7.5)	0.85 (0.51-1.40)	.52
Refractory barotrauma	14 (3.0)	12 (2.4)	1.10 (0.54-2.26)	.80

JAMA®

Online article and related content current as of September 11, 2010.

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

Matthias Briel; Maureen Meade; Alain Mercat; et al.

JAMA. 2010;303(9):865-873 (doi:10.1001/jama.2010.218)

Table 1. Characteristics of Included Trials

Characteristic	Trial: ALVEOLI,[8] 2004	LOVS,[9] 2008	EXPRESS,[10] 2008
Inclusion criteria	Acute lung injury with Pa_{O_2}:Fi_{O_2} ≤300[a]	Acute lung injury with Pa_{O_2}:Fi_{O_2} ≤250[a]	Acute lung injury with Pa_{O_2}:Fi_{O_2} ≤300[a]
Recruitment period	1999-2002	2000-2006	2002-2005
Recruiting hospitals (country)	23 (United States)	30 (Canada, Australia, Saudi Arabia)	37 (France)

JAMA®

Online article and related content current as of September 11, 2010.

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

Matthias Briel; Maureen Meade; Alain Mercat; et al.

JAMA. 2010;303(9):865-873 (doi:10.1001/jama.2010.218)

Table 4. Clinical Outcomes in All Patients and Stratified by Presence of ARDS at Baseline

	All Patients				With ARDS				Without ARDS			
	No. (%)				No. (%)				No. (%)			
Outcomes	Higher PEEP (n = 1136)	Lower PEEP (n = 1163)	Adjusted RR (95% CI)[a]	*P* Value	Higher PEEP (n = 951)	Lower PEEP (n = 941)	Adjusted RR (95% CI)[a]	*P* Value	Higher PEEP (n = 184)	Lower PEEP (n = 220)	Adjusted RR (95% CI)[a]	*P* Value
Death in hospital	374 (32.9)	409 (35.2)	0.94 (0.86 to 1.04)	.25	324 (34.1)	368 (39.1)	0.90 (0.81 to 1.00)	.049	50 (27.2)	44 (19.4)	1.37 (0.98 to 1.92)	.07
Death in ICU[b]	324 (28.5)	381 (32.8)	0.87 (0.78 to 0.97)	.01	288 (30.3)	344 (36.6)	0.85 (0.76 to 0.95)	.001	36 (19.6)	37 (16.8)	1.07 (0.74 to 1.55)	.71

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

A Meta-analysis

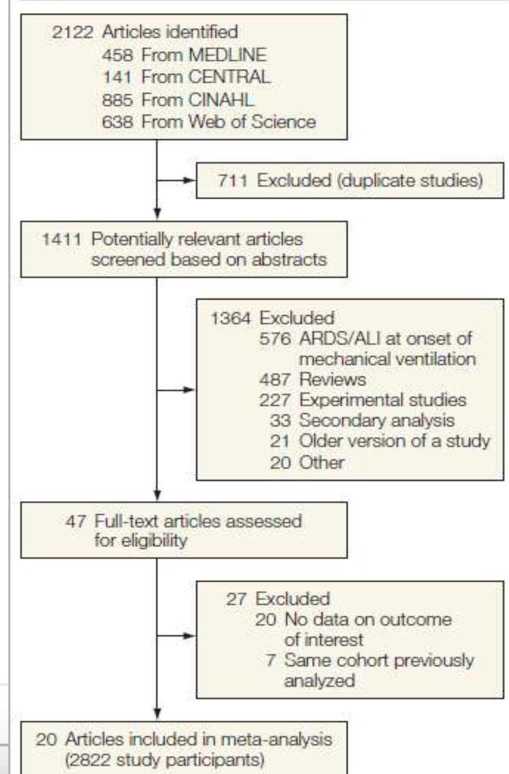
JAMA. 2012;308:1651-9

Ary Serpa Neto, MD, MSc

Table 2. Demographic, Ventilation, and Laboratory Characteristics of the Patients at the Final Follow-up Visit

	Mean (SD)		
	Protective Ventilation (n = 1416)	Conventional Ventilation (n = 1406)	*P* Value
Age, y	59.97 (7.92)	60.22 (7.36)	.93
Weight, kg	72.71 (12.34)	72.13 (12.16)	.93
Tidal volume, mL/kg IBW[a]	6.45 (1.09)	10.60 (1.14)	<.001
PEEP, cm H_2O[a]	6.40 (2.39)	3.41 (2.79)	.01
Plateau pressure, cm H_2O[a]	16.63 (2.58)	21.35 (3.61)	.006
Respiratory rate, breaths/min[a]	18.02 (4.14)	13.20 (4.43)	.01
Minute-volume, L/min[a,b]	8.46 (2.90)	9.13 (2.70)	.72
Pa_{O_2}/F_{IO_2}[a]	304.41 (65.74)	312.97 (68.13)	.51
Pa_{CO_2}, mm Hg[a]	41.05 (3.79)	37.90 (4.19)	.003
pH[a]	7.37 (0.03)	7.40 (0.03)	.11

Figure 1. Literature Search Strategy

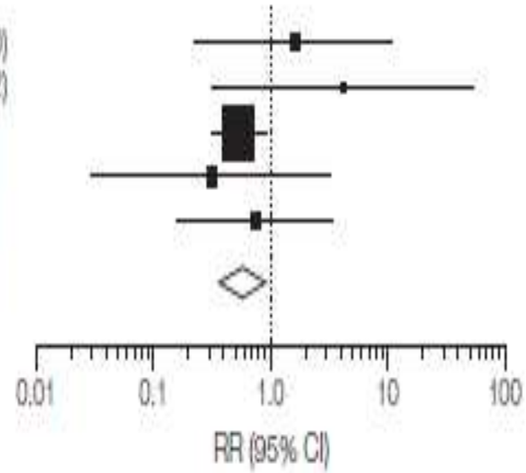


Atelectasis

Lin et al,[25] 2008	2	20	3	20	3.1	1.59 (0.24-10.70)
Cai et al,[21] 2007	5	8	7	8	1.1	4.20 (0.33-53.12)
Licker et al,[26] 2009	47	533	28	558	83.1	0.55 (0.34-0.89)
Yang et al,[31] 2011	3	50	1	50	5.4	0.32 (0.03-3.18)
Weingarten et al,[32] 2012	5	20	4	20	7.3	0.75 (0.17-3.33)
Subtotal (95% CI)		631		656	100.0	0.62 (0.41-0.95)
Total events	62		43			

Heterogeneity: $\chi^2_4 = 3.76$; $P = .44$, $I^2 = 0\%$

Test for overall effect: $z = 2.18$; $P = .03$

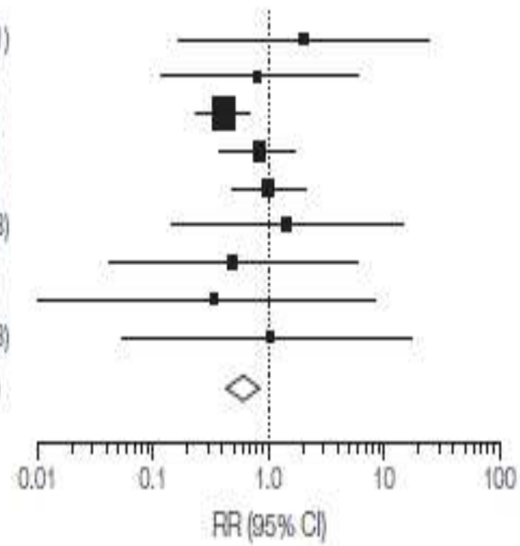


Mortality

Michelet et al,[20] 2006	1	26	2	26	1.0	2.08 (0.18-24.51)
Wolthuis et al,[22] 2007	2	13	3	23	2.5	0.82 (0.12-5.71)
Yilmaz et al,[23] 2007	69	212	27	163	55.7	0.41 (0.25-0.68)
Licker et al,[26] 2009	15	533	13	558	16.7	0.82 (0.39-1.75)
Determann et al,[27] 2010	23	74	24	76	17.7	1.02 (0.51-2.04)
Fernandez-Bustamante et al,[29] 2011	1	75	3	154	1.5	1.47 (0.15-14.38)
Sundar et al,[30] 2011	2	74	1	75	2.2	0.49 (0.04-5.48)
Yang et al,[31] 2011	1	50	0	50	1.7	0.33 (0.01-8.21)
Weingarten et al,[32] 2012	1	20	1	20	1.1	1.00 (0.06-17.18)
Subtotal (95% CI)		1077		1145	100.0	0.64 (0.46-0.86)
Total events	115		74			

Heterogeneity: $\chi^2_8 = 6.94$; $P = .54$, $I^2 = 0\%$

Test for overall effect: $z = 2.68$; $P = .007$



JAMA. 2012;308:1651-9

Individualized PEEP

Alternatives for setting the PEEP

These studies did not evaluate completely the effect of using individualised PEEP on the survival rate of patients with and without ARDS.

Lung Protective Strategy

Amato el al. AJRCCM 1995; 152: 1835

AMERICAN JOURNAL OF Respiratory and Critical Care Medicine

MV to preserve the normal lung regions

Lung recruitment (Paw 35-40 cmH_2O 40 seg.)

VT ≤ 6 ml/kg.

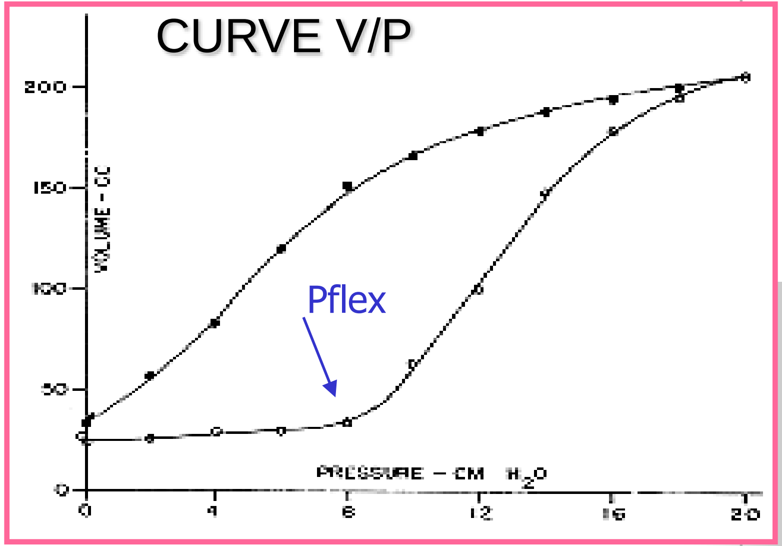
P diff (peak-PEEP) < 20 cmH_2O

P max < 40 cmH_2O (PCV)

FR < 30 p.m.

Permissive hypercapnia

(PCO_2 < 80 mmHg and pH > 7.20)



High PEEP

= Pflex + 2 cmH_2O (or 16 cmH_2O)

MORTALITY: 70% vs 37%

Lung Protective Strategy

Amato el al. AJRCCM 1995; 152: 1835

AMERICAN JOURNAL OF
Respiratory and Critical Care Medicine

Lung protective strategy:
RECRUITING MANEUVER

1. Enough PEEP to prevent derecruitment:
Avoid opening and closing of alveoli
2. Low VT to prevent high alveolar distending pressures and overdistention

MORTALITY: 70% vs 37%

Lung Recruitment in Patients with ARDS

[Correspondence]

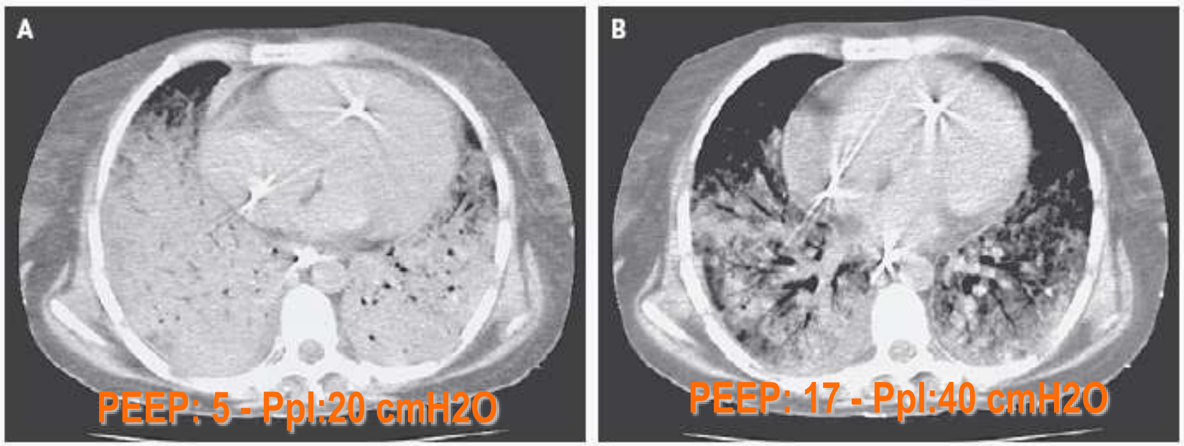
Borges, Joao B.; Carvalho, Carlos R.R.; Amato, Marcelo B.P.

NEJM Volume 355(3), 20 July 2006, pp 319-322

Patient with Pneumocystosis and ARDS.

TC at the End-Expiratory Pause

Potential recruitment (relative to A) B: 35%



Lung Recruitment in Patients with ARDS

[Correspondence]

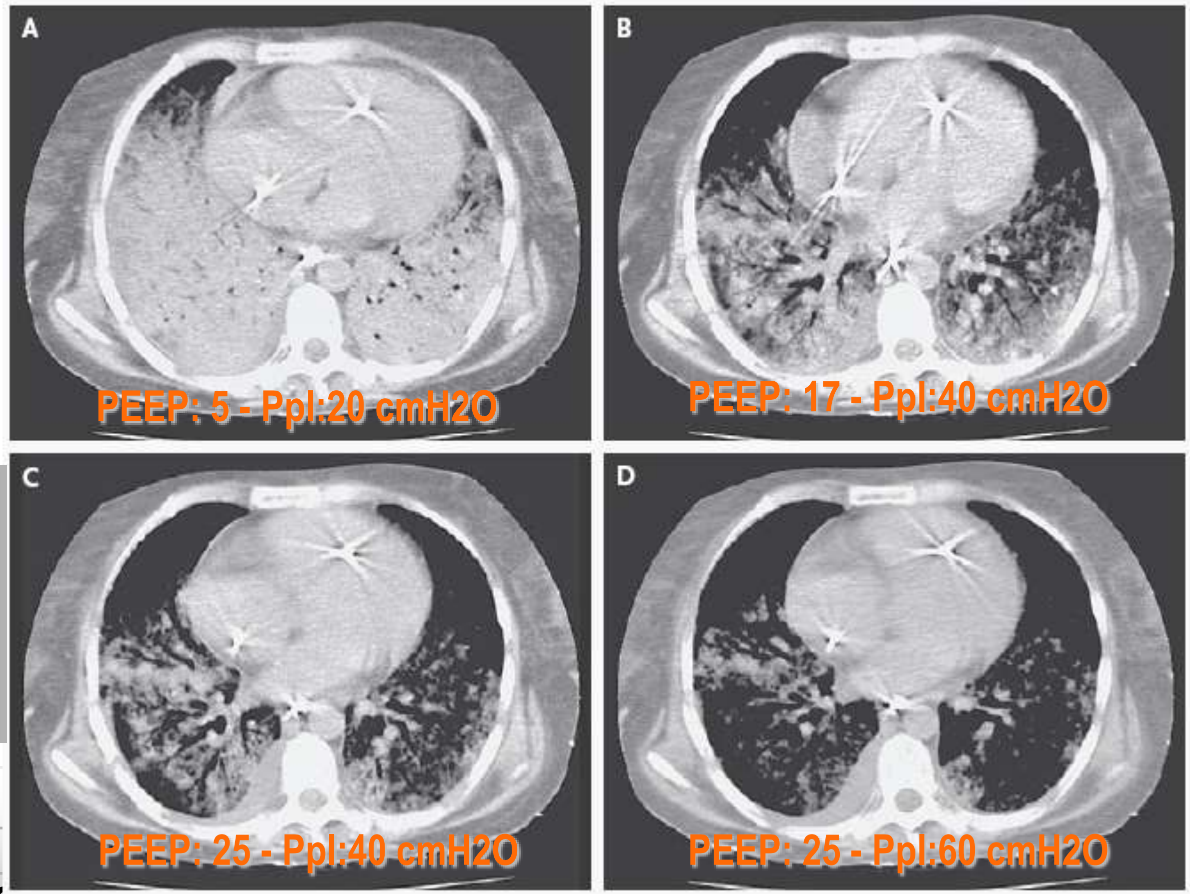
Borges, Joao B.; Carvalho, Carlos R.R.; Amato, Marcelo B.P.

NEJM Volume 355(3), 20 July 2006, pp 319-322

Patient with Pneumocystosis and ARDS.

TC at the End-Expiratory Pause

Potential recruitment (relative to A)
B: 35%
C: 67%
D: 87%



Improving the efficacy
C. Same Ppl and higher PEEP (25)
D. Further increase in Ppl: full potential for recruitment

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

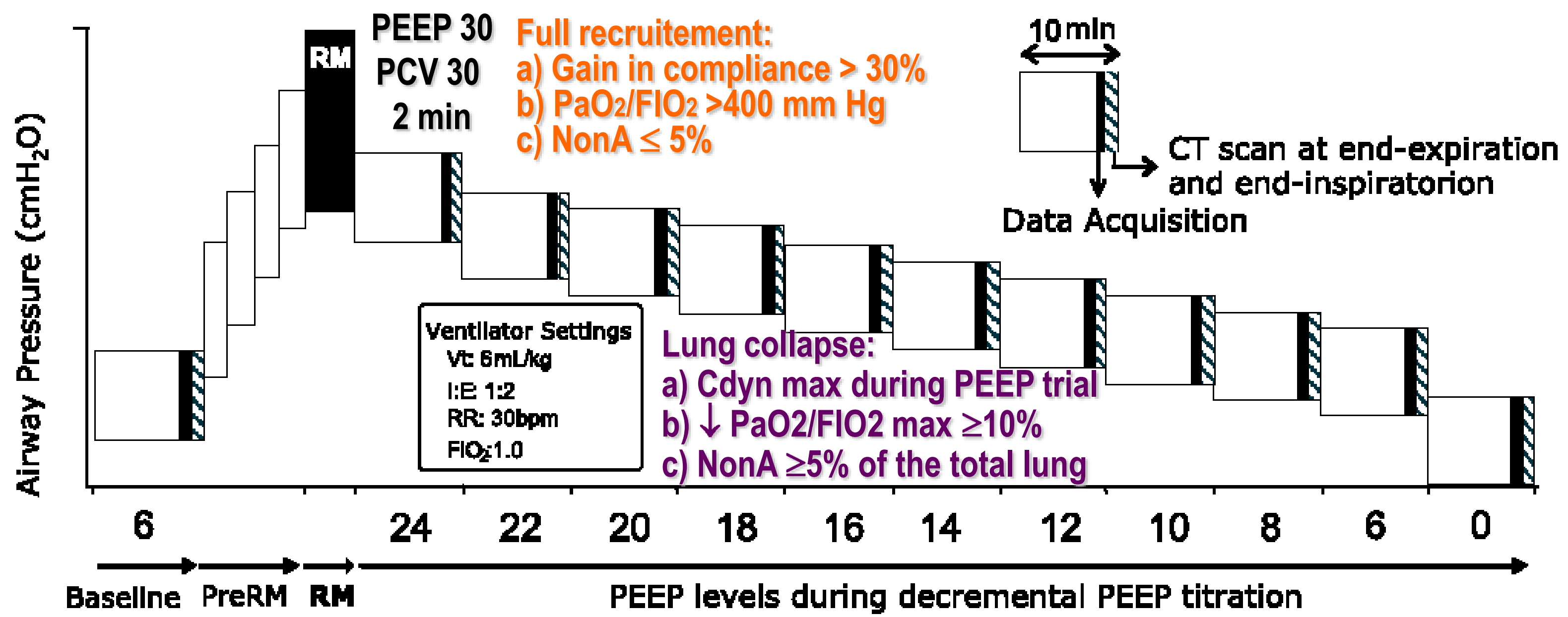
Critical Care Medicine
OFFICIAL JOURNAL OF THE SOCIETY OF CRITICAL CARE MEDICINE

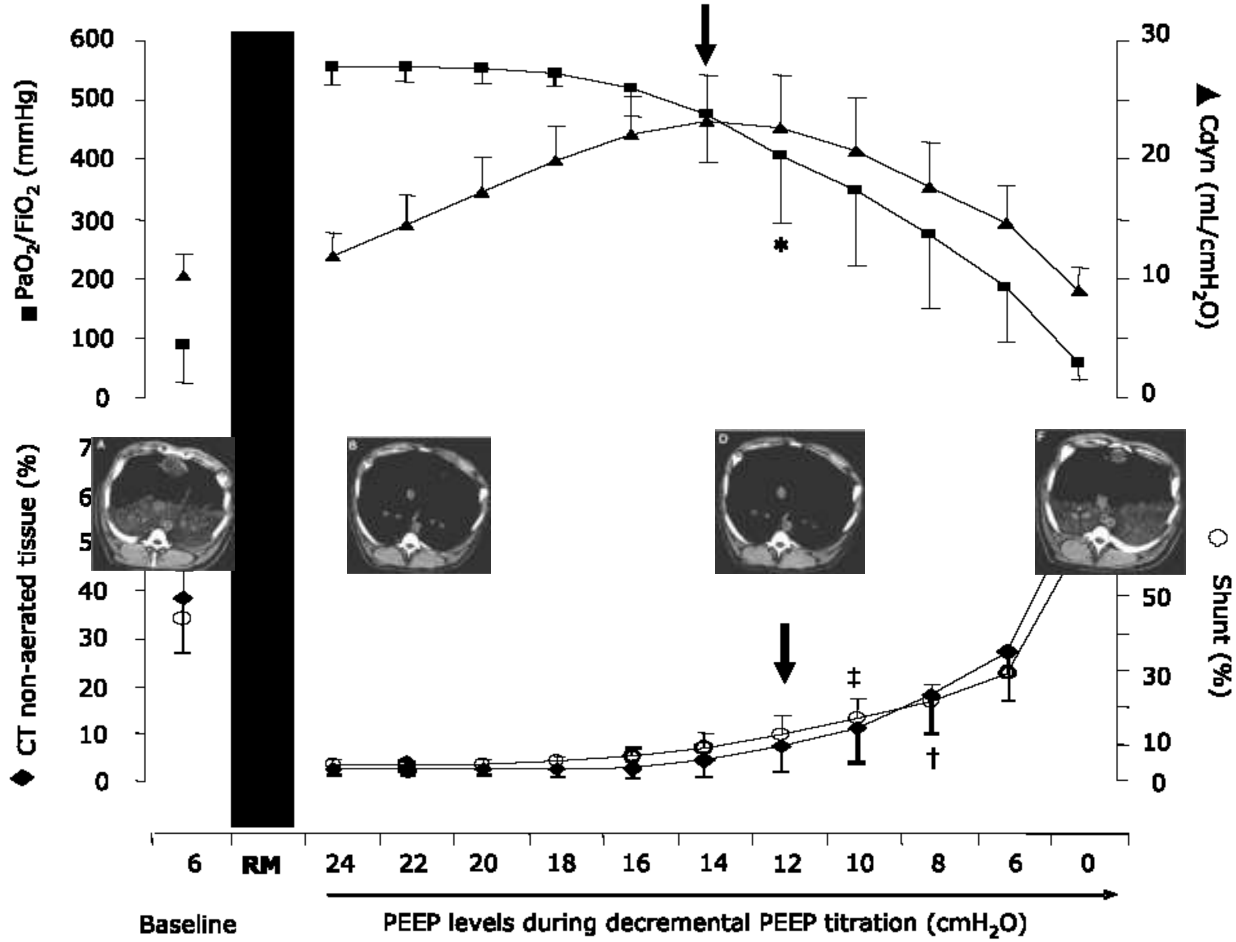
Crit Care Med 2007; 35:214–221

Fernando Suarez-Sipmann, MD; Stephan H. Böhm, MD; Gerardo Tusman, MD; Tanja Pesch; Oliver Thamm; Hajo Reissmann, MD; Andreas Reske, MD; Anders Magnusson, MD, PhD; Göran Hedenstierna, MD, PhD

8 pigs with ARDS (lung lavage): RM+ decremental PEEP trial

P/F, Crs, CT-scan





Conclusions:

Cdyn identified the beginning of collapse after recruitment.
This is confirmed by oxygenation and CT-scans.

ELSEVIER

Contents lists available at ScienceDirect

Current Anaesthesia & Critical Care

journal homepage: www.elsevier.com/locate/cacc

FOCUS ON: MECHANICAL VENTILATION

Treatment of anesthesia-induced lung collapse with lung recruitment maneuvers

Gerardo Tusman [a,*], Javier F. Belda [b]

[a] Department of Anesthesiology, Hospital Privado de Comunidad, 7600 Mar del Plata, Argentina
[b] Department of Anesthesiology, Hospital Universitario, Valencia, Spain

Trends in Anaesthesia and Critical Care 3 (2013) 238–245

ELSEVIER

Contents lists available at SciVerse ScienceDirect

Trends in Anaesthesia and Critical Care

journal homepage: www.elsevier.com/locate/tacc

REVIEW

Alveolar recruitment during mechanical ventilation – Where are we in 2013?

Gerardo Tusman [a,*], Stephan H. Bohm [b], Fernando Suarez-Sipmann [c,d]

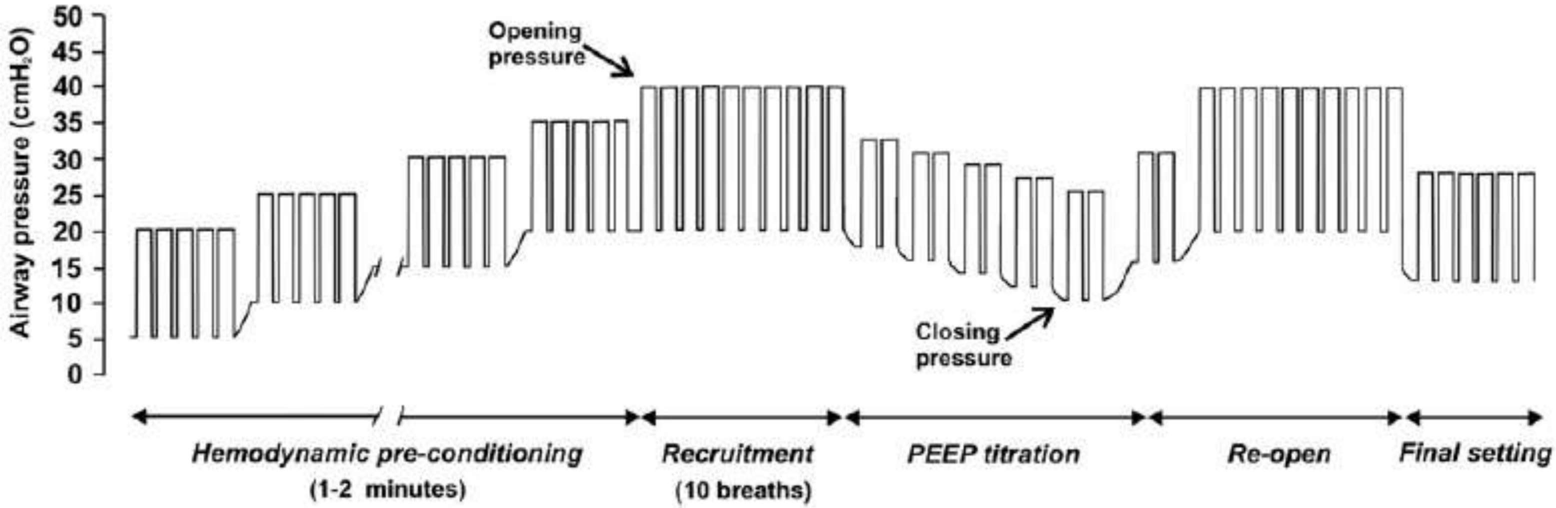
[a] Department of Anesthesiology, Hospital Privado de Comunidad, Mar del Plata, Argentina
[b] Swisstom AG, Landquart, Switzerland
[c] Department of Surgical Sciences, Clinical Physiology, University Hospital, Uppsala, Sweden
[d] CIBERES, Madrid, Spain

Recruiting maneuvers

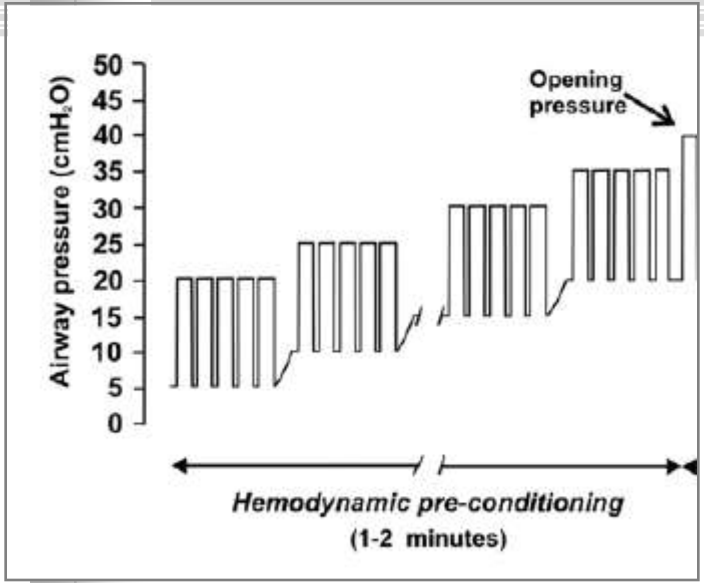
Tusman, Belda CACC 2010

Cycling maneuvers:

PCV (10-15 cmH_2O in normal lungs) for VT ≤ 8ml/kg
+ PEEP increments in steps of 5 cmH_2O, from 5 to 20.



Characteristics



Stepwise increases in PEEP

Time to adapt haemodynamics

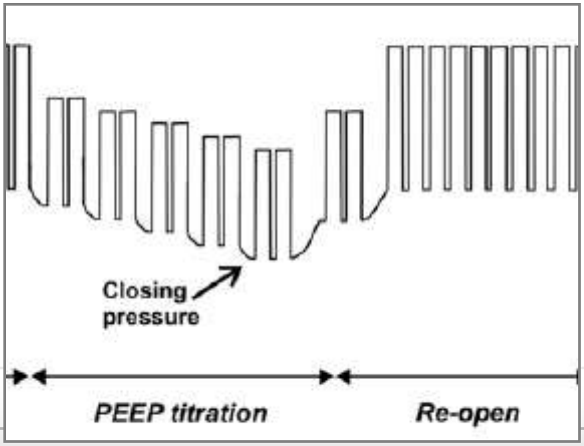
Help to diagnose and treat an unrecognized hypovolaemic state.

Lower pulmonary tissue stress

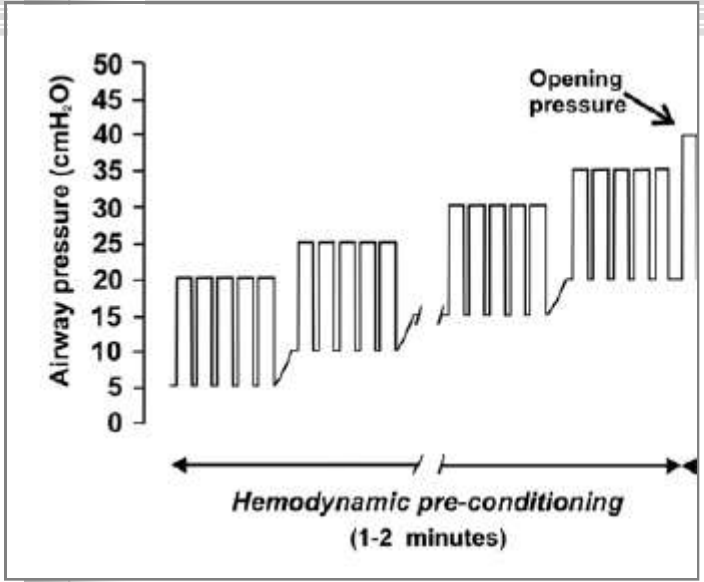
Increments in pressure and volume spread progressively within more and more 'recruited' tissue

PEEP titration phase

helps to detect the level of PEEP



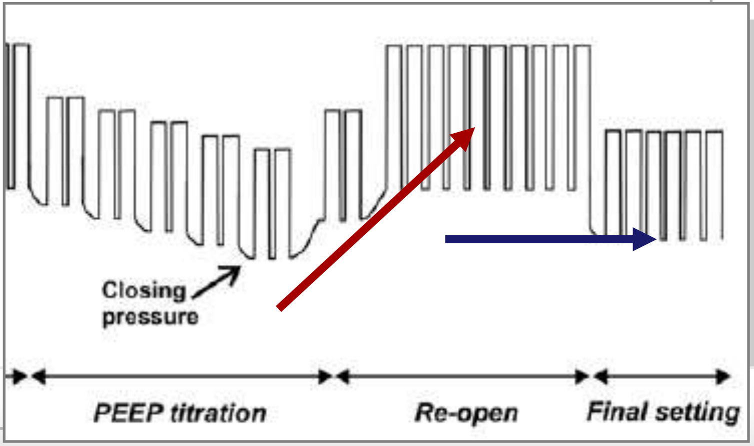
Characteristics



Stepwise increases in PEEP
Time to adapt haemodynamics
Help to diagnose and treat an unrecognised hypovolaemic state.

Lower pulmonary tissue stress
Increments in pressure and volume spread progressively within more and more ‘recruited’ tissue

PEEP titration phase
helps to detect the level of PEEP



“ADRSnet vs Open Lung approach for the ventilatory management of patients with severe ARDS“

Robert M. Kacmarek, Jesus Villar et al.

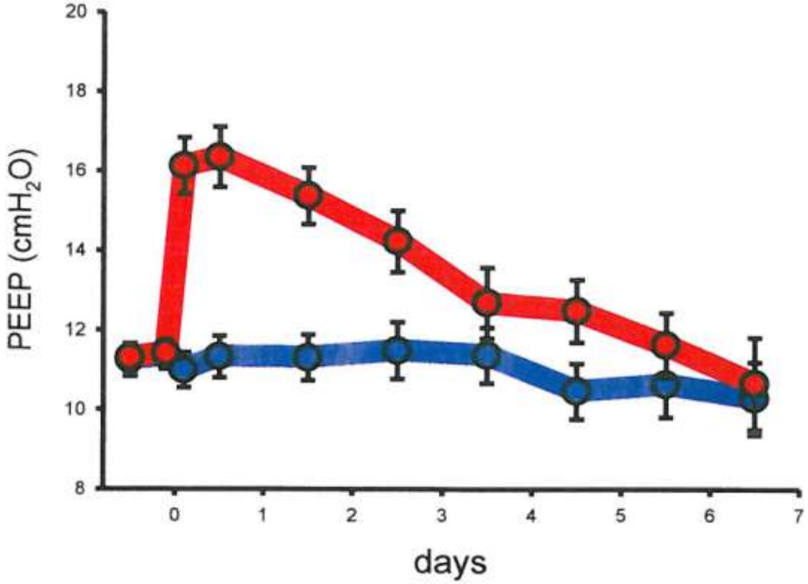
30 worldwide centers
2007-2012

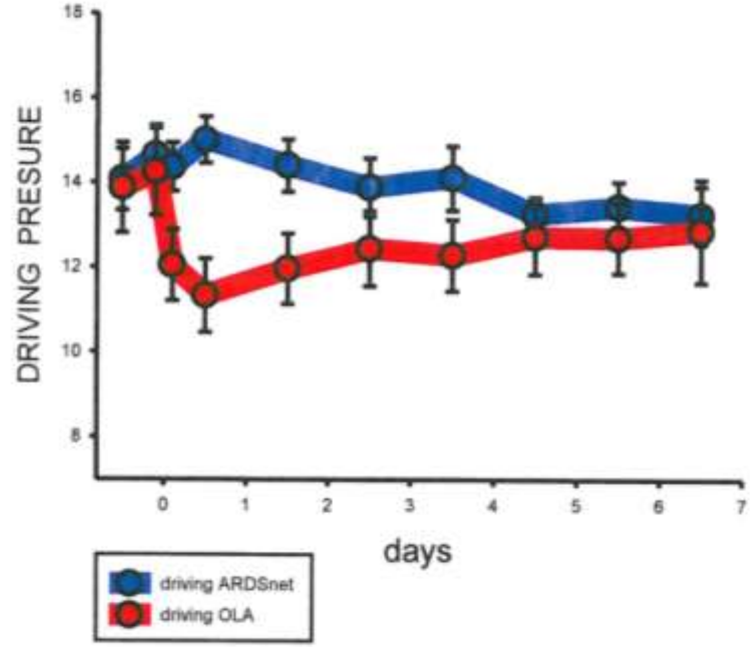
Stopped at 250 /500 planned patients

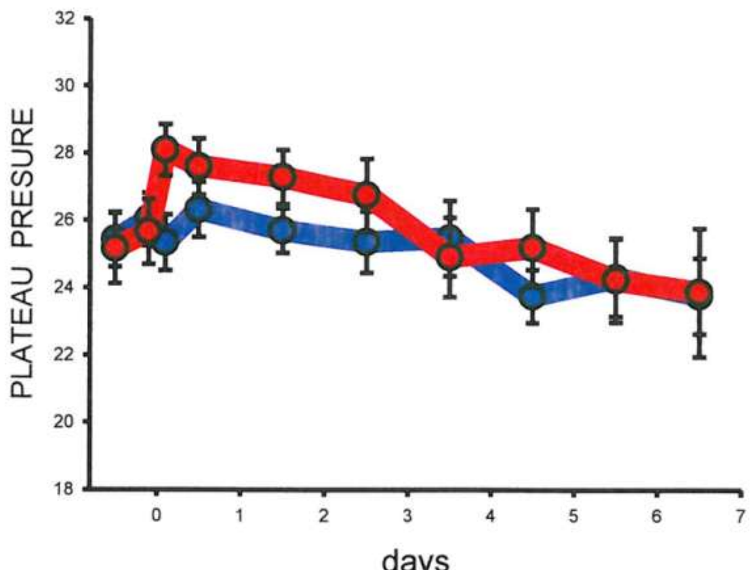
ARDS confirmed at 24 horas

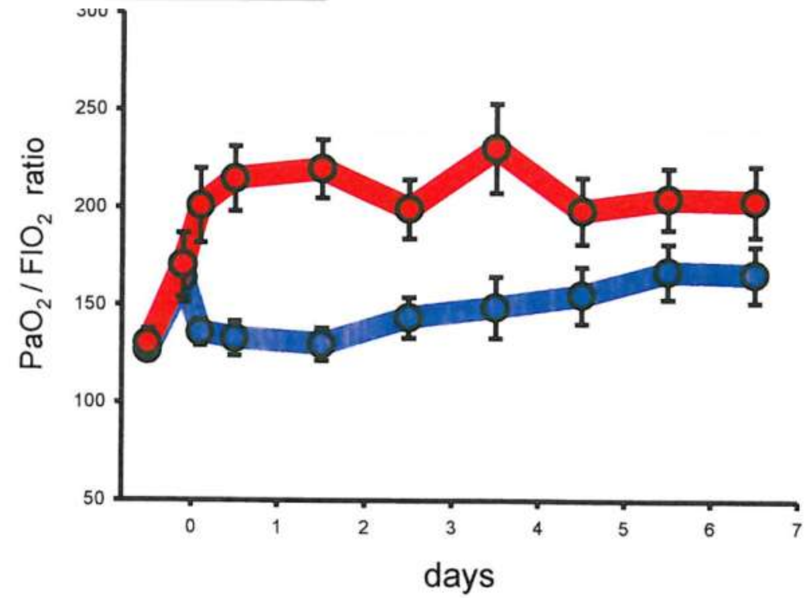
VCV VT: 6 ml/Kg, RF<35 pm, Ppl<30 cmH_2O

Protocol ARDSnet: P/F tabla vs Open-Lung Approach


PEEP (cmH$_2$O)
days

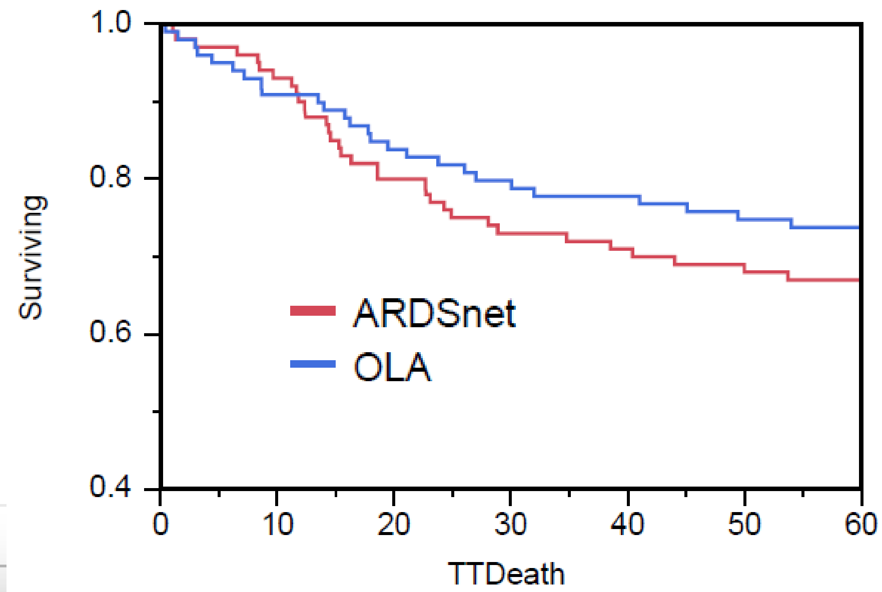

DRIVING PRESURE
days
driving ARDSnet
driving OLA


PLATEAU PRESURE
days


PaO$_2$ / FIO$_2$ ratio
days

OLA vs ARDSnet

Outcome	OLA	ARDSnet
Death in the ICU	23 (23%)	32 (32%)
Death by 60 days	28 (28%)	34 (34%)
LOS ICU (days)	18 (10-28)	15 (11-28)
Vent free days (days)	9 (0-20)	5 (0-19)



General Articles

Detection of Tidal Recruitment/Overdistension in Lung-Healthy Mechanically Ventilated Patients Under General Anesthesia

Anesth Analg 2013;116:677–84

Alysson Roncally Carvalho, PhD,*† Sergio A. Pacheco, MSc, MD,* Patricia Vieira de Souza Rocha, MSc,* Bruno Curty Bergamini,* Luís Felipe Paula,† Frederico C. Jandre, DSc,* and Antonio Giannella-Neto, DSc*

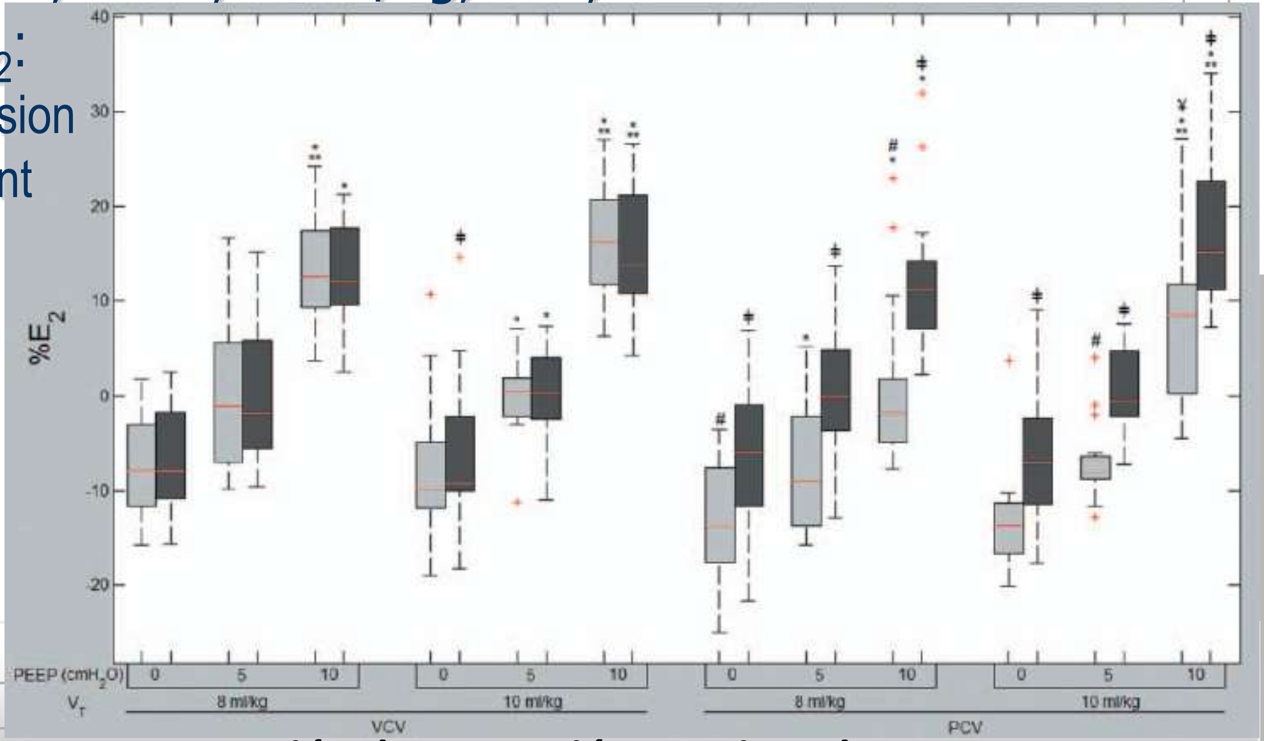
15 patients ASA I-II Breast reconstruction

PEEP: 0, 5, 10 cmH2O; VT: 8, 10 ml/Kg; PCV, VCV

Distension Index $5E_2$:

Positive: tidal overdistension

Negative: tidal recruitment



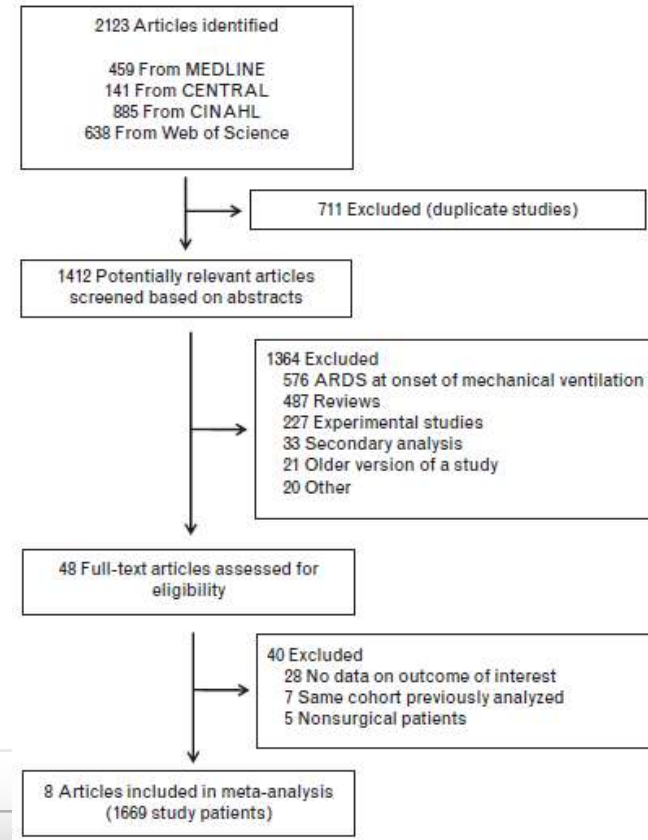
REVIEW

Curr Opin Anesthesiol 2013, 26:126–133

Current Opinion in Anesthesiology

Intraoperative ventilatory strategies to prevent postoperative pulmonary complications: a meta-analysis

Sabrine N.T. Hemmes[a,b], Ary Serpa Neto[c,d], and Marcus J. Schultz[a,e]



REVIEW

Curr Opin Anesthesiol 2013, 26:126–133

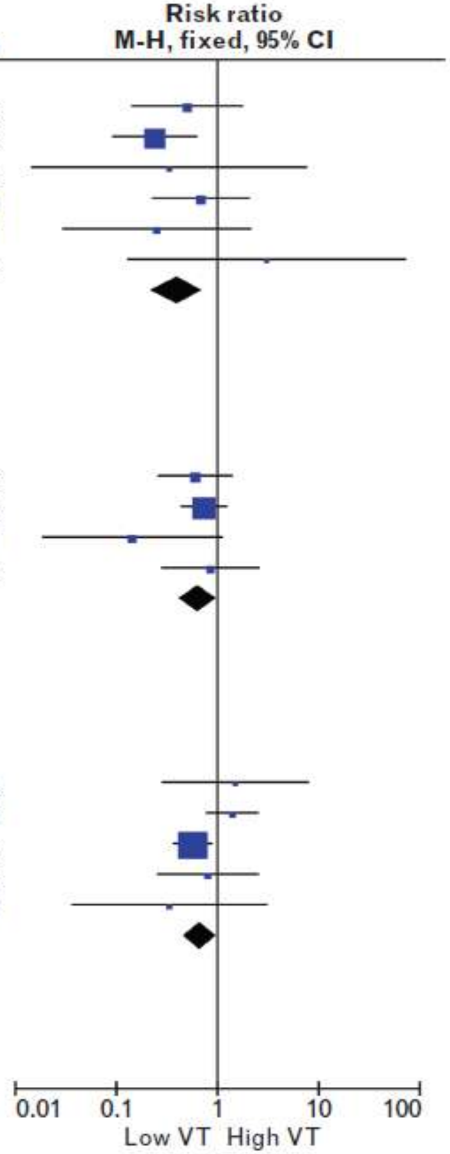
Current Opinion in Anesthesiology

Intraoperative ventilatory strategies to prevent postoperative pulmonary complications: a meta-analysis

Sabrine N.T. Hemmes[a,b], Ary Serpa Neto[c,d], and Marcus J. Schultz[a,e]

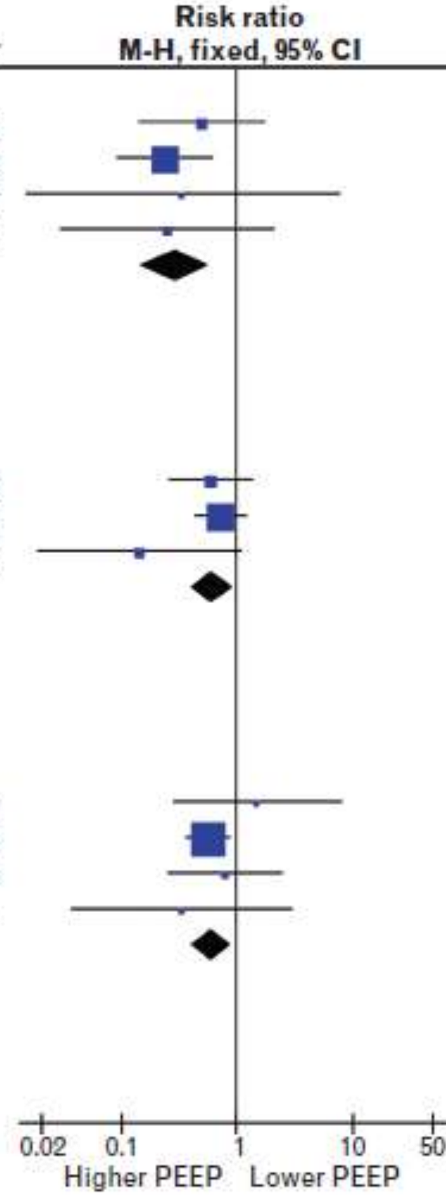
	Protective ventilation ($n=886$)	Conventional ventilation ($n=783$)	P value
Age (years)	60.27 ± 8.31	60.33 ± 8.06	0.910
Weight (kg)	73.04 ± 13.04	73.01 ± 12.56	0.965
Tidal volume (ml/kg) IBW[a]	6.14 ± 0.86	10.35 ± 1.15	<0.0001
PEEP (cm H_2O[a])	6.62 ± 2.65	2.74 ± 2.82	0.001
Plateau pressure (cm H_2O[a])	16.62 ± 2.76	20.45 ± 2.54	0.021
Respiratory rate (beats/min[a])	16.62 ± 2.72	10.78 ± 2.67	0.007
Minute-ventilation (l/min[a])	7.76 ± 2.61	8.56 ± 2.58	0.917
PaO_2/FiO_2[a]	332.86 ± 61.48	339.68 ± 67.70	0.797
PaCO2 (mmHg[a])	41.86 ± 3.32	39.05 ± 3.42	0.052
pH[a]	7.35 ± 0.03	7.39 ± 0.03	0.073

Study or subgroup	Low VT Events	Low VT Total	High VT Events	High VT Total	Weight	Risk ratio M-H, fixed, 95% CI	Year
1.2.1 Lung injury							
Michelet *et al*. 2006 [15]	3	26	6	26	15.3%	0.50 [0.14, 1.79]	2006
Licker *et al*. 2009 [18]	5	558	20	533	52.2%	0.24 [0.90, 0.63]	2009
Weingarten *et al*. 2010 [19]	0	20	1	20	3.8%	0.33 [0.01, 7.72]	2010
Fernandez-Bustamante *et al*. 2011 [20]	7	154	5	75	17.2%	0.68 [0.22, 2.08]	2011
Yang *et al*. 2011 [21]	1	50	4	50	10.2%	0.25 [0.03, 2.16]	2011
Treschan *et al*. 2012 [22]	1	50	0	51	1.3%	3.06 [0.13, 73.35]	2012
Subtotal (95% CI)		**858**		**755**	**100.0%**	**0.40 [0.22, 0.70]**	
Total events	17		36				
Heterogeneity: $Chi^2 = 3.86$, $df = 5$ ($P = 0.57$); $I^2 = 0\%$							
Test for overall effect: $Z = 3.20$ ($P = 0.001$)							
1.2.3 Pulmonary infection							
Michelet *et al*. 2006 [15]	6	26	10	26	18.6%	0.60 [0.26, 1.41]	2006
Licker *et al*. 2009 [18]	23	558	30	533	57.2%	0.73 [0.43, 1.24]	2009
Yang *et al*. 2011 [21]	1	50	7	50	13.1%	0.14 [0.02, 1.12]	2011
Treschan *et al*. 2012 [22]	5	50	6	51	11.1%	0.85 [0.28, 2.61]	2012
Subtotal (95% CI)		**684**		**660**	**100.0%**	**0.64 [0.43, 0.97]**	
Total events	35		53				
Heterogeneity: $Chi^2 = 2.54$, $df = 3$ ($P = 0.47$); $I^2 = 0\%$							
Test for overall effect: $Z = 2.13$ ($P = 0.003$)							
1.2.4 Atelectasis							
Lin *et al*. 2008 [17]	3	20	2	20	3.2%	1.50 [0.28, 8.04]	2004
Cai *et al*. 2007 [16]	7	8	5	8	7.9%	1.40 [0.77, 2.54]	2007
Licker *et al*. 2009 [18]	28	558	47	533	76.2%	0.57 [0.36, 0.89]	2009
Weingarten *et al*. 2010 [19]	4	20	5	20	7.9%	0.80 [0.25, 2.55]	2010
Yang *et al*. 2011 [21]	1	50	3	50	4.8%	0.33 [0.04, 3.10]	2011
Subtotal (95% CI)		**656**		**631**	**100.0%**	**0.67 [0.47, 0.96]**	
Total events	43		62				
Heterogeneity: $Chi^2 = 7.67$, $df = 4$ ($P = 0.10$); $I^2 = 48\%$							
Test for overall effect: $Z = 2.19$ ($P = 0.003$)							



Test for subgroup differences: $Chi^2 = 2.57$, $df = 2$ ($P = 0.28$), $I^2 = 22.3\%$

Study or subgroup	Higher PEEP Events	Higher PEEP Total	Lower PEEP Events	Lower PEEP Total	Weight	Risk ratio M-H, fixed, 95% CI	Year
1.9.1 Lung injury							
Michelet *et al.* 2006 [15]	3	26	6	26	18.8%	0.50 [0.14, 1.79]	2006
Licker *et al.* 2009 [18]	5	558	20	533	64.0%	0.24 [0.09, 0.63]	2009
Weingarten *et al.* 2010 [19]	0	20	1	20	4.7%	0.33 [0.01, 7.72]	2010
Yang *et al.* 2011 [21]	1	50	4	50	12.5%	0.25 [0.03, 2.16]	2011
Subtotal (95% CI)		**654**		**629**	**100.0%**	**0.29 [0.14, 0.60]**	
Total events	9		31				
Heterogeneity: Chi² = 0.87, df = 3 (*P* = 0.83); *I*² = 0%							
Test for overall effect: Z = 3.40 (*P* = 0.0007)							
1.9.3 Pulmonary infection							
Michelet *et al.* 2006 [15]	6	26	10	26	21.0%	0.60 [0.26, 1.41]	2006
Licker *et al.* 2009 [18]	23	558	30	533	64.4%	0.73 [0.43, 1.24]	2009
Yang *et al.* 2011 [21]	1	50	7	50	14.7%	0.14 [0.02, 1.12]	2011
Subtotal (95% CI)		**634**		**609**	**100.0%**	**0.62 [0.40, 0.96]**	
Total events	30		47				
Heterogeneity: Chi² = 2.34, df = 2 (*P* = 0.31); *I*² = 15%							
Test for overall effect: *Z* = 2.16 (*P* = 0.03)							
1.9.4 Atelectasis							
Lin *et al.* 2008 [17]	3	20	2	20	3.4%	1.50 [0.28, 8.04]	2004
Licker *et al.* 2009 [18]	28	558	47	533	82.8%	0.57 [0.36, 0.89]	2009
Weingarten *et al.* 2010 [19]	4	20	5	20	8.6%	0.80 [0.25, 2.55]	2010
Yang *et al.* 2011 [21]	1	50	3	50	5.2%	0.33 [0.04, 3.10]	2011
Subtotal (95% CI)		**648**		**623**	**100.0%**	**0.61 [0.41, 0.91]**	
Total events	36		57				
Heterogeneity: Chi² = 1.69, df = 3 (*P* = 0.64); *I*² = 0%							
Test for overall effect: Z = 2.43 (*P* = 0.01)							



Test for subgroup differences: Chi² = 3.55, df = 2 (*P* = 0.17), *I*² = 43.7%

A Description of Intraoperative Ventilator Management and Ventilation Strategies in Hypoxic Patients

ANESTHESIA & ANALGESIA

James M. Blum, MD,* Douglas M. Fetterman, MD,* Pauline K. Park, MD,† Michelle Morris, MS,* and Andrew L. Rosenberg, MD*

Anesth Analg 2010;110:1616–22

11445 Cases: 28706 ABGs

Table 1. Demographics of Cohort and Distribution of ABGs by Surgical Service

	Mean	Minimum	Maximum	SD
Age (y)	57.18	18	103	15.62
ASA physical status	2.86	1	5	0.73
Weight (kg)	84.90	35	215	22.39
Height (in.)	67.42	60	80	3.93
PBW	65.26	46	96	10.70
OR time (min)	382.00	30	2191	204.92

Service	Operative cases		ABGs	
Neurosurgery	2260	19.58%	5890	20.52%
General surgery and subspecialties	1849	16.02%	4412	15.37%
Vascular	1497	12.97%	3745	13.05%
Orthopedic	1333	11.55%	2635	9.18%
Otolaryngology/ maxillofacial	1321	11.45%	4011	13.97%
Urology	990	8.58%	2246	7.82%
Transplant	799	6.92%	2801	9.76%
Trauma	565	4.89%	1097	3.82%
Other/combined/ unknown	428	3.71%	969	3.38%
OB/gyn	294	2.55%	515	1.79%
Plastic	205	1.78%	385	1.34%
Total	11,541	100%	28,706	100%

Table 2. Mean and SD Where N= the Number of ABGs

	Normal		Mild hypoxia		Moderate hypoxia		Severe hypoxia	
	P/F >300 (N = 19,679)		300 ≥ P/F > 200 (N = 5364)		200 ≥ P/F > 100 (N = 3101)		100≥P/F (N = 562)	
	Mean		Mean		Mean		Mean	
Age (y)	56.94		58.64*		56.70		54.16*	
ASA physical status	2.80		2.95*		2.98*		3.27*	
Height (in.)	67.28		67.76*		67.63*		68.01*	
Weight (kg)	81.38		91.75*		93.60*		94.56*	
Predicted body weight	64.88		66.19*		65.83*		66.71*	
P/F ratio	427.86		253.84*		158.15*		81.51*	
Pao_2 (mm Hg)	249.61		149.94*		103.85*		74.13*	
Fio_2 (%)	58.46		59.21		66.75*		91.43*	
PEEP (cm H_2O)	2.86		3.40*		3.98*		5.48*	
V_T (mL/kg PBW)	9.05		9.16*		9.10		8.64*	
PIP (cm H_2O)	22.18		24.41*		26.08*		28.82*	
$Paco_2$ (mm Hg)	36.34		38.21*		39.93*		44.79*	
pH	7.43		7.41*		7.40*		7.36*	
Spo_2 (%)	99.29		98.57*		97.93*		96.20*	
Actual V_T (mL)	578.72		597.49*		591.46*		568.17	
$ETco_2$ (mm Hg)	32.99		33.42*		33.55*		33.95*	

Table 3. Comparison of Ventilator Strategies at the Beginning and End of the Operation

	Normal		Mild hypoxia		Moderate hypoxia		Severe hypoxia	
	P/F >300 (*N* = 3659)		300 ≥ P/F > 200 (*N* = 1858)		200 ≥ P/F > 100 (*N* = 1308)		100≥P/F (*N* = 288)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Earliest mL/kg PBW	8.91	1.76	9.07	1.88	9.07	1.88	8.65	1.96
Latest mL/kg PBW	9.01*	1.85	9.21*	1.89	9.14	2.07	8.78	2.16
Earliest PEEP (cm H_2O)	2.48	2.19	2.79	2.37	3.36	2.76	4.64	3.51
Latest PEEP (cm H_2O)	2.81*	2.21	3.28*	2.37	4.14*	2.74	5.92*	3.64
Earliest FIO_2 (%)	60.78	21.56	59.47	20.66	64.34	19.86	84.07	17.74
Latest FIO_2 (%)	57.42*	21.92	57.74*	21.24	65.23	20.75	83.97	18.51

Table 4. Changes in Ventilation by Calendar Year

	Normal		Mild hypoxia		Moderate hypoxia		Severe hypoxia		Total	
Year	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Average tidal volumes by hypoxia group in mL/kg pbw										
2005	9.35	1.98	9.51	2.03	9.55	2.20	9.73	2.60	9.41	2.03
2006	9.51*	1.95	9.82*	2.11	9.60	2.04	8.55*	2.20	9.56*	2.00
2007	9.06*	1.78	9.13*	1.82	9.14*	1.84	8.81†	2.16	9.08*	1.80
2008	8.82*	1.60	8.91*	1.71	8.94*	1.85	8.57*	1.81	8.85*	1.66
2009	8.60*	1.62	8.64*	1.67	8.42*	1.76	7.78*	1.89	8.57*	1.66
Average PEEP by hypoxia group in cm H_2O										
2005	2.04	1.37	2.43	1.73	2.86	2.07	4.04	2.93	2.25	1.63
2006	2.12	1.34	2.52	1.78	3.06*	2.20	4.40	3.15	2.32*	1.63
2007	2.38*	2.59	2.99*	2.85	3.69*	3.27	5.88*	3.95	2.70*	2.82
2008	3.42*	2.54	4.03*	2.74	4.64*	3.01	6.03*	3.58	3.73*	2.72
2009	4.06*	2.25	4.57*	2.41	5.14*	3.11	6.21*	3.70	4.32*	2.47

Conclusions (personal recomendations)

Make an accurate diagnosis of ARDS

At 24 h P/F ratio with FiO_2-50 PEEP-10

Perform early recruiting maneuvers

PEEP titration (Decremental PEEP trial)

- –FiO_2/PEEP algorithms
- –Consensus based: No pathophysiological background
- –Not individualized

Apply Protective Ventilation in OR


Thank you very much