CEEA Région Grand Sud-Ouest - 9/11 Juin 2016
Module 1 - Respiration et Thorax

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Committee for European Education in Anaesthesiology

Ventilation Mécanique au bloc opératoire en 2016

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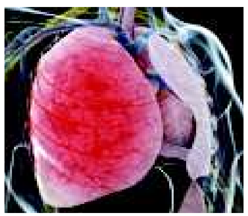

Objectifs

CEEA

- Rappeler les risques de réglages inadaptés
- Identifier le(s) risque(s) chez le patient chirurgical
- Présenter quelques solutions : concept POP®

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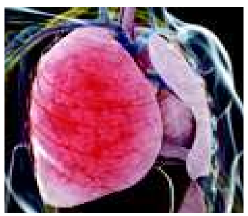
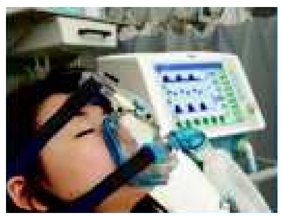


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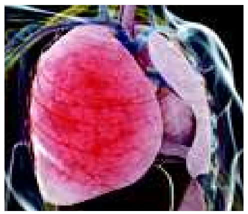


The NEW ENGLAND JOURNAL of MEDICINE

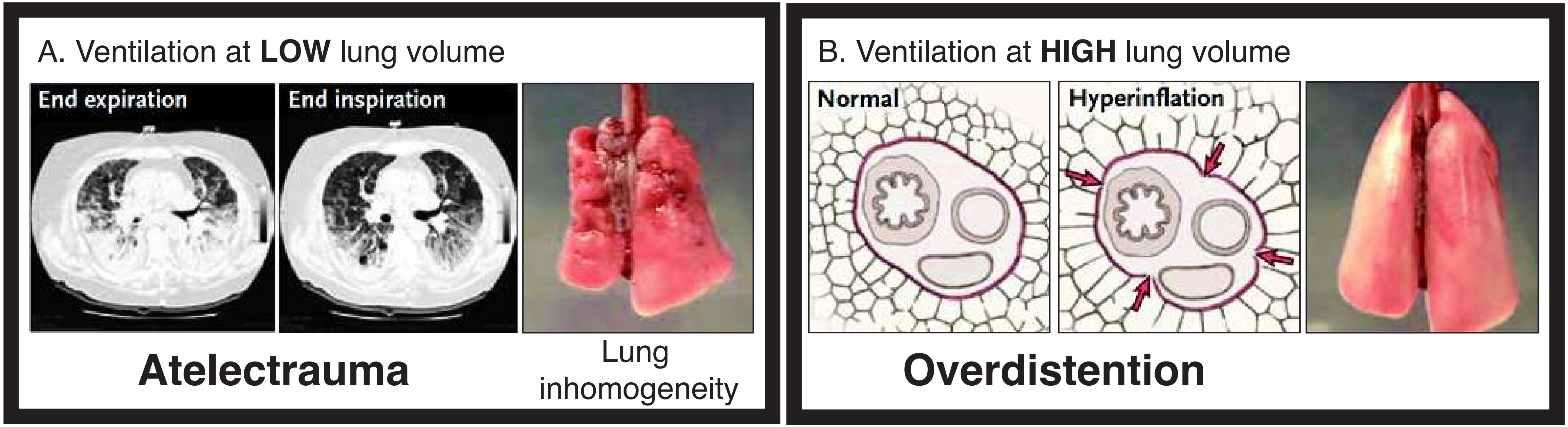
REVIEW ARTICLE

CRITICAL CARE MEDICINE

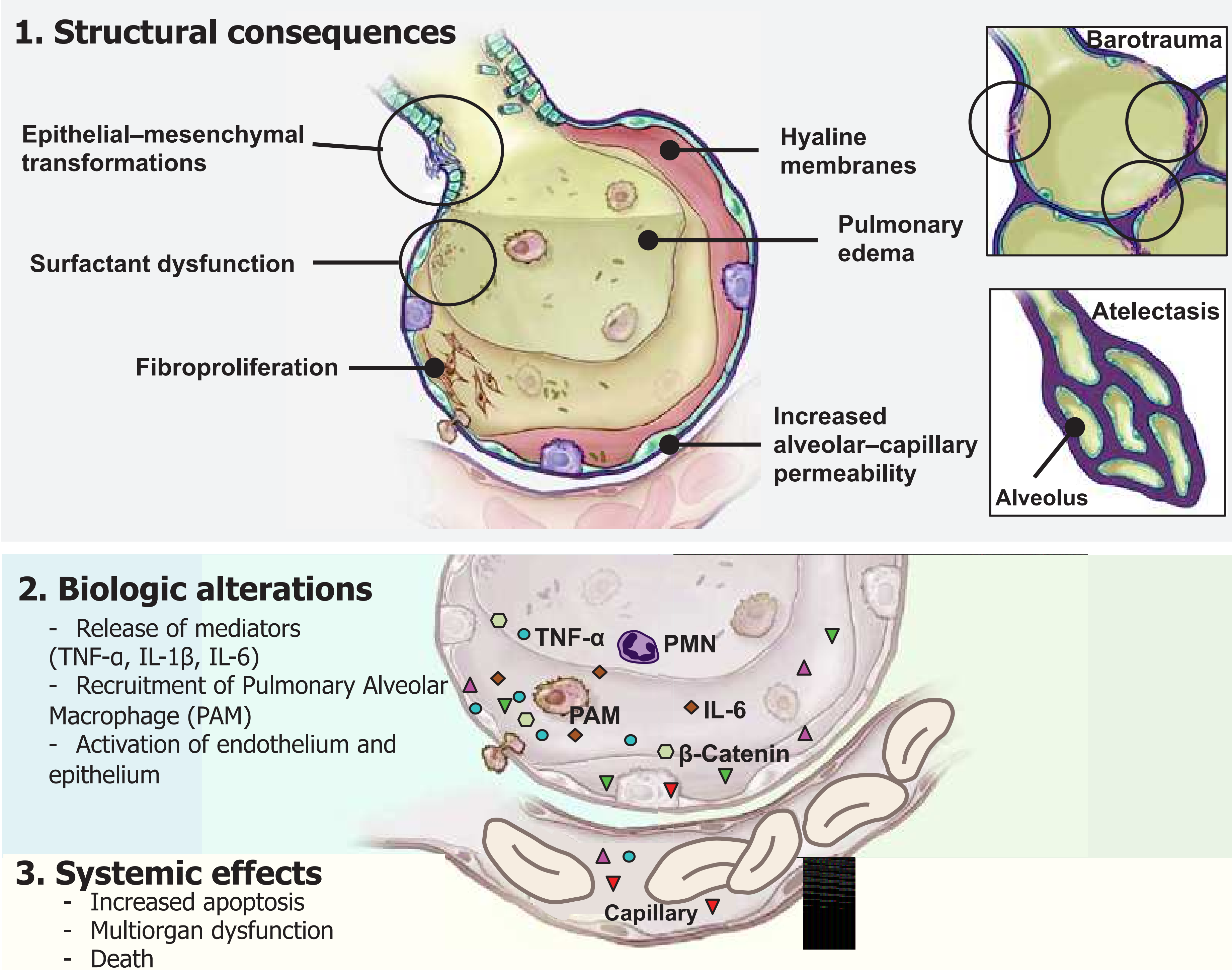
Simon R. Finfer, M.D., and Jean-Louis Vincent, M.D., Ph.D., *Editors*

Ventilator-Induced Lung Injury

Arthur S. Slutsky, M.D., and V. Marco Ranieri, M.D.



N Engl J Med 2013;369:2126-36



Slutsky AS, Ranieri VM. N Engl J Med 2013;369:2126-2136

VOLUME 342 NUMBER 18 MAY 4, 2000

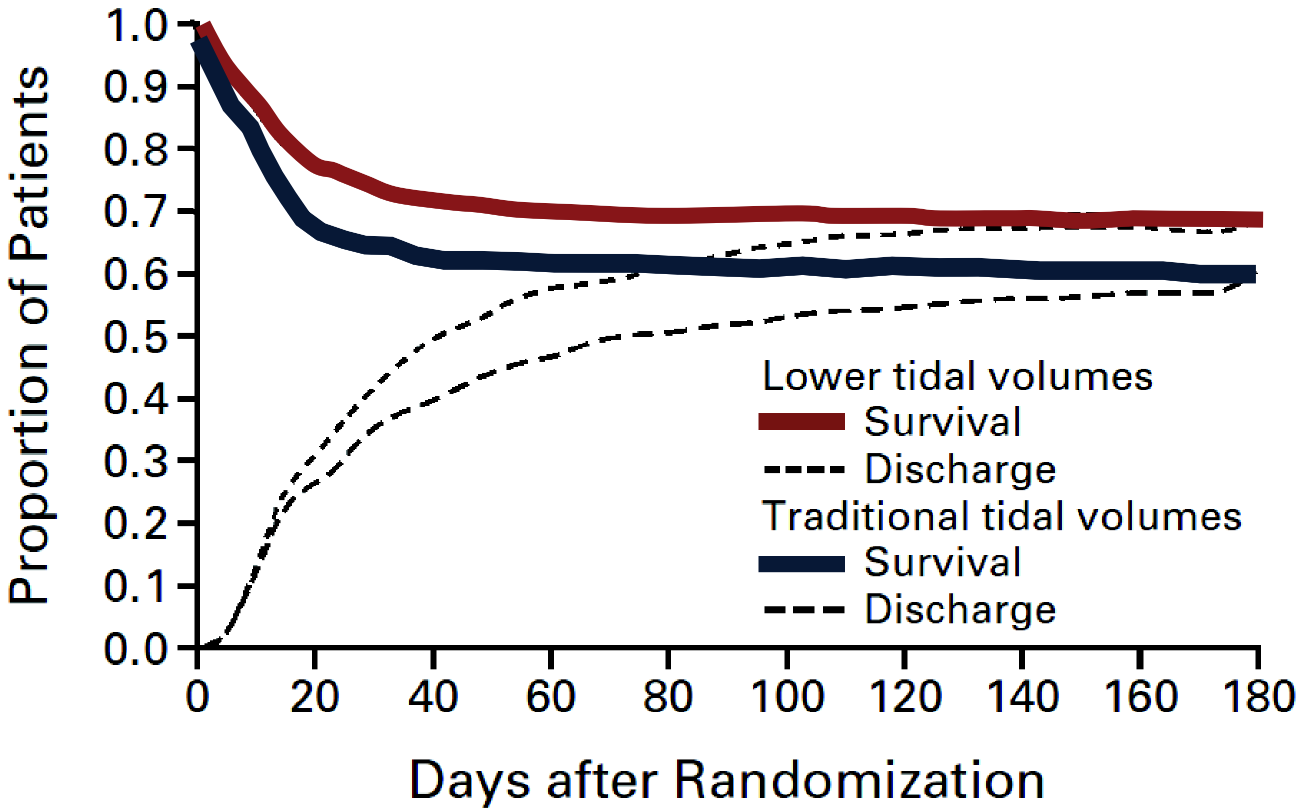
VENTILATION WITH LOWER TIDAL VOLUMES AS COMPARED WITH TRADITIONAL TIDAL VOLUMES FOR ACUTE LUNG INJURY AND THE ACUTE RESPIRATORY DISTRESS SYNDROME

THE ACUTE RESPIRATORY DISTRESS SYNDROME NETWORK*

Traditional VT ventilation
(N=429)
VT 11.8±0.8 ml/kg PBW
PEEP 9.4±3.6 cmH_2O

VS.

Lower TV ventilation
(N=432)
VT 6.2±0.9 ml/kg PBW
PEEP 8.6±3.6 cmH_2O

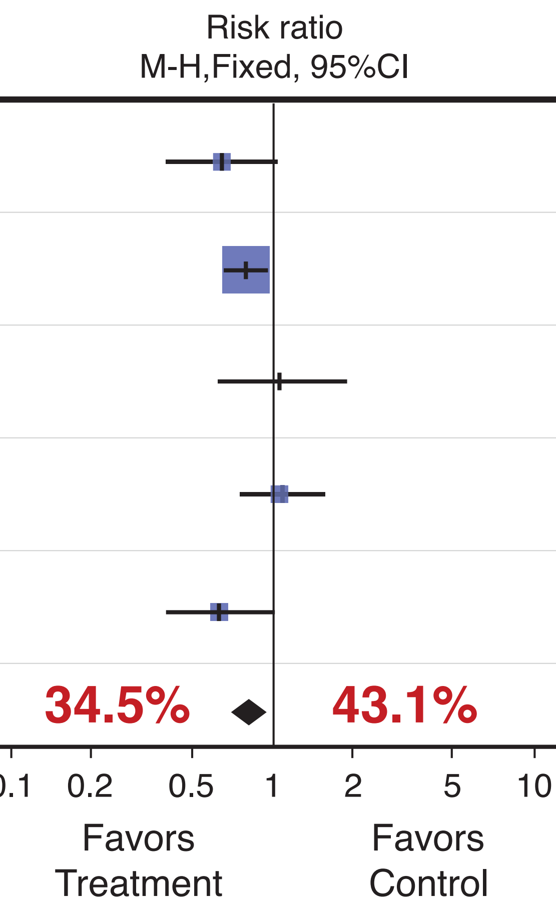


Lung protective ventilation strategy for the acute respiratory distress syndrome (Review)

Petrucci N, De Feo C

Outcome: Hospital mortality

Study or subgroup	Treatment n/N	Control n/N	Weight	Risk ratio M-H,Fixed, 95%CI
Amato, 1998	13/29	17/24	7.3%	0.63 [0.39,1.02]
ARDS Network, 2000	133/432	170/429	66.8%	0.78 [0.65,0.93]
Brower, 1999	13/26	17/26	4.7%	1.08 [0.62,1.91]
Stewart, 1998	30/60	28/60	11.0%	1.07 [0.74,1.55]
Villar, 2006	17/50	25/45	10.3%	0.61 [0.38,0.98]
Total (95%CI)	**597**	**584**	**100%**	**0.80 [0.69,0.92]**



THE COCHRANE COLLABORATION®

Authors' conclusions

Mortality was significantly reduced at day 28 and at the end of the hospital stay. **Ventilation with lower tidal volumes is becoming a routine strategy of treatment** in patients with ARDS and ALI.

Cochrane Database Syst Rev. 2013

Lung protective ventilation strategy for the acute respiratory distress syndrome (Review)

Petrucci N, De Feo C

	Treatment		Control	
Study or subgroup	**VT** ml/kg IBW	**PEEP** cmH2O	**VT** ml/kg IBW	**PEEP** cmH2O
Amato, 1998	7.0±0.4	16.3±0.7	12.1±0.6	6.3±0.8
ARDS Network, 2000	6.2±0.9	9.4±3.6	11.2±0.8	8.6±3.6
Brower, 1999	7.3±0.1	9.5	10.2±0.1	8.3
Stewart, 1998	7.0±0.7	8.6±3.0	10.7±1.4	7.2±3.3
Villar, 2006	7.3±0.9	14.1±2.8	10.2±1.2	9.0±2.7

THE COCHRANE COLLABORATION®

Cochrane Database Syst Rev. 2013

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Take Home Message #1

A lung protective ventilation refers to the use of:

- **Low tidal volume (i.e., VT of 8 ml/kg IBW or less)**
- **PEEP**

VT calculated on ideal and NOT on actual body weight!

The main objective is to protect the lungs against physical (mechanical) forces associated with:

- **Lung overdistension**
- **Repetitive opening and closing of lung units**

EDITORIAL

JAMA. **2012** Oct 24;308(16):1689-90

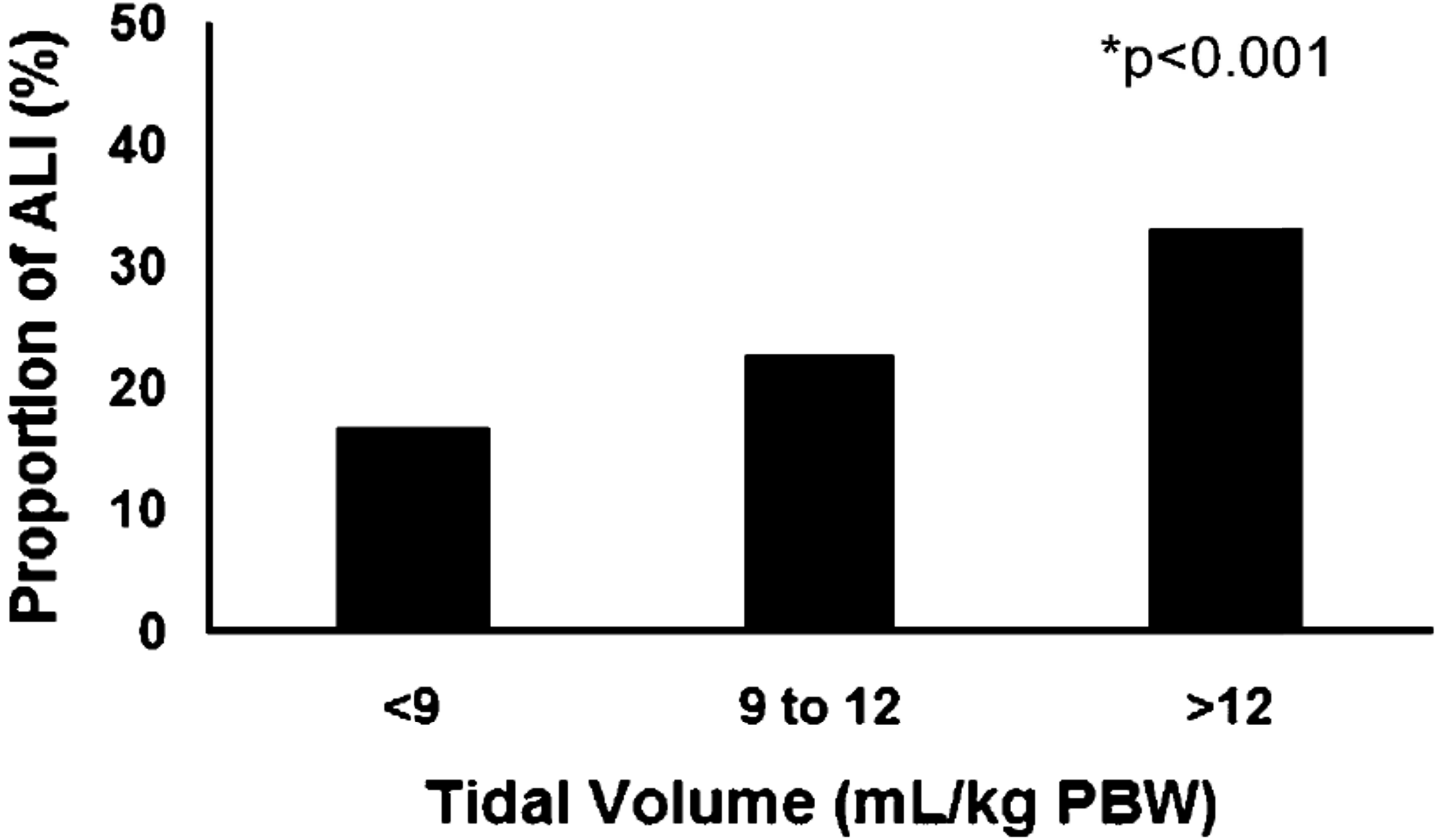
Low Tidal Volumes for All?

Niall D. Ferguson, MD, MSc

Crit Care Med 2004; 32:1817–1824

Ventilator-associated lung injury in patients without acute lung injury at the onset of mechanical ventilation*

Ognjen Gajic, MD; Saqib I. Dara, MD; Jose L. Mendez, MD; Adebola O. Adesanya, MD; Emir Festic, MD; Sean M. Caples, MD; Rimki Rana, MD; Jennifer L. St. Sauver, PhD; James F. Lymp, PhD; Bekele Afessa, MD; Rolf D. Hubmayr, MD



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

JAMA
The Journal of the American Medical Association

Serpa Neto et al. JAMA 2012;308:1651-1659

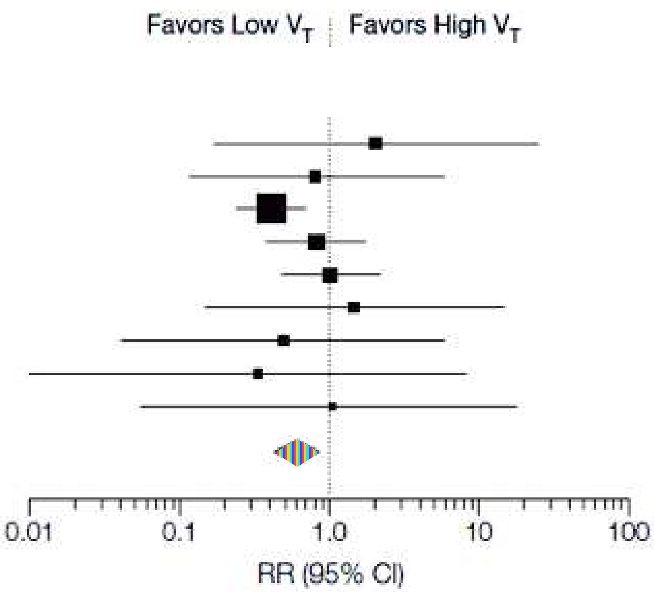
A Meta-analysis

N=2822 patients
(20 articles)

	High VT ventilation	Low VT ventilation
VT (ml/kg PBW)	10.6±1.14	6.45±1.09
PEEP (cmH_2O)	**3.41±2.79**	**6.4±2.39**

	High V_T, No. Events	High V_T, No. Total	Low V_T, No. Events	Low V_T, No. Total	Weight, %	RR (95% CI)
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 (**10.7%**)		74 (**6.5%**)			

Heterogeneity: $\chi^2_8 = 6.94$; $P = .54$; $I^2 = 0\%$
Test for overall effect: $z = 2.68$; $P = .007$



Conclusions Among patients without ARDS, protective ventilation with lower tidal volumes was associated with better clinical outcomes.

Objectifs

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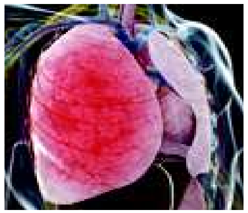
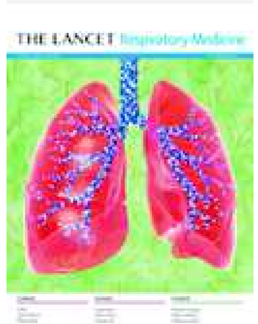


Incidence of mortality and morbidity related to postoperative lung injury in patients who have undergone abdominal or thoracic surgery: a systematic review and meta-analysis

Articles



Ary Serpa Neto, Sabrine NT Hemmes, Carmen SV Barbas, Martin Beiderlinden, Ana Fernandez-Bustamante, Emmanuel Futier, Markus W Hollmann, Samir Jaber, Alf Kozian, Marc Licker, Wen-Qian Lin, Pierre Moine, Federica Scavonetto, Thomas Schilling, Gabriele Selmo, Paolo Severgnini, Juraj Sprung, Tanja Treschan, Carmen Unzueta, Toby N Weingarten, Esther K Wolthuis, Hermann Wrigge, Marcelo Gama de Abreu, Paolo Pelosi, Marcus J Schultz, for the the PROVE Network investigators

Lancet Respir Med 2014; 2(12):1007-15

Individual data analysis of 3365 patients from 12 observational and RCTs
Postoperative lung injury: 3.65%

Figure 3: **Timing of PLI during hospital stay**

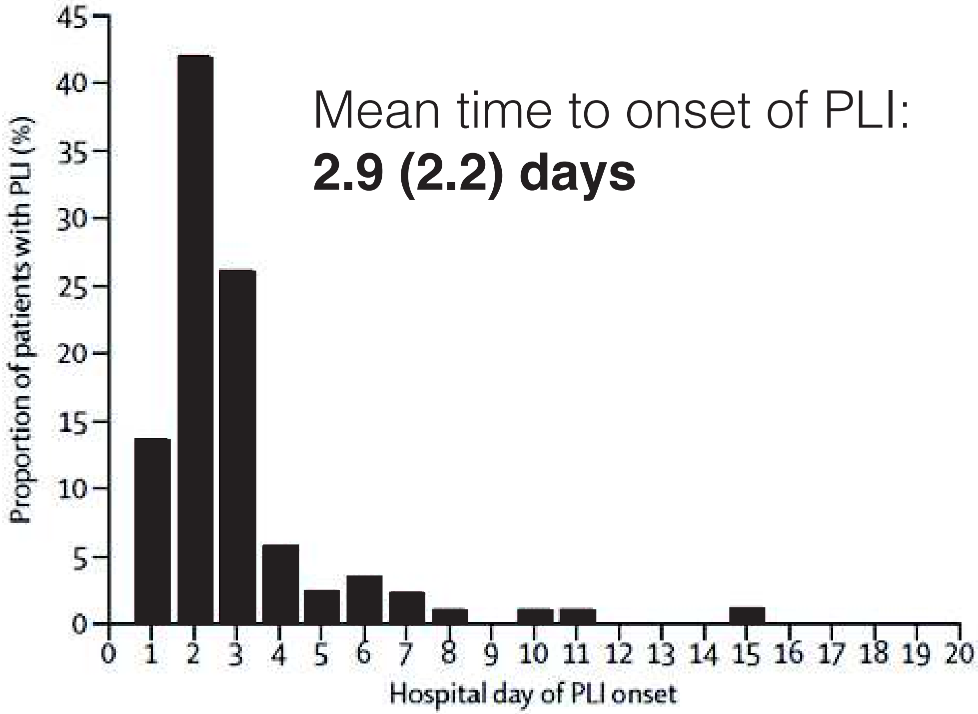
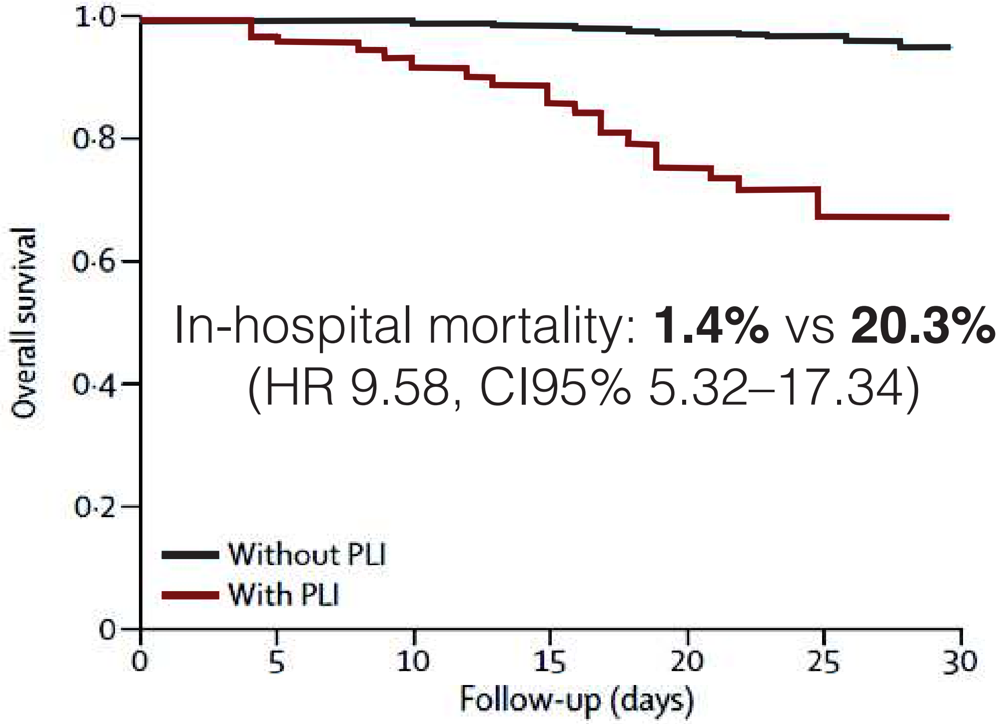


Figure 4: **Kaplan-Meier estimates of overall survival in patients with and without PLI**



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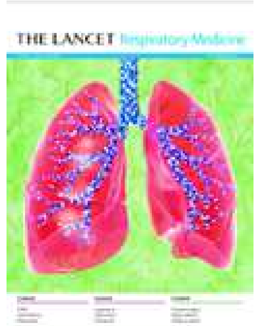

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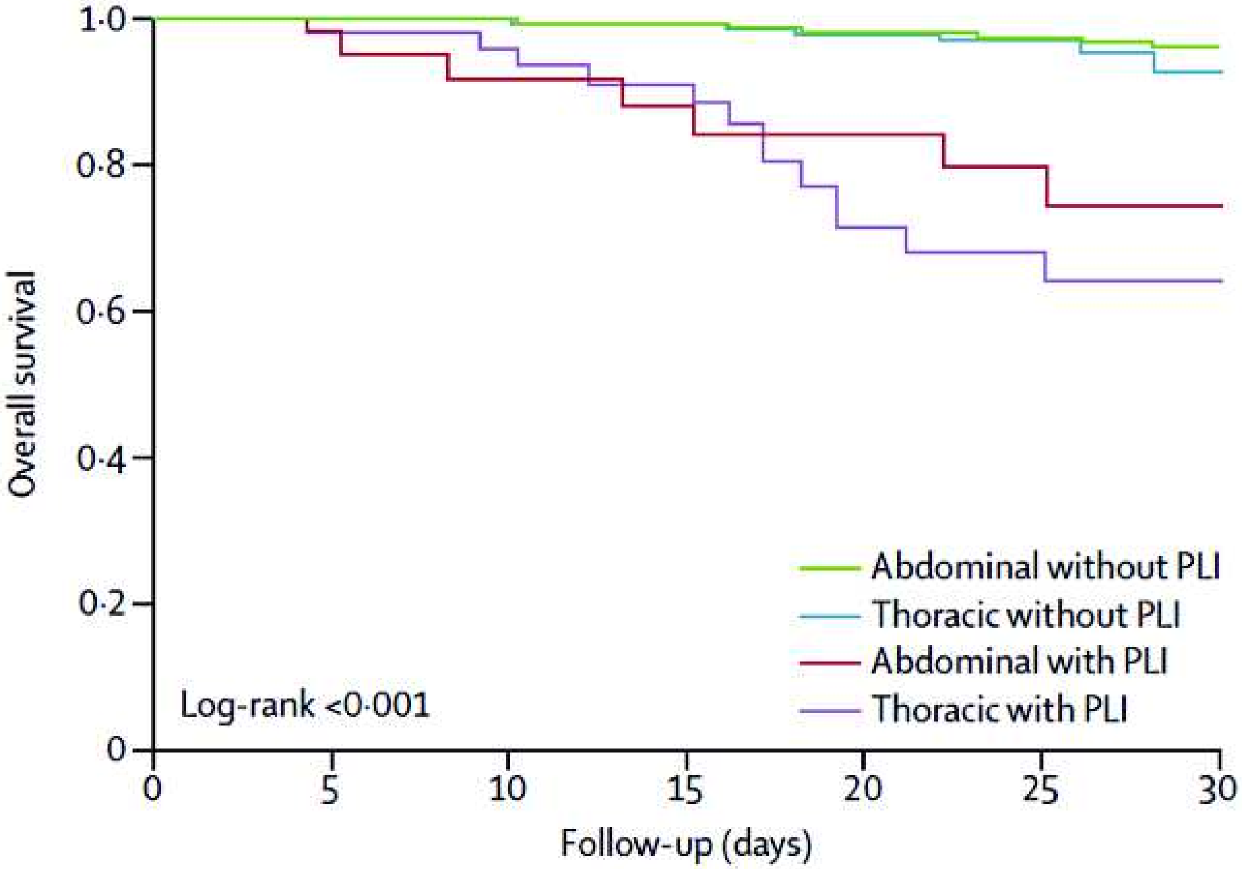


Mortality

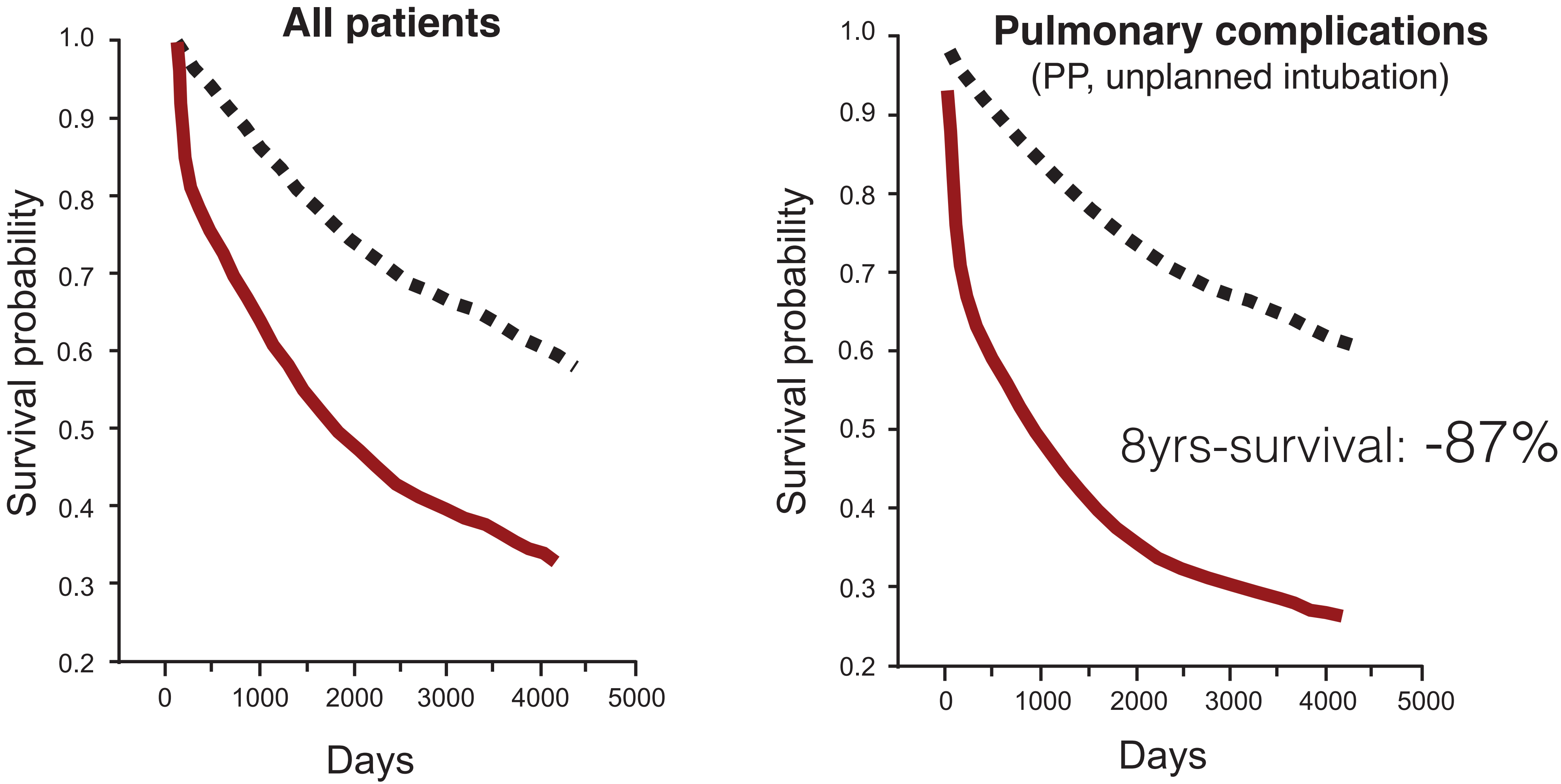
1.4%

25.2%

35.9%

Determinants of Long-Term Survival After Major Surgery and the Adverse Effect of Postoperative Complications

NSQIP data from 105,951 patients follow-up 8 years after surgery



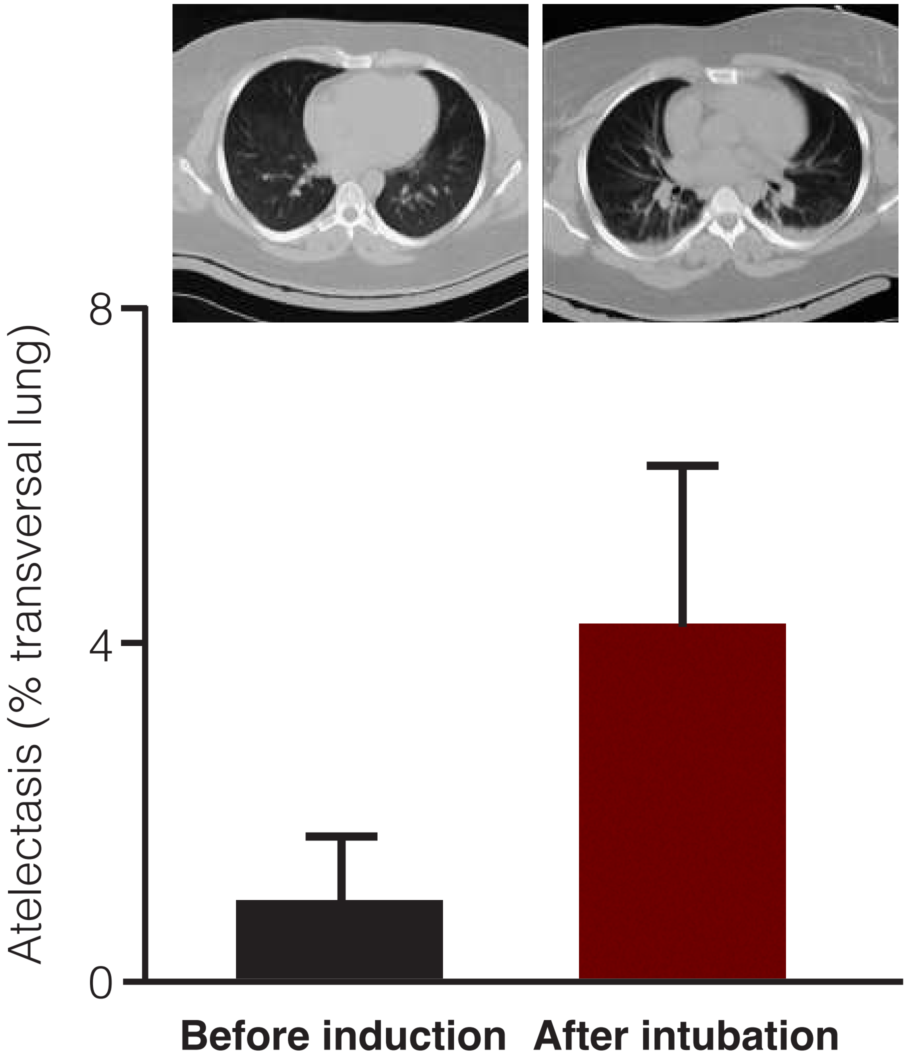
Patients with no complications

Patients with 1 or more 30-day complications

Khuri SF et al. **Ann Surg** 2005;242: 326–343

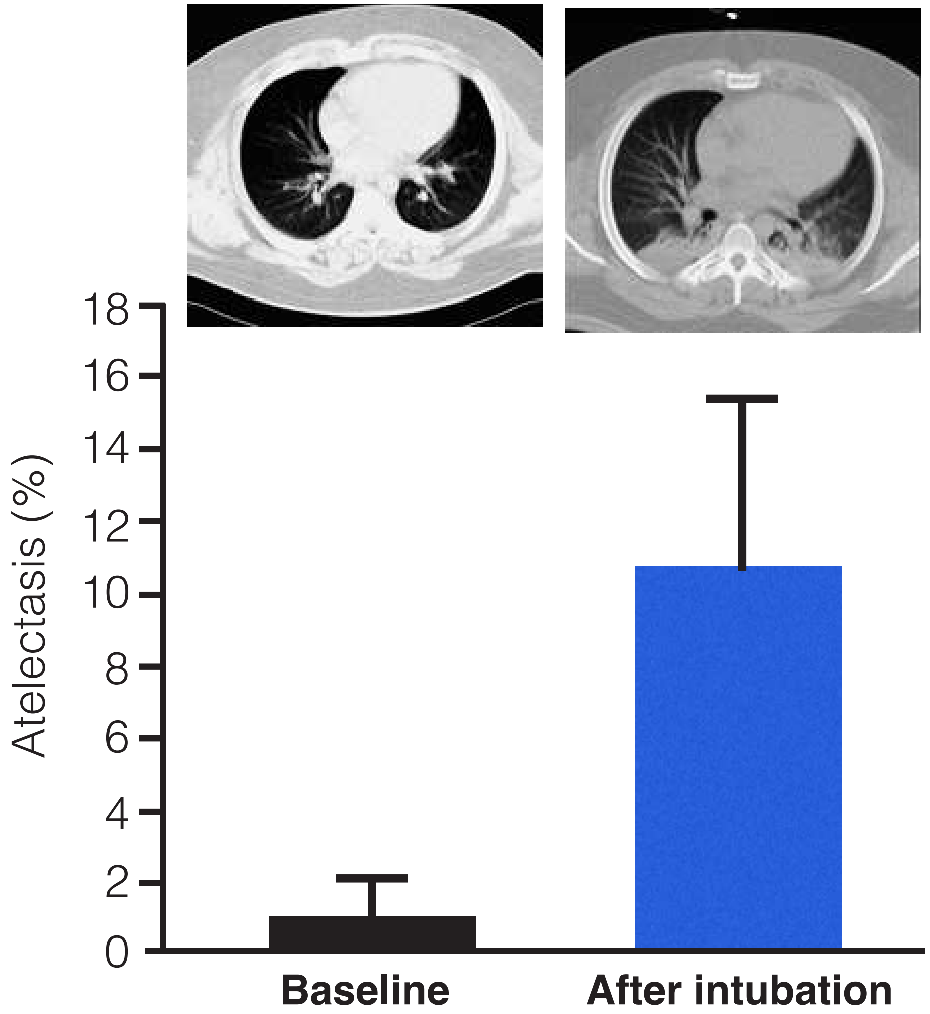
Atelectasis and General Anesthesia

Non obese patients



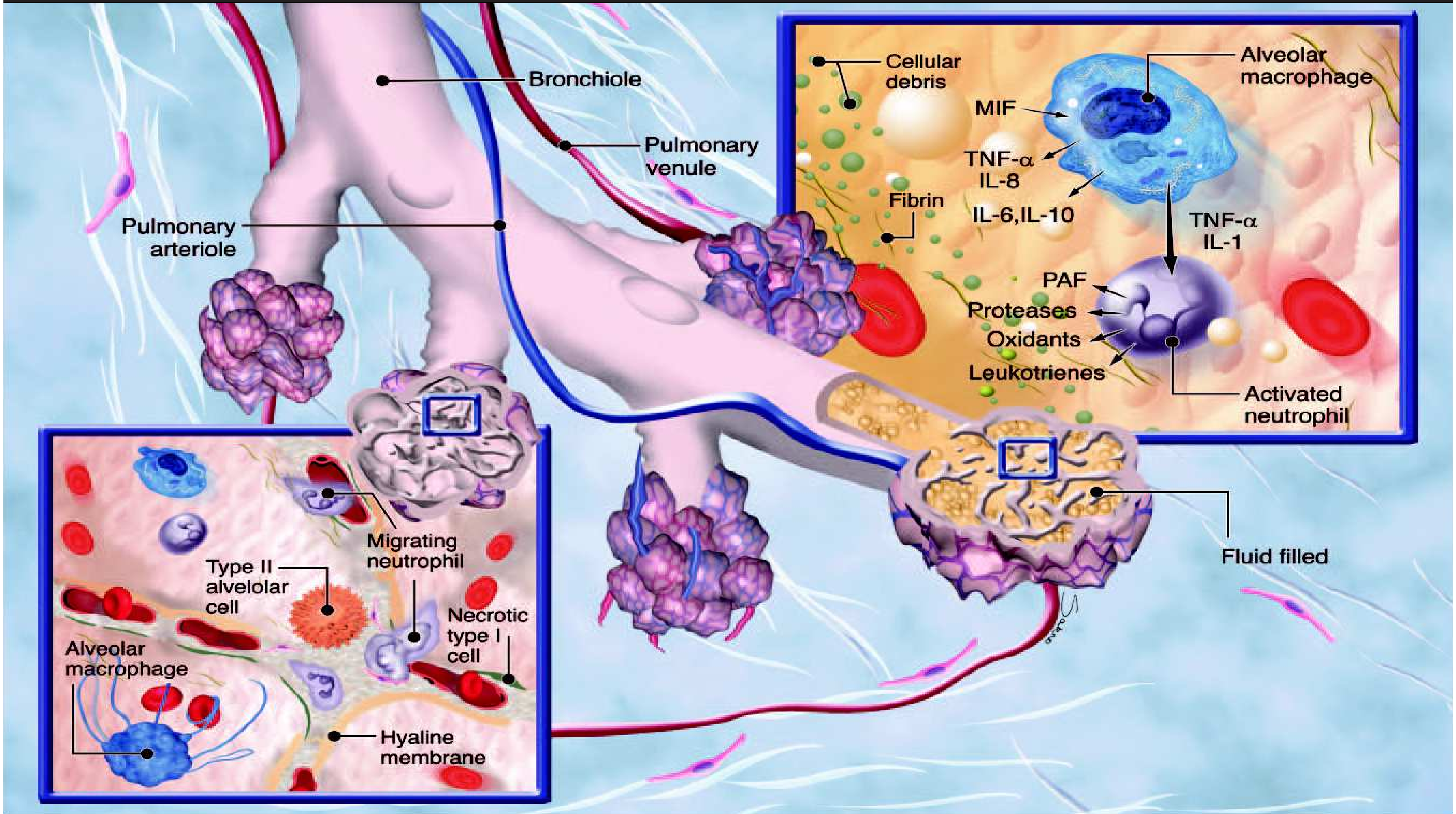
Rusca M. et al. Anesth Analg 2003;97:1835–9

Obese patients



Coussa M. et al Anesth Analg 2004;98:1491–5

Pulmonary Atelectasis:
A Pathogenic Perioperative Entity



Duggan M. Anesthesiology 2005; 102: 838-54

Atelectasis may contribute to injury

- **Atelectasis Causes Alveolar Injury in Nonatelectatic Lung Regions**

Shinya Tsuchida, Doreen Engelberts, Vanya Peltekova, Natalie Hopkins, Helena Frndova, Paul Babyn, Colin McKerlie, Martin Post, Paul McLoughlin, and Brian P. Kavanagh

Lung Biology Program, and Departments of Critical Care Medicine and Radiology, Hospital for Sick Children; Departments of Anesthesia, Laboratory Medicine, and Physiology, and the Interdepartmental Division of Critical Care Medicine, University of Toronto, Toronto, Ontario, Canada; and School of Medicine and Medical Sciences, Conway Institute, University College Dublin, Dublin, Ireland

Am J Respir Crit Care Med 2006;174:279–289

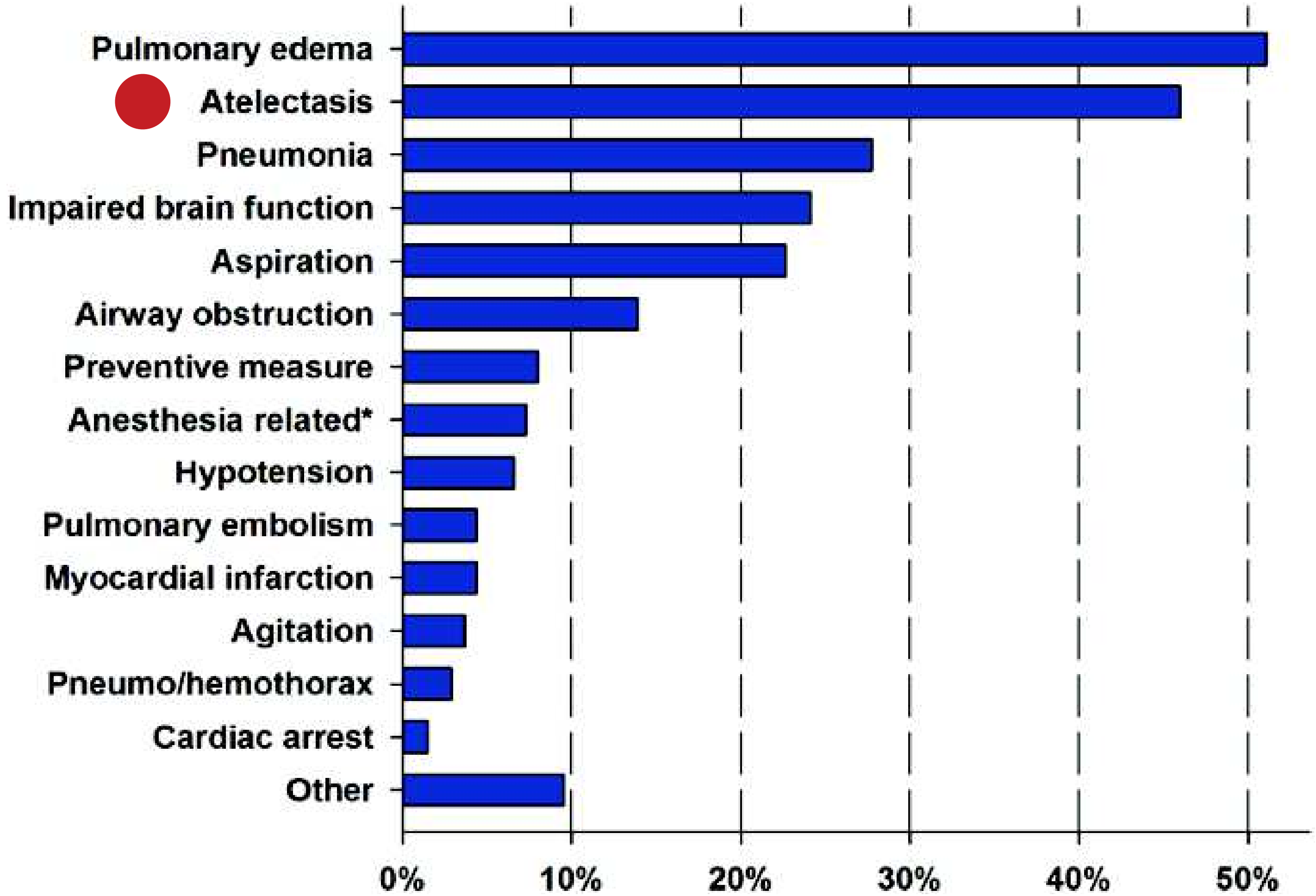
- **Reducing Atelectasis Attenuates Bacterial Growth and Translocation in Experimental Pneumonia**

Anton H. van Kaam, Robert A. Lachmann, Egbert Herting, Anne De Jaegere, Freek van Iwaarden, L. Arnold Noorduyn, Joke H. Kok, Jack J. Haitsma, and Burkhard Lachmann

Department of Anesthesiology and Laboratory of Pediatrics, Erasmus-MC Faculty, Rotterdam; Department of Neonatology, Emma Children's Hospital AMC; Department of Pathology Academic Medical Center, University of Amsterdam, Amsterdam, The Netherlands; and Department of Pediatrics, University of Göttingen, Göttingen, Germany

Am J Respir Crit Care Med 2004;169:1046–1053

Unplanned tracheal intubation after surgery for postoperative respiratory failure



Unplanned tracheal reintubation within 3 days after surgery is associated with an increased risk (72-fold) for in-hospital death: Mortality **16%** versus **0.26%**

Brueckmann B et al. Anesthesiology **2013**; 118:1276-85

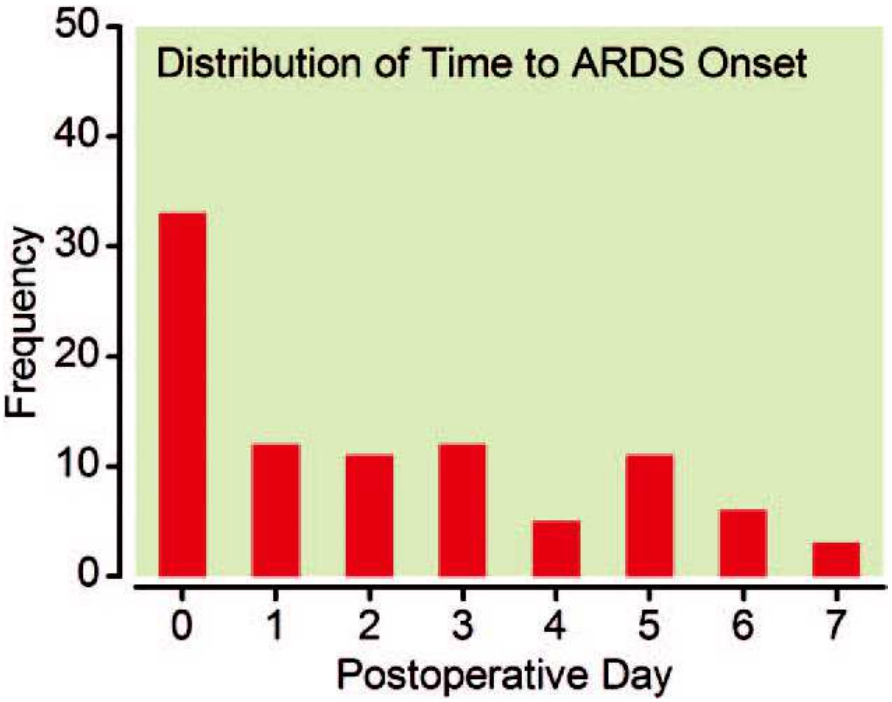
Identification of individual risk factors of postoperative pulmonary complications

Risk factors		
Surgical	**Anesthetics**	**Patient-related**
Surgical procedure	Excessive fluid administration	Age >65yr
Vascular	Blood transfusion (> 4 units)	ASA physical status ≥3
Thoracic	Residual neuromuscular blockade	History of respiratory disease
Upper abdominal	Intraoperative hypothermia	Obstructive sleep apnea
Neurosurgery	Inadequate ventilator settings	Preoperative SpO_2 <96%
Head and Neck		History of congestive heart failure
Emergent procedure		Recent respiratory infection (<1 mo)
Reintervention		Partial or total functional dependency
Surgical duration ≥2 h		Active smoking
Open laparotomy > laparoscopy		Alcohol abuse
		Preoperative sepsis
		Weight loss >10% in the last 6
		Preoperative anemia (<10 g/dl)
		Obesity

Futier E et al. Anesthesiology 2014; 121:400–8
Canet J et al. Anesthesiology 2010;113:1338-50
Arozullah AM et al. Ann Intern Med 2001;135:847-57

Preoperative and Intraoperative Predictors of Postoperative Acute Respiratory Distress Syndrome in a General Surgical Population

50,367 hospitalizations analyzed (from June 1, 2004 to May 31, 2004)
93 (0.2%) were complicated by postoperative ARDS



Intraoperative Predictors of ARDS after matching on Preoperative Risk of ARDS

	Odds ratio
Median drive pressure	1.17 (1.09, 1.31)
Packed erythrocyte transfusion	5.36 (1.39, 11.11)
Median FiO_2	1.02 (1.00, 1.05)
Crystalloid (liters)	1.43 (1.15, 1.93)

Blum JM et al. Anesthesiology 2013;118:19-29

Injurious mechanical ventilation and end-organ epithelial cell apoptosis and organ dysfunction in an experimental model of acute respiratory distress syndrome

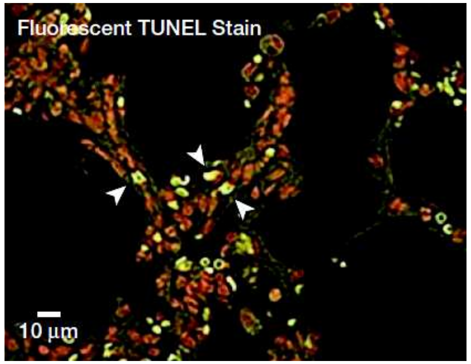
JAMA®
The Journal of the American Medical Association

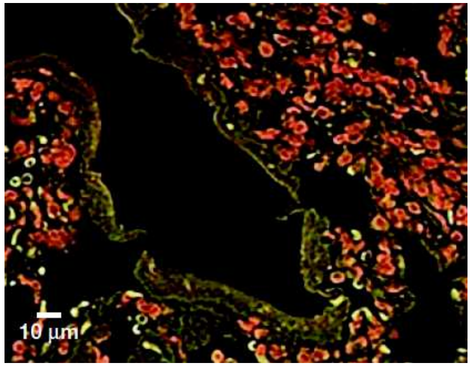
Imai Y et al. Jama 2003;289:1104-12

Non-Injurious Ventilation	*Injurious Ventilation*
TV 5-7 ml/kg	**TV 15-17 ml/kg**
PEEP 9-12 cmH_2O	**PEEP 0-3 cmH_2O**

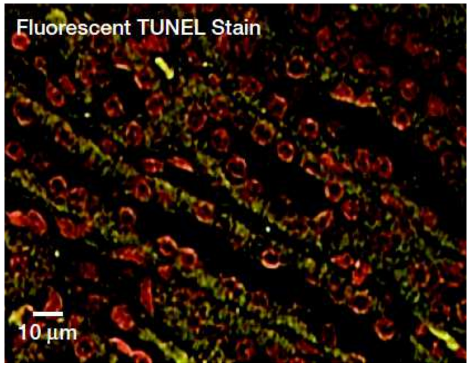
8 hours

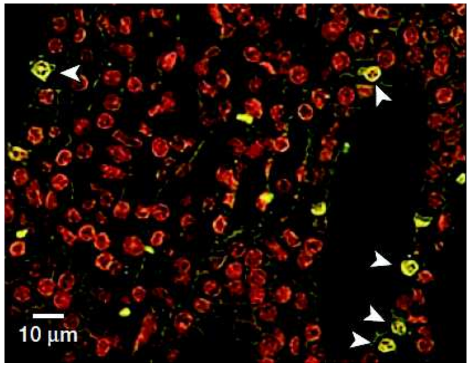
Lung

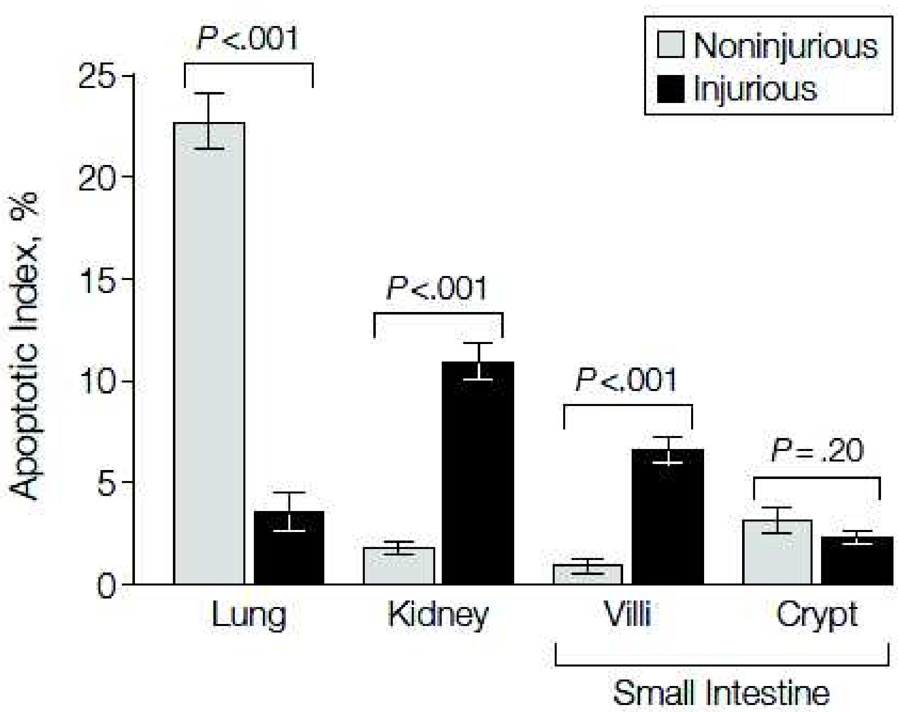




Kidney





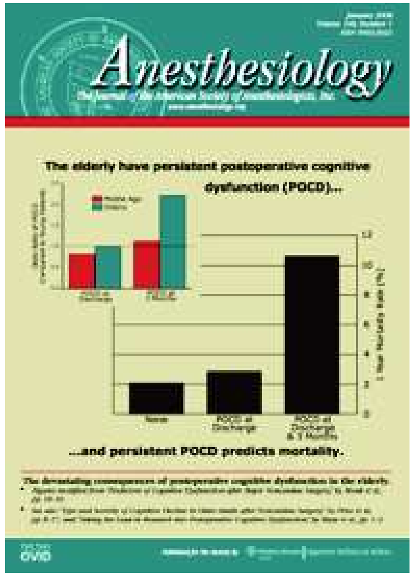


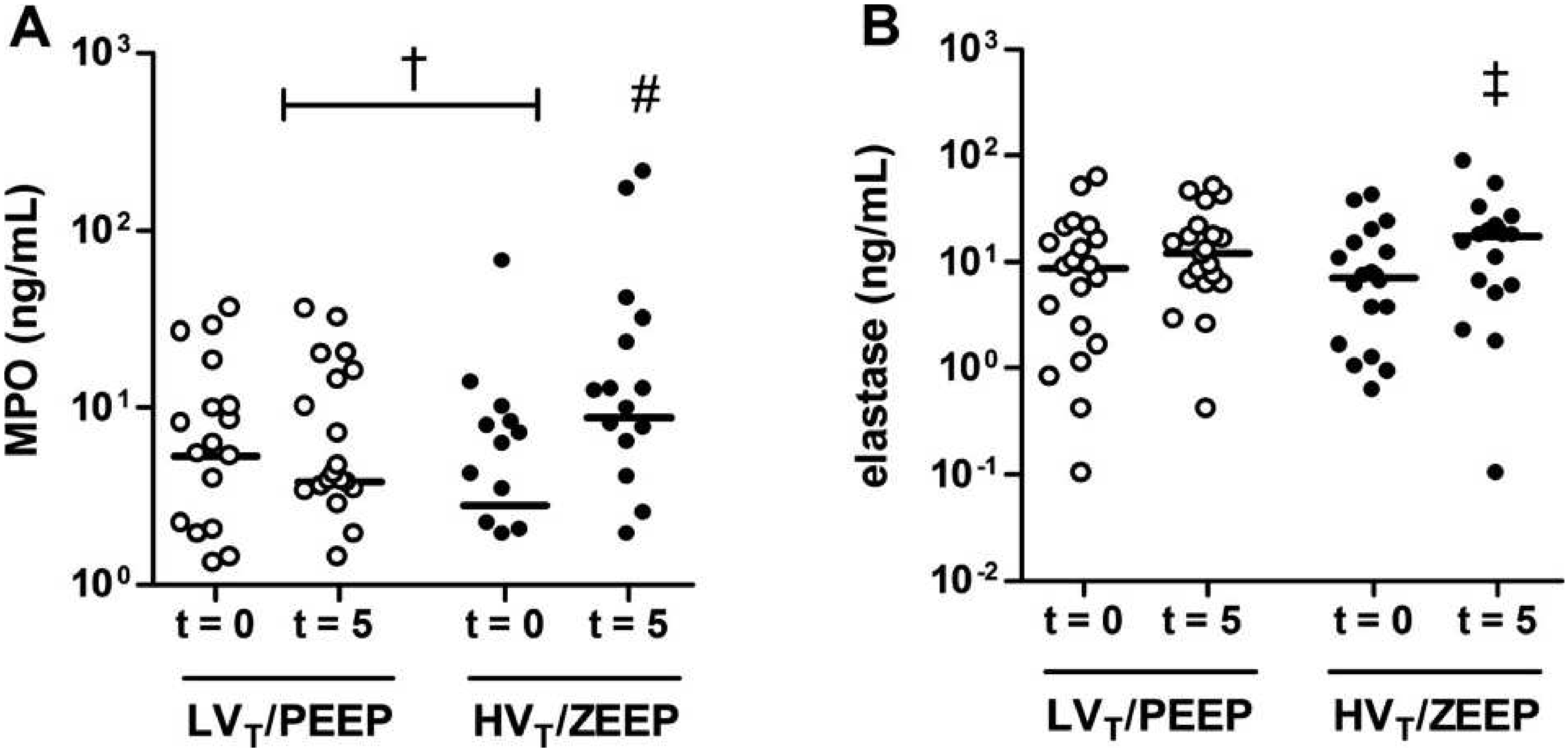
- **Even short-term injurious ventilation can produce lung damage**
- **Injurious mechanical ventilation can lead to epithelial cell apoptosis (kidney, small intestine) – Could be mediated by solube factors (Fas-Fas ligand system)**

Mechanical Ventilation with Lower Tidal Volumes and Positive End-expiratory Pressure Prevents Pulmonary Inflammation in Patients without Preexisting Lung Injury

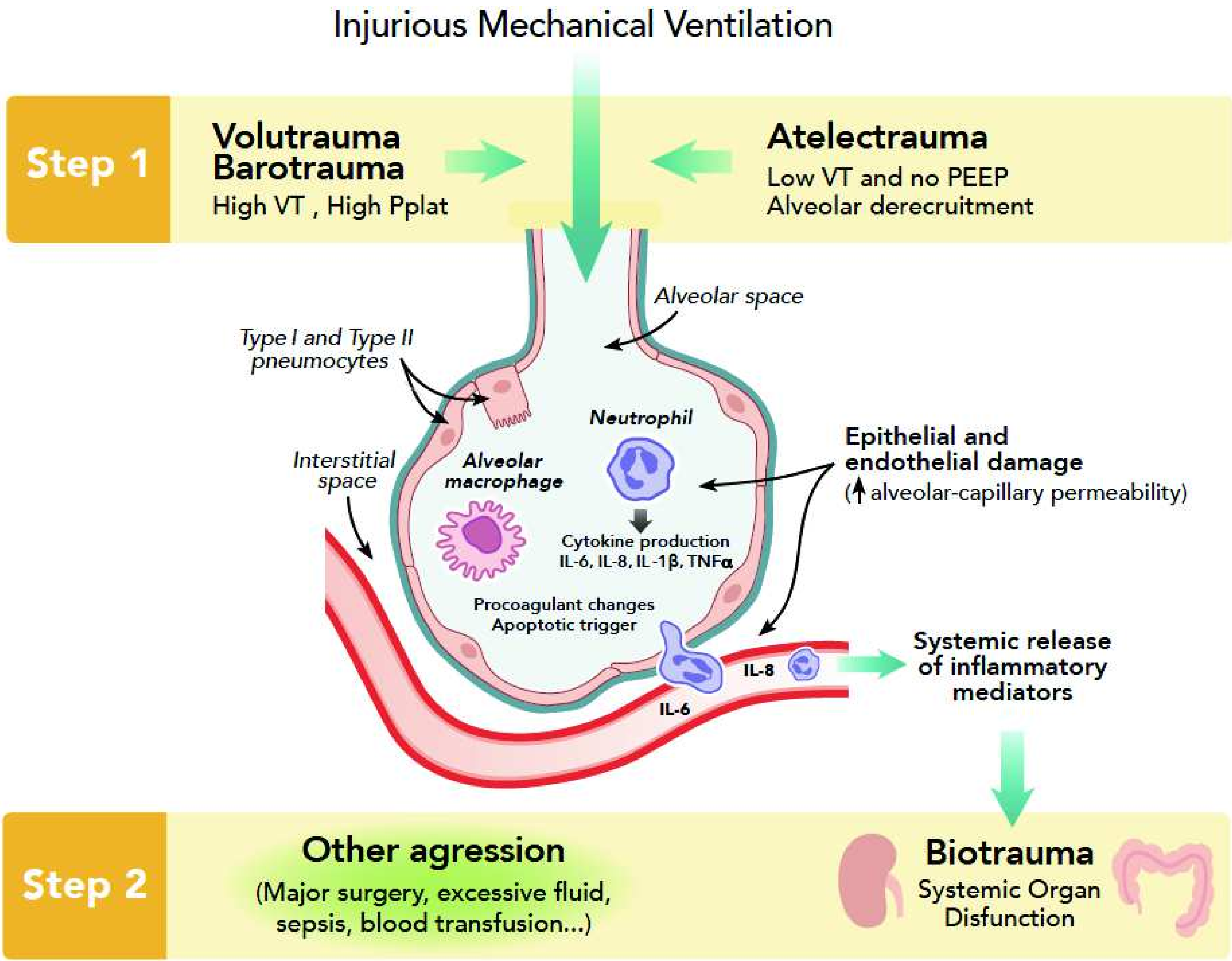
Esther K. Wolthuis, M.D.,* Goda Choi, M.D., Ph.D.,† Mark C. Dessing, Ph.D.,‡ Paul Bresser, M.D., Ph.D.,§ Rene Lutter, Ph.D., Misa Dzoljic, M.D., Ph.D.,# Tom van der Poll, M.D., Ph.D.,** Margreeth B. Vroom, M.D., Ph.D.,†† Markus Hollmann, M.D., Ph.D.,‡‡ Marcus J. Schultz, M.D., Ph.D.§§

Anesthesiology 2008; 108:46–54





The Multiple "hits" theory



Futier E et al. Anesthesiology 2014; 121:400–8

EDITORIAL VIEWS

Daryl J. Kor and Daniel Talmor. Anesthesiology 2013;118(1):1-4

Anesthesiology and the Acute Respiratory Distress Syndrome

An Ounce of Prevention Is Worth a Pound of Cure

Objectifs

CEEA

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Committee for European Education in Anaesthesiology

- Rappeler les risques de réglages inadaptés
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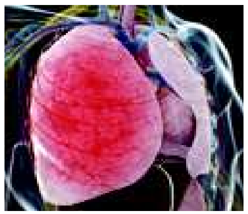
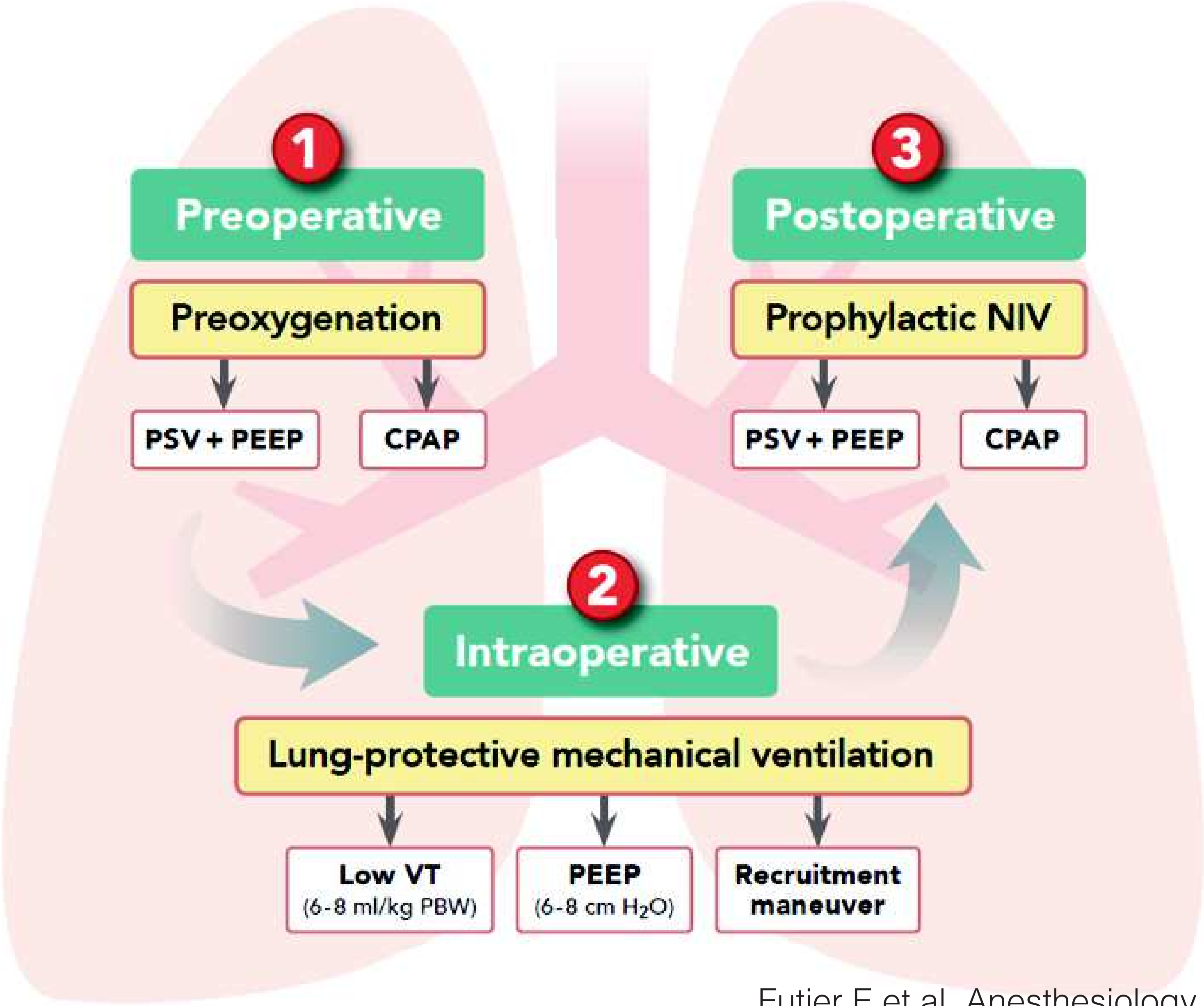


Perioperative **P**ositive **P**ressure Ventilation

The P.O.P® Ventilation concept



Futier E et al. Anesthesiology 2014; 121:400–8

The P.O.P® Ventilation concept

1

To optimize preoxygenation

Standard
(spontaneous ventilation)

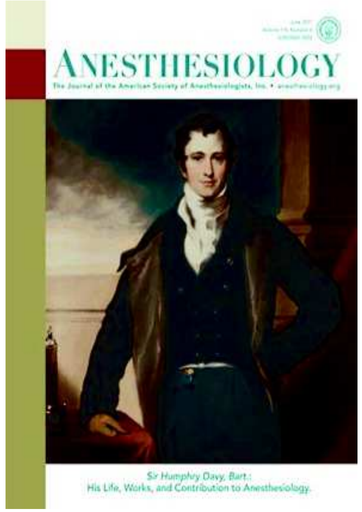
VS.

NIV
(PSV+PEEP)

Noninvasive Ventilation and Alveolar Recruitment Maneuver Improve Respiratory Function during and after Intubation of Morbidly Obese Patients

A Randomized Controlled Study

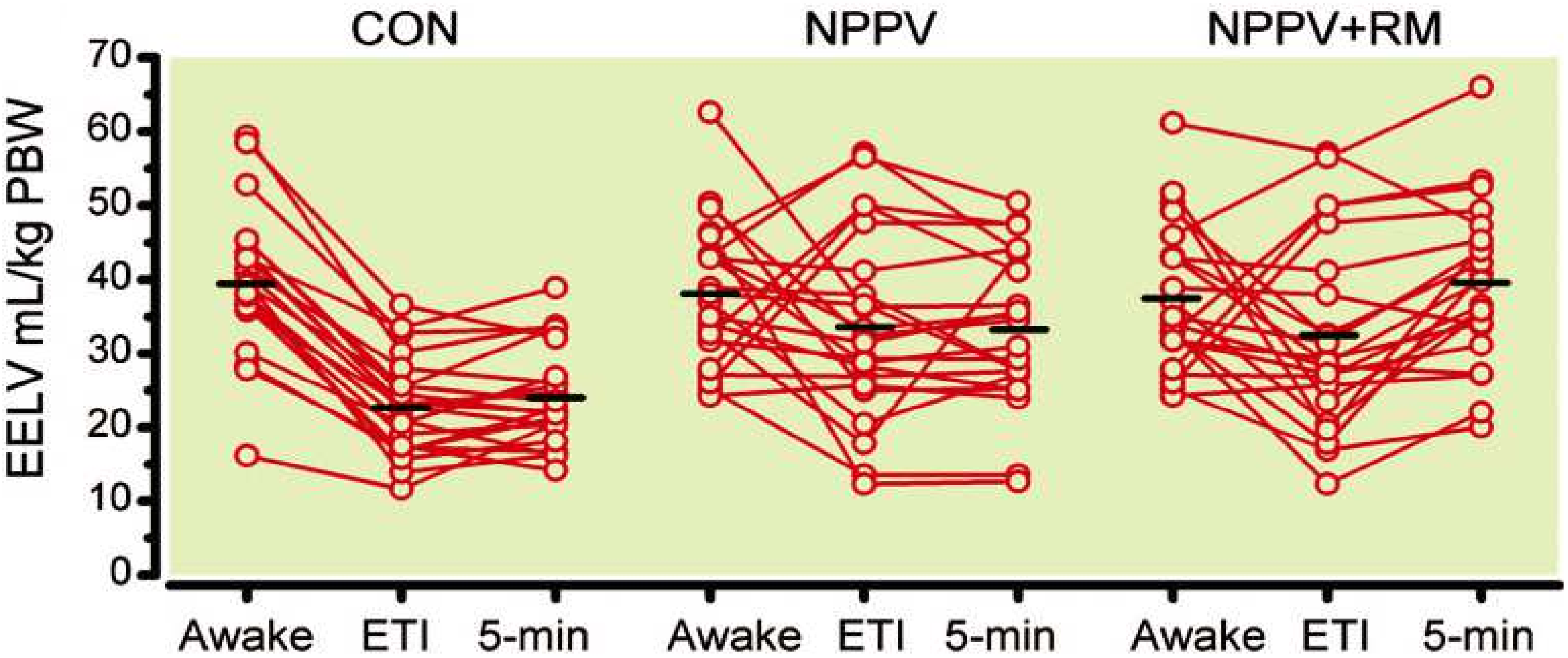
Emmanuel Futier, Jean-Michel Constantin, Paolo Pelosi, Gerald Chanques, Alexandre Massone, Antoine Petit, Fabrice Kwiatkowski, Jean-Etienne Bazin, Samir Jaber



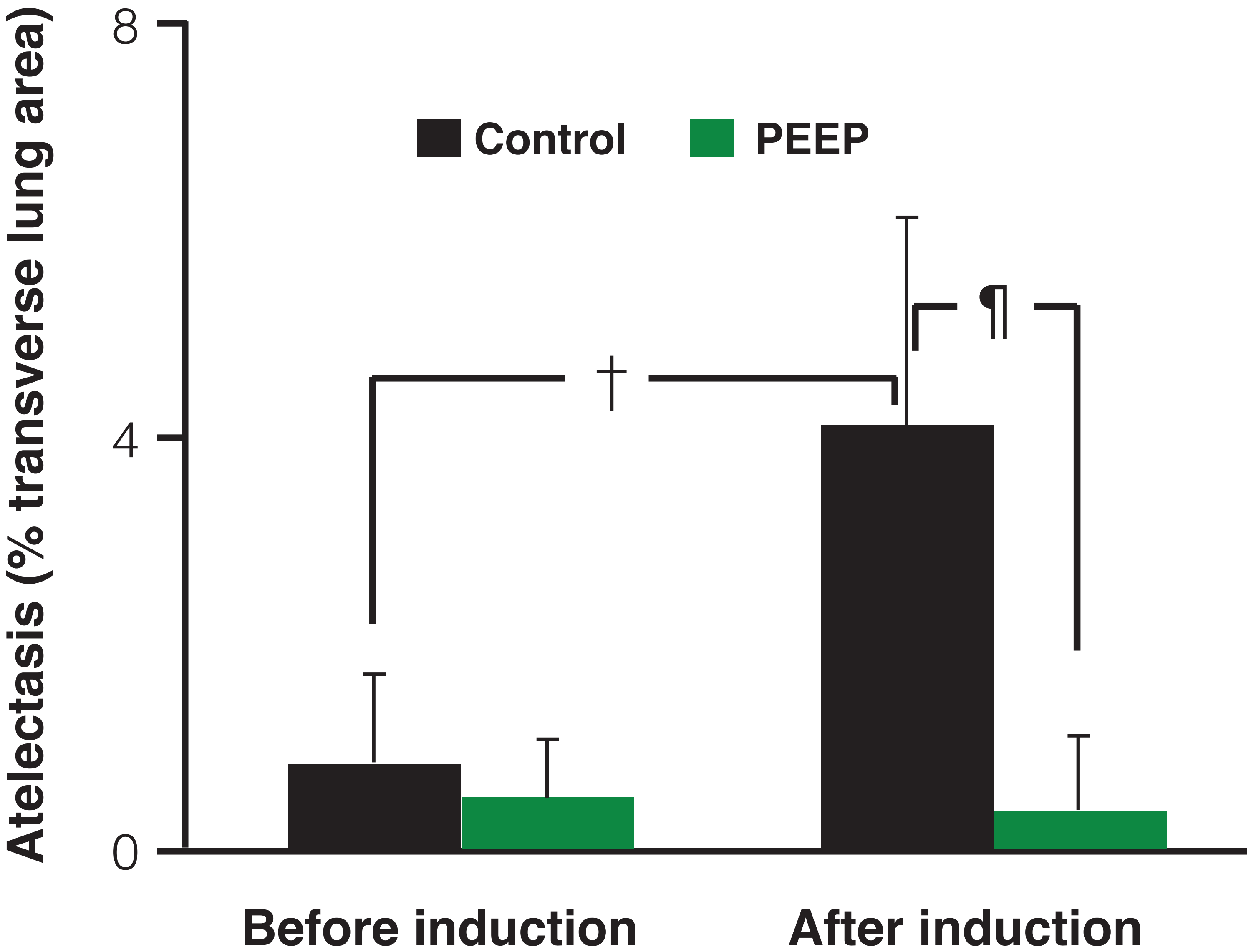
Anesthesiology 2011;114:1354–63

N=66 patients
Preoxygenation:

- **CON: facial mask, 5 min, FiO_2=1.0**
- **NIV: PSV 9±2 cmH_2O, PEEP 7±1 cmH_2O**

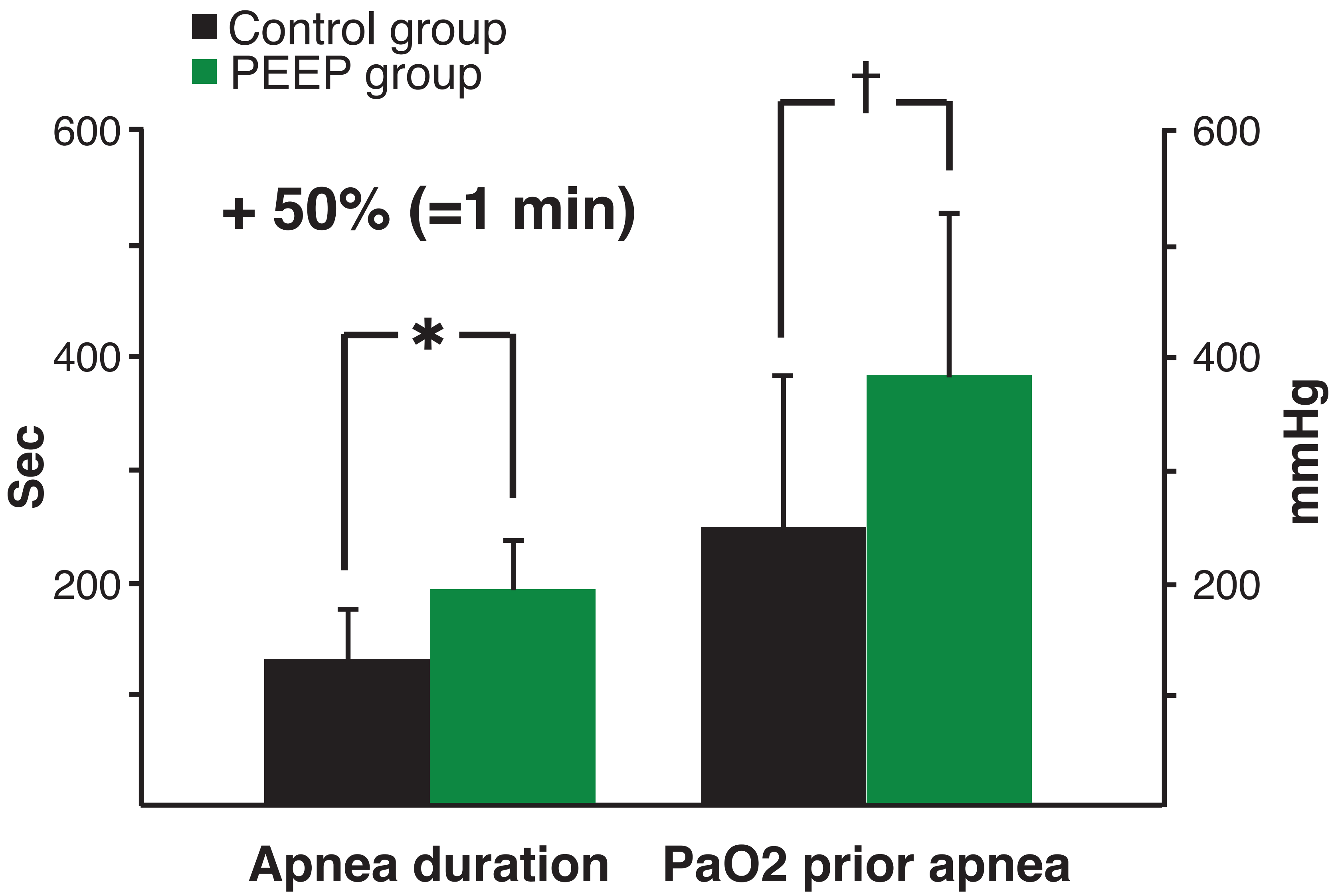


Use of PEEP during preoxygenation



Rusca M. et al. Anesth Analg 2003;97:1835–9

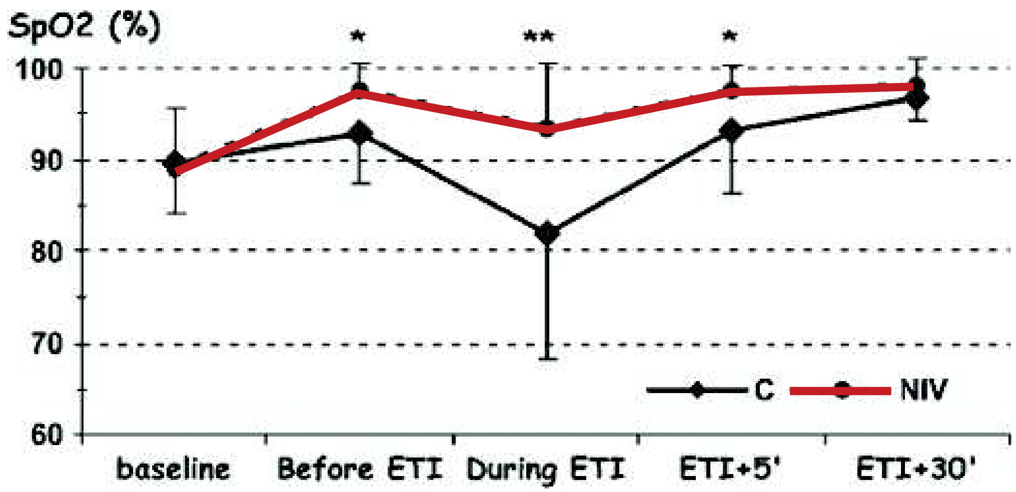
Apnea duration

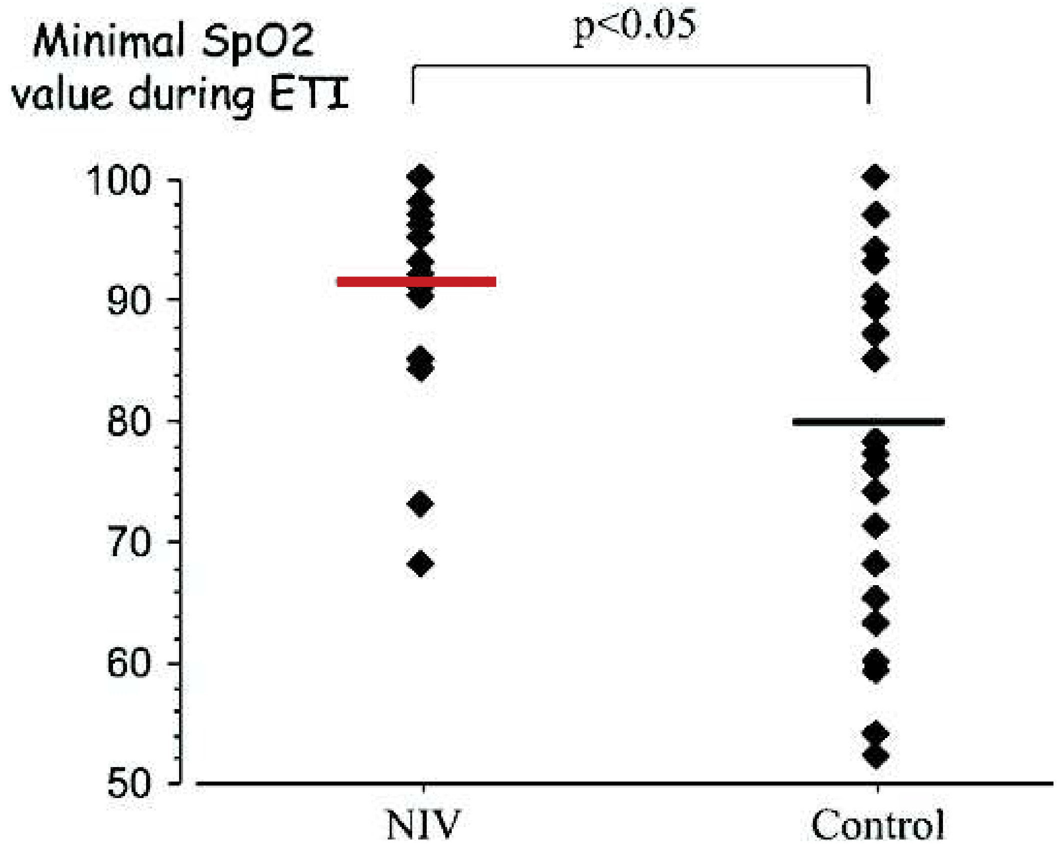


Gander S et al. Anesth Analg 2005;100:580-4

Noninvasive Ventilation Improves Preoxygenation before Intubation of Hypoxic Patients

Christophe Baillard, Jean-Philippe Fosse, Mustapha Sebbane, Gérald Chanques, François Vincent, Patricia Courouble, Yves Cohen, Jean-Jacques Eledjam, Frédéric Adnet, and Samir Jaber





Am J Respir Crit Care Med 2006,174:171–177

The P.O.P® Ventilation concept

2

Optimize ventilator settings

Pressure controlled ventilation (**PCV**)

Volume controlled ventilation (**VCV**)

	IMPROVE study	PROVHILO study
N=56	N=400	N=900

Protective Mechanical Ventilation during General Anesthesia for Open Abdominal Surgery Improves Postoperative Pulmonary Function

Paolo Severgnini, M.D.,* Gabriele Selmo, M.D.,* Christian Lanza, M.D.,* Alessandro Chiesa, M.D.,* Alice Frigerio, M.D.,* Alessandro Bacuzzi, M.D.,* Gianlorenzo Dionigi, M.D., Ph.D.,‡ Raffaele Novario, P.H.,§ Cesare Gregoretti, M.D.,|| Marcelo Gama de Abreu, M.D., Ph.D.,# Marcus J. Schultz, M.D., Ph.D.,** Samir Jaber, M.D., Ph.D.,†† Emmanuel Futier, M.D.,‡‡ Maurizio Chiaranda, M.D., Ph.D.,§§ Paolo Pelosi, M.D.,||||

ABSTRACT

Background: The impact of intraoperative ventilation on postoperative pulmonary complications is not defined. The authors aimed at determining the effectiveness of protective mechanical ventilation during open abdominal surgery on a modified Clinical Pulmonary Infection Score as primary outcome and postoperative pulmonary function.

Methods: Prospective randomized, open-label, clinical trial performed in 56 patients scheduled to undergo elective open abdominal surgery lasting more than 2 h. Patients were assigned by envelopes to mechanical ventilation with tidal volume of 9 ml/kg ideal body weight and zero-positive end-expiratory pressure (standard ventilation strategy) or tidal volumes of 7 ml/kg ideal body weight, 10 cm H_2O positive end-expiratory pressure, and recruitment maneuvers (protective ventilation strategy). Modified Clinical Pulmonary Infection Score, gas exchange, and pulmonary functional tests were measured preoperatively, as well as at days 1, 3, and 5 after surgery.

Results: Patients ventilated protectively showed better pulmonary functional tests up to day 5, fewer alterations on chest x-ray up to day 3 and higher arterial oxygenation in air at days 1, 3, and 5 (mmHg; mean ± SD): 77.1 ± 13.0 *versus* 64.9 ± 11.3 (*P* = 0.0006), 80.5 ± 10.1 *versus* 69.7 ± 9.3 (*P* = 0.0002), and 82.1 ± 10.7 *versus* 78.5 ± 21.7 (*P* = 0.44) respectively. The modified Clinical Pulmonary Infection Score was lower in the protective ventilation strategy at days 1 and 3. The percentage of patients in hospital at day 28 after surgery was not different between groups (7 *vs.* 15% respectively, *P* = 0.42).

Conclusion: A protective ventilation strategy during abdominal surgery lasting more than 2 h improved respiratory function and reduced the modified Clinical Pulmonary Infection Score without affecting length of hospital stay.

What We Already Know about This Topic

- The use of large tidal volumes during mechanical ventilation of the lungs can injure the lungs of critically ill patients

What This Article Tells Us That Is New

- A prospective, randomized, open-label trial of protective ventilation in 56 patients undergoing more than 2 h of open abdominal surgery showed that lower tidal volumes, positive end-expiratory pressure, and recruitment maneuvers led to significantly improved pulmonary function test results up to 5 days after surgery, fewer chest x-ray findings and improved Clinical Pulmonary Infection Scores

◆ This article is accompanied by an Editorial View. Please see: Vidal Melo MF, Eikermann M: Protect the lungs during abdominal surgery. It may change the postoperative outcome. Anesthesiology 2013; 118:1254–7.

2013

ORIGINAL ARTICLE

A Trial of Intraoperative Low-Tidal-Volume Ventilation in Abdominal Surgery

Emmanuel Futier, M.D., Jean-Michel Constantin, M.D., Ph.D., Catherine Paugam-Burtz, M.D., Ph.D., Julien Pascal, M.D., Mathilde Eurin, M.D., Arthur Neuschwander, M.D., Emmanuel Marret, M.D., Marc Beaussier, M.D., Ph.D., Christophe Gutton, M.D., Jean-Yves Lefrant, M.D., Ph.D., Bernard Allaouchiche, M.D., Ph.D., Daniel Verzilli, M.D., Marc Leone, M.D., Ph.D., Audrey De Jong, M.D., Jean-Etienne Bazin, M.D., Ph.D., Bruno Pereira, Ph.D., and Samir Jaber, M.D., Ph.D., for the IMPROVE Study Group*

ABSTRACT

BACKGROUND

Lung-protective ventilation with the use of low tidal volumes and positive end-expiratory pressure is considered best practice in the care of many critically ill patients. However, its role in anesthetized patients undergoing major surgery is not known.

METHODS

In this multicenter, double-blind, parallel-group trial, we randomly assigned 400 adults at intermediate to high risk of pulmonary complications after major abdominal surgery to either nonprotective mechanical ventilation or a strategy of lung-protective ventilation. The primary outcome was a composite of major pulmonary and extrapulmonary complications occurring within the first 7 days after surgery.

RESULTS

The two intervention groups had similar characteristics at baseline. In the intention-to-treat analysis, the primary outcome occurred in 21 of 200 patients (10.5%) assigned to lung-protective ventilation, as compared with 55 of 200 (27.5%) assigned to nonprotective ventilation (relative risk, 0.40; 95% confidence interval [CI], 0.24 to 0.68; P=0.001). Over the 7-day postoperative period, 10 patients (5.0%) assigned to lung-protective ventilation required noninvasive ventilation or intubation for acute respiratory failure, as compared with 34 (17.0%) assigned to nonprotective ventilation (relative risk, 0.29; 95% CI, 0.14 to 0.61; P=0.001). The length of the hospital stay was shorter among patients receiving lung-protective ventilation than among those receiving nonprotective ventilation (mean difference, −2.45 days; 95% CI, −4.17 to −0.72; P=0.006).

CONCLUSIONS

As compared with a practice of nonprotective mechanical ventilation, the use of a lung-protective ventilation strategy in intermediate-risk and high-risk patients undergoing major abdominal surgery was associated with improved clinical outcomes and reduced health care utilization. (IMPROVE ClinicalTrials.gov number, NCT01282996.)

2013

Articles

High versus low positive end-expiratory pressure during general anaesthesia for open abdominal surgery (PROVHILO trial): a multicentre randomised controlled trial

The PROVE Network Investigators for the Clinical Trial Network of the European Society of Anaesthesiology*

Summary

Background The role of positive end-expiratory pressure in mechanical ventilation during general anaesthesia for surgery remains uncertain. Levels of pressure higher than 0 cm H_2O might protect against postoperative pulmonary complications but could also cause intraoperative circulatory depression and lung injury from overdistension. We tested the hypothesis that a high level of positive end-expiratory pressure with recruitment manoeuvres protects against postoperative pulmonary complications in patients at risk of complications who are receiving mechanical ventilation with low tidal volumes during general anaesthesia for open abdominal surgery.

Methods In this randomised controlled trial at 30 centres in Europe and North and South America, we recruited 900 patients at risk for postoperative pulmonary complications who were planned for open abdominal surgery under general anaesthesia and ventilation at tidal volumes of 8 mL/kg. We randomly allocated patients to either a high level of positive end-expiratory pressure (12 cm H_2O) with recruitment manoeuvres (higher PEEP group) or a low level of pressure (≤2 cm H_2O) without recruitment manoeuvres (lower PEEP group). We used a centralised computer-generated randomisation system. Patients and outcome assessors were masked to the intervention. Primary endpoint was a composite of postoperative pulmonary complications by postoperative day 5. Analysis was by intention-to-treat. The study is registered at Controlled-Trials.com, number ISRCTN70332574.

Findings From February, 2011, to January, 2013, 447 patients were randomly allocated to the higher PEEP group and 453 to the lower PEEP group. Six patients were excluded from the analysis, four because they withdrew consent and two for violation of inclusion criteria. Median levels of positive end-expiratory pressure were 12 cm H_2O (IQR 12–12) in the higher PEEP group and 2 cm H_2O (0–2) in the lower PEEP group. Postoperative pulmonary complications were reported in 174 (40%) of 445 patients in the higher PEEP group versus 172 (39%) of 449 patients in the lower PEEP group (relative risk 1·01; 95% CI 0·86–1·20; p=0·86). Compared with patients in the lower PEEP group, those in the higher PEEP group developed intraoperative hypotension and needed more vasoactive drugs.

Interpretation A strategy with a high level of positive end-expiratory pressure and recruitment manoeuvres during open abdominal surgery does not protect against postoperative pulmonary complications. An intraoperative protective ventilation strategy should include a low tidal volume and low positive end-expiratory pressure, without recruitment manoeuvres.

Funding Academic Medical Center (Amsterdam, Netherlands), European Society of Anaesthesiology.

Introduction

About 234 million major surgical procedures are undertaken worldwide every year. Of these interventions, around 2·6 million represent high-risk procedures, with 1·3 million patients developing complications that result in 315 000 in-hospital deaths.[1] Postoperative pulmonary complications are at least as frequent as cardiac complications during non-cardiac surgery[2] and are associated with increased risk of in-hospital death, particularly after open abdominal surgery.[3,4] Mechanical ventilation might affect the incidence of postoperative pulmonary complications[5] and, possibly, distal organ dysfunction.[6] Different mechanisms have been proposed to account for the injurious effects of ventilation. Both hyperinflation and repetitive tidal recruitment of lung units can induce the release of proinflammatory mediators, leading to lung and distal organ injury.[7]

Prevention of hyperinflation by use of low tidal volumes reduces mortality in patients with acute respiratory distress syndrome.[8] Mortality can also be decreased in individuals with severe acute respiratory distress syndrome by avoiding repetitive tidal recruitment with high levels of positive end-expiratory pressure.[9] Furthermore, use of low tidal volumes in patients without lung injury under general anaesthesia might also reduce the incidence of postoperative pulmonary complications.[5] This hypothesis was proven in a single-centre[10] and a national multicentre trial.[11] However, in both studies, use of lower tidal volumes was combined with higher levels of positive end-expiratory pressure; thus, did beneficial effects come from prevention of hyperinflation or avoidance of repetitive tidal recruitment? Use of very low levels of positive end-expiratory pressure could lead to atelectasis with ventilation strategies that incorporate

2014

IMPROVE study

A pragmatic multicenter, double-blinded, randomized controlled trial

Lung-Protective Ventilation N=200		Non-Protective Ventilation N=200
VT 6 to 8 ml/kg PBW **PEEP 6 to 8 cmH_2O** **Recruitment Maneuver**	***VS.***	**VT 10 to 12 ml/kg PBW** **No PEEP** **No Recruitment Maneuver**

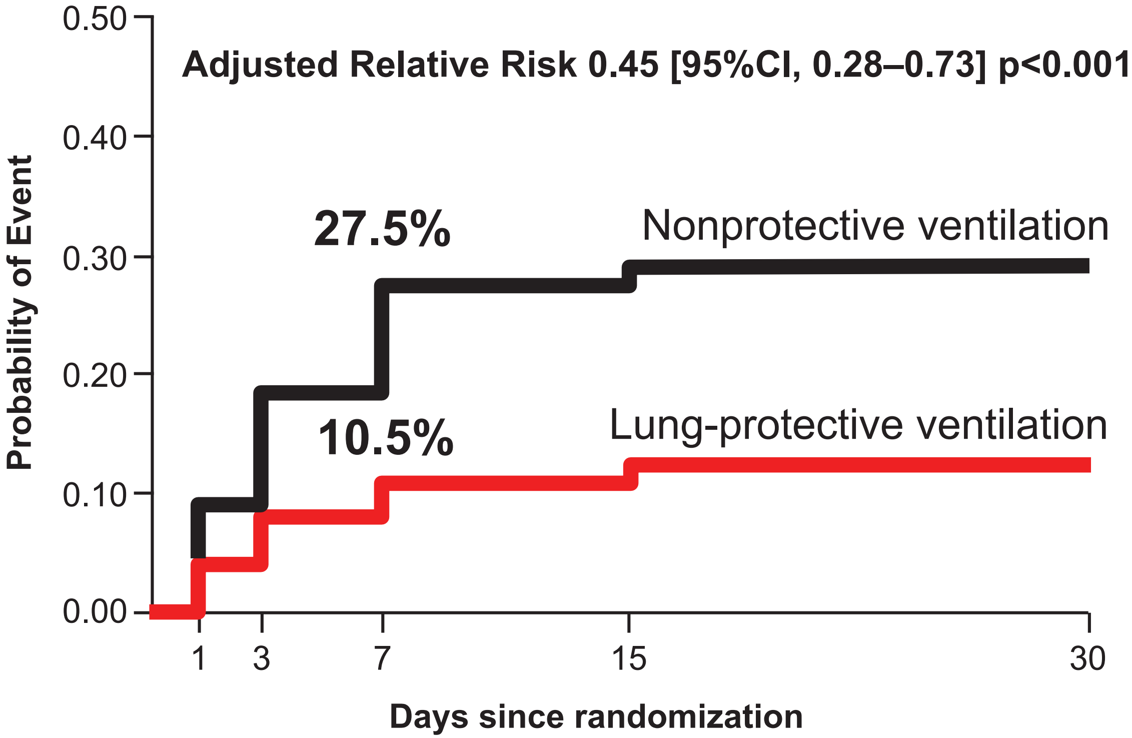
In both groups:

- Plateau pressure <30 cmH_2O
- Volume-controlled ventilation mode
- FiO_2 adjusted to maintain SpO_2 ≥95%
- RR adjusted to maintain $ETCO_2$ between 35 and 40 mmHg

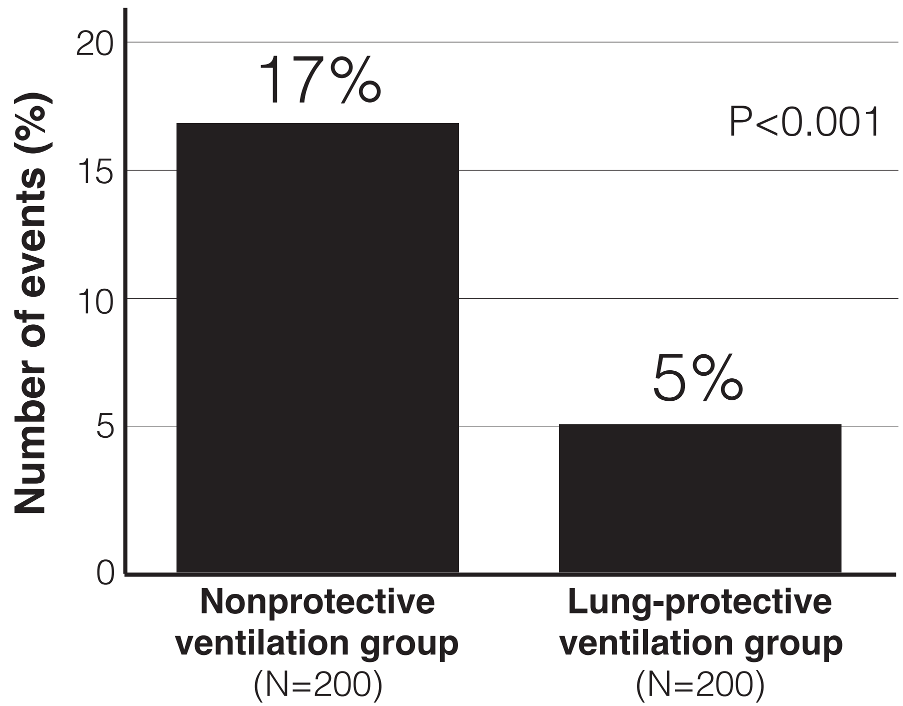
ORIGINAL ARTICLE

A Trial of Intraoperative Low-Tidal-Volume Ventilation in Abdominal Surgery

IMPROVE study



Secondary outcome: Need for invasive or noninvasive ventilation for ARF to postoperative day 7



CONCLUSIONS

The use of a lung-protective ventilation strategy composer of low VT ventilation, moderate PEEP and repeated recruitment maneuvers in intermediate-risk and high-risk patients undergoing major abdominal surgery was associated with improved clinical outcomes

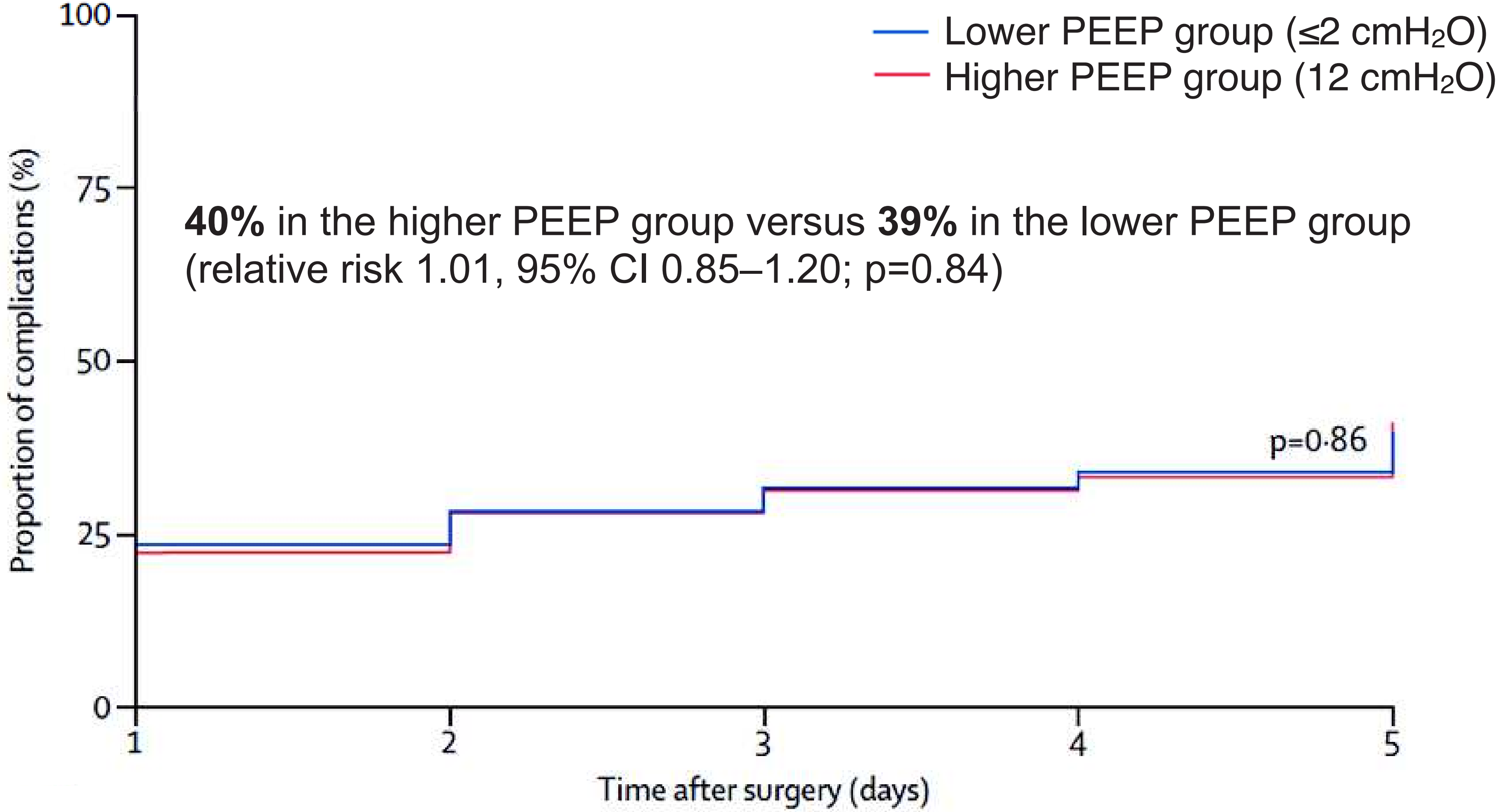
Futier E et al. N Engl J Med 2013;369:428-37

High versus **low** positive end-expiratory pressure during general anaesthesia for open abdominal surgery (PROVHILO trial): a multicentre randomised controlled trial

The PROVE Network Investigators* for the Clinical Trial Network of the European Society of Anaesthesiology

N=900

PROVHILO trial



Lancet. 2014 May 30. pii: S0140-6736

High versus **low** positive end-expiratory pressure during general anaesthesia for open abdominal surgery (PROVHILO trial): a multicentre randomised controlled trial

The PROVE Network Investigators* for the Clinical Trial Network of the European Society of Anaesthesiology

PROVHILO trial

	Higher PEEP group (n=445)	Lower PEEP group (n=449)	Relative risk (95%CI)	P
Intraoperative complications				
Rescue strategy for desaturation	11/442 (2%)	34/445 (8%)	0.34 (0.18-0.67)	0.0008
Hypotension	205/441 (46%)	162/449 (36%)	1.29 (1.10-1.51)	0.0016
Vasoactive drugs needed	274/444 (62%)	228/445 (51%)	1.20 (1.07-1.35)	0.0016
New arrhythmias needing intervention	12/442 (3%)	5/445 (1%)	2.38 (0.84-6.70)	0.09

Lancet. 2014 May 30. pii: S0140-6736

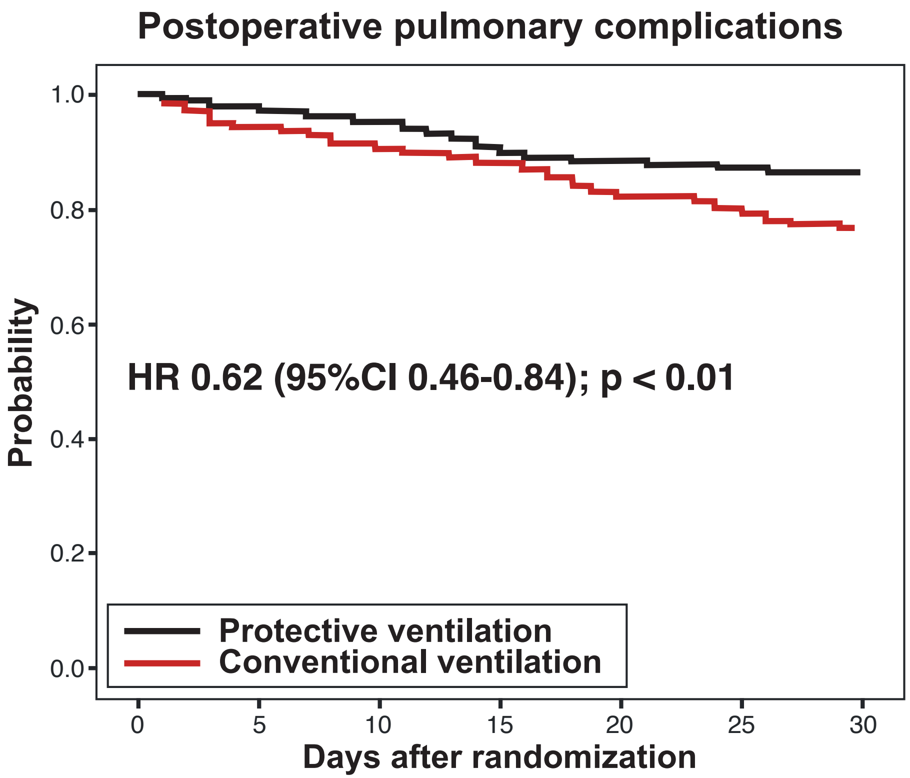
	IMPROVE trial N=400		**PROVHILO trial** N=900	
	Non-protective group (n=200)	Protective group (n=200)	High PEEP group (n=445)	Low PEEP group (n=449)
VT, ml/kg IBW	11.1±1.1	6.4±0.8	7.2±1.5	7.1±1.2
PEEP, cmH_2O	0	6 [6-8]	12 [12-12]	2 [0-2]
RM	NO	CPAP 30-30	Increase in VT (step of 4 cmH_2O) until a Pplat of 30-35 cmH_2O	NO
Repeated RM		Every 30-45 min 9 [6-12]	After intubation: 99% Most patients received only once	
FiO_2, %	47.2±7.6	46.4±7.3	40 [40-49]	41 [40-50]
Duration of surgery	2-4 hr: 39.6% 4-6 hr: 39.1% >6 hr: 21.4%	2-4 hr: 38.5% 4-6 hr: 39.0% >6 hr: 22.6%	200 [140-300] min	190 [140-262] min
Preoperative risk of PPCs	Intermediate and high-risk patients (AROZULLAH)		Most patients (78%) at intermediate risk (ARISCAT)	
Laparoscopic surgery	21.2 %		Not included	

Protective versus Conventional Ventilation for Surgery

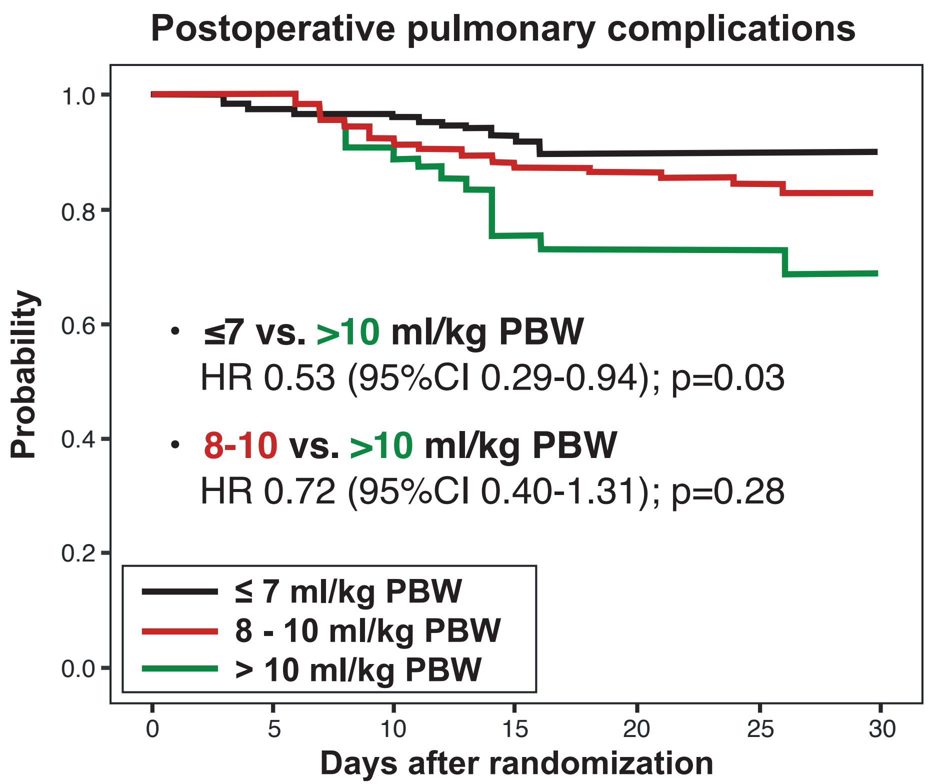
A Systematic Review and Individual Patient Data Meta-analysis

- Data from 15 RCTs (N=2127 patients)
- Surgical procedures: Abdominal, n=5 studies
  Cardiothoracic, n=7 studies
  Others, n=3 studies

Protective *vs* Non-protective

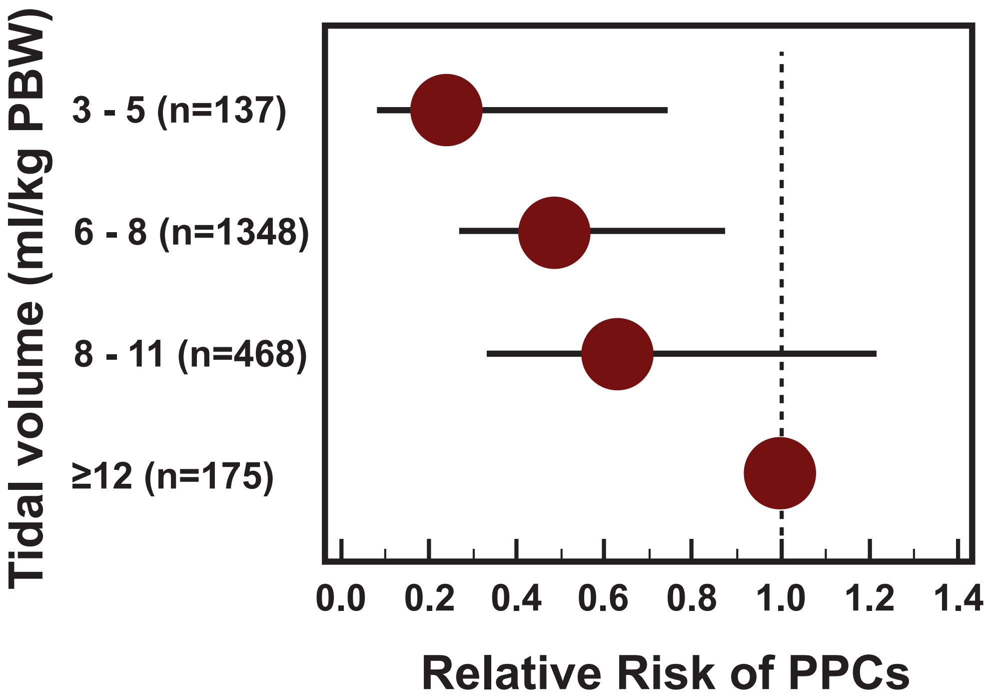


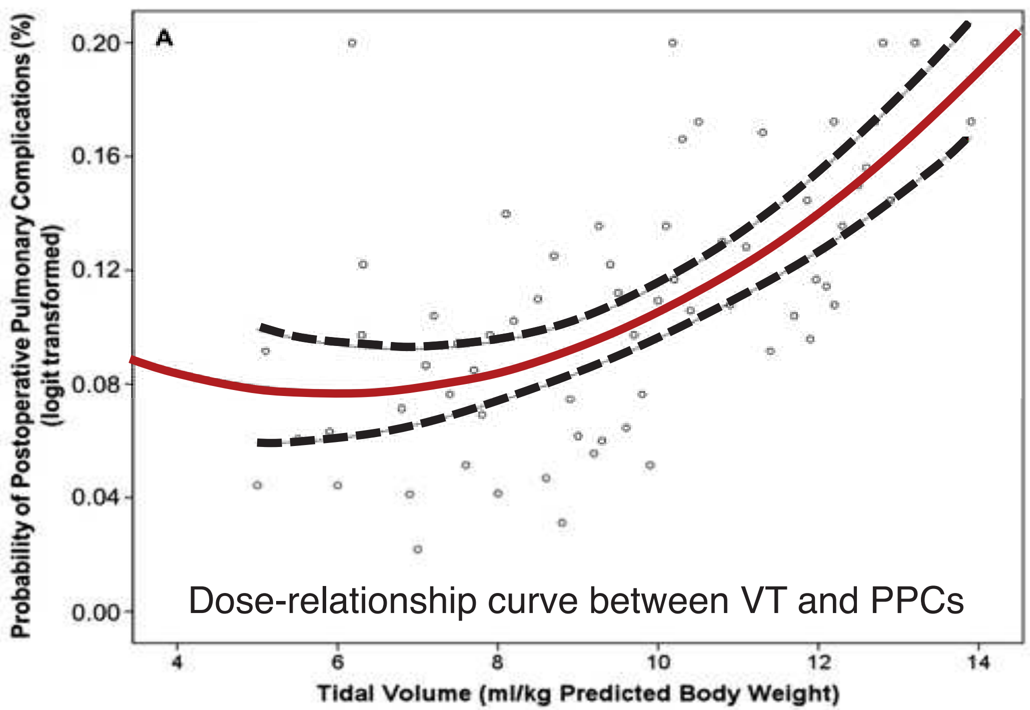
Lower *vs* Higher VT



PROVE Network. Anesthesiology 2015,123:66-78

Dose-Response Relationship Between PPC and VT





PROVE Network. Anesthesiology 2015,123:66-78

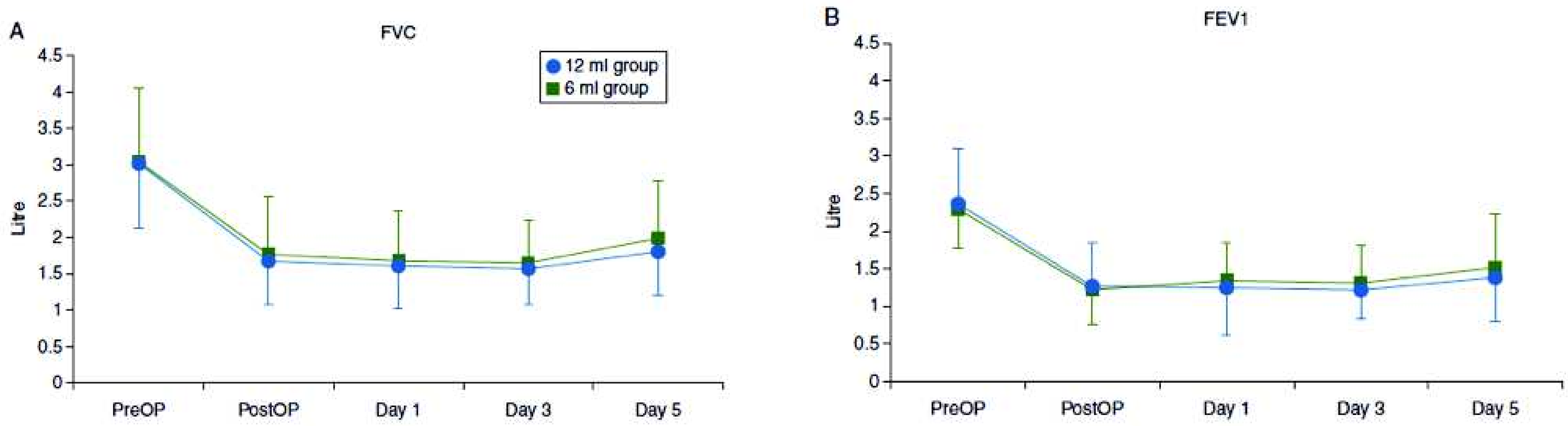
Br J Anaesth. 2012 Aug;109(2):263-71

BJA

Ventilation with low tidal volumes during upper abdominal surgery does not improve postoperative lung function

T. A. Treschan[1*], W. Kaisers[1], M. S. Schaefer[1], B. Bastin[1], U. Schmalz[1], V. Wania[1], C. F. Eisenberger[2], A. Saleh[3], M. Weiss[1], A. Schmitz[1], P. Kienbaum[1], D. I. Sessler[4,5], B. Pannen[1] and M. Beiderlinden[1,6]

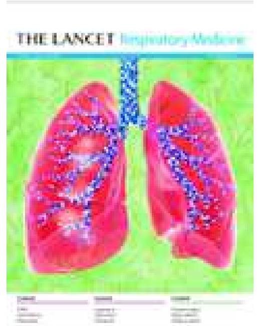
[1] Department of Anaesthesiology, [2] Department of General, Visceral, and Paediatric Surgery and [3] Institute of Diagnostic and Interventional Radiology, Düsseldorf University Hospital, Düsseldorf, Germany
[4] Department of Outcomes Research, Cleveland Clinic, Cleveland, OH, USA
[5] Population Health Research Institute, McMaster University, Hamilton, Ontario, Canada
[6] Department of Anaesthesiology, Marienhospital Osnabrück, Osnabrück, Germany



Conclusions. **Prolonged impaired lung function after major abdominal surgery is not ameliorated by low tidal volume ventilation.**

Incidence of mortality and morbidity related to postoperative lung injury in patients who have undergone abdominal or thoracic surgery: a systematic review and meta-analysis

Articles



Ary Serpa Neto, Sabrine NT Hemmes, Carmen SV Barbas, Martin Beiderlinden, Ana Fernandez-Bustamante, Emmanuel Futier, Markus W Hollmann, Samir Jaber, Alf Kozian, Marc Licker, Wen-Qian Lin, Pierre Moine, Federica Scavonetto, Thomas Schilling, Gabriele Selmo, Paolo Severgnini, Juraj Sprung, Tanja Treschan, Carmen Unzueta, Toby N Weingarten, Esther K Wolthuis, Hermann Wrigge, Marcelo Gama de Abreu, Paolo Pelosi, Marcus J Schultz, for the the PROVE Network investigators

Lancet Respir Med 2014; 2(12):1007-15

	HR for in-hospital mortality (95% CI)	HR for ICU discharge (95% CI)
All patients	9·58 (5·32–17·34)	0·45 (0·33–0·66)
Ventilation		
Conventional	14·22 (5·91–34·26)	0·39 (0·25–0·58)
Protective	6·07 (2·47–14·55)	0·71 (0·42–1·19)

	Total (n=3365)	No postoperative lung injury (n=3150)*	Postoperative lung injury (n=123)*	p value
Tidal volume (mL/kg PBW)	8.2 (1.9)	8.2 (1.8)	9.3 (2.1)	<0.0001
PEEP (cm H2O)	4.4 (3.8)	**4.3 (3.7)**	**2.9 (3.4)**	<0.0001

Editorial

Open up the lung and keep the lung open

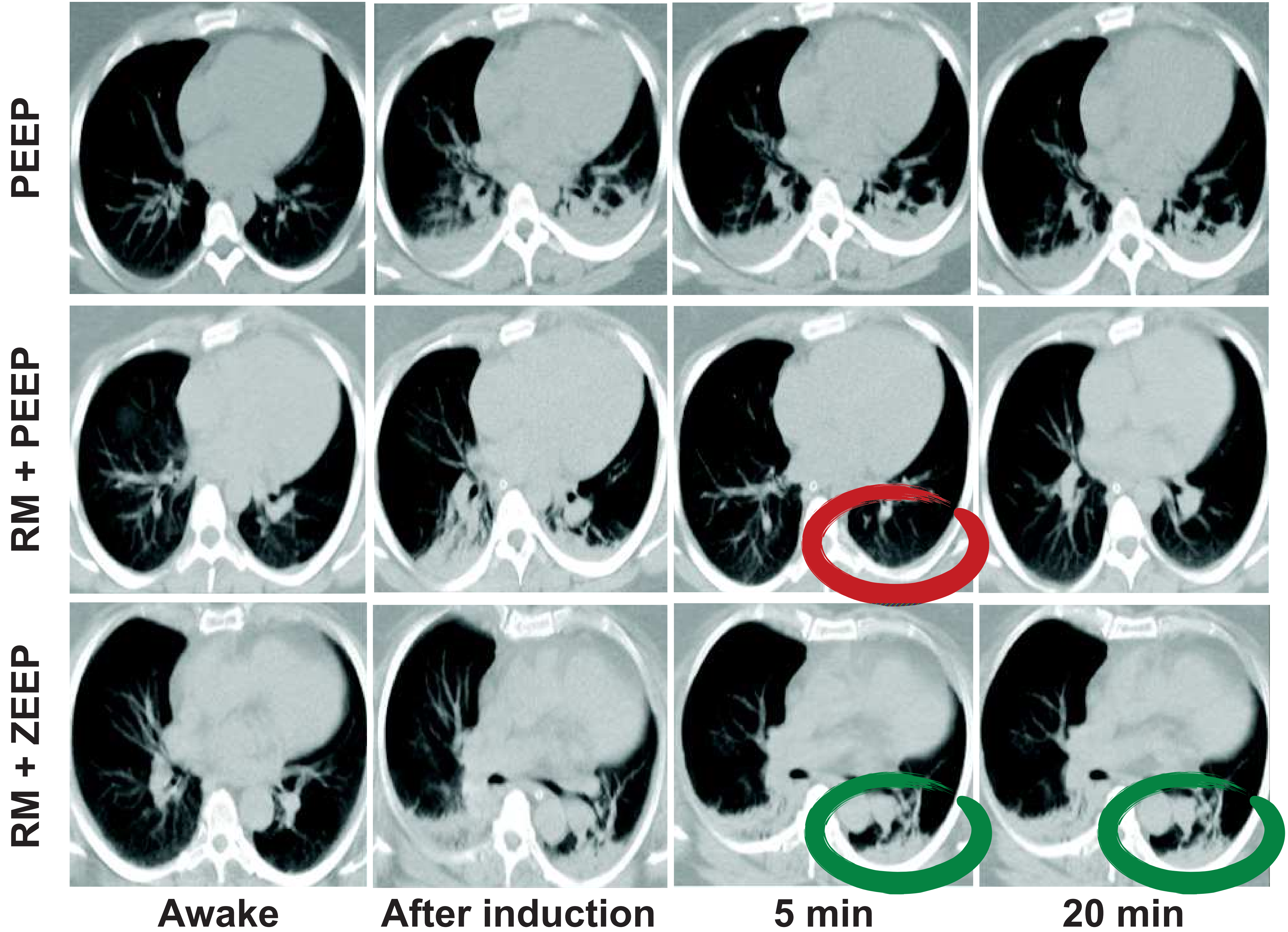
B Lachmann

Department of Anesthesiology, Erasmus University Rotterdam, The Netherlands

"there is only one rational concept to preserve lung integrity: open up the whole lung and keep it totally open, with the least influence on the cardiocirculatory system."

Intensive Care Med **1992**; 18: 319-21

Reinius H et al. Anesthesiology 2009; 111:979–87



Quel niveau de PEEP après recrutement ?

Individualisation !

SPECIAL ARTICLE

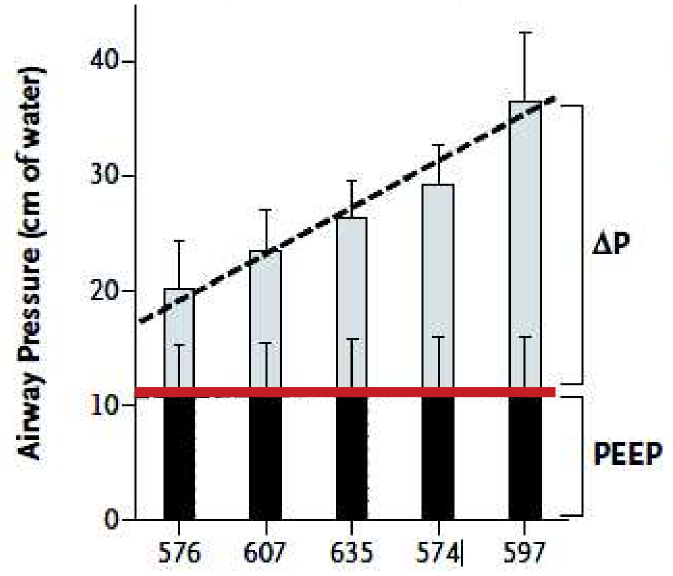
Driving Pressure and Survival in the Acute Respiratory Distress Syndrome

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

- The proportion of lung available for ventilation is markedly decreased in ARDS, which is reflected by lower respiratory-system compliance (C_{RS})
- Normalizing V_T to C_{RS} and using the driving pressure (ΔP = Pplat - PEEP) indicating the "functional" size of the lung would provide a better predictor of outcomes in patients with ARDS than V_T alone

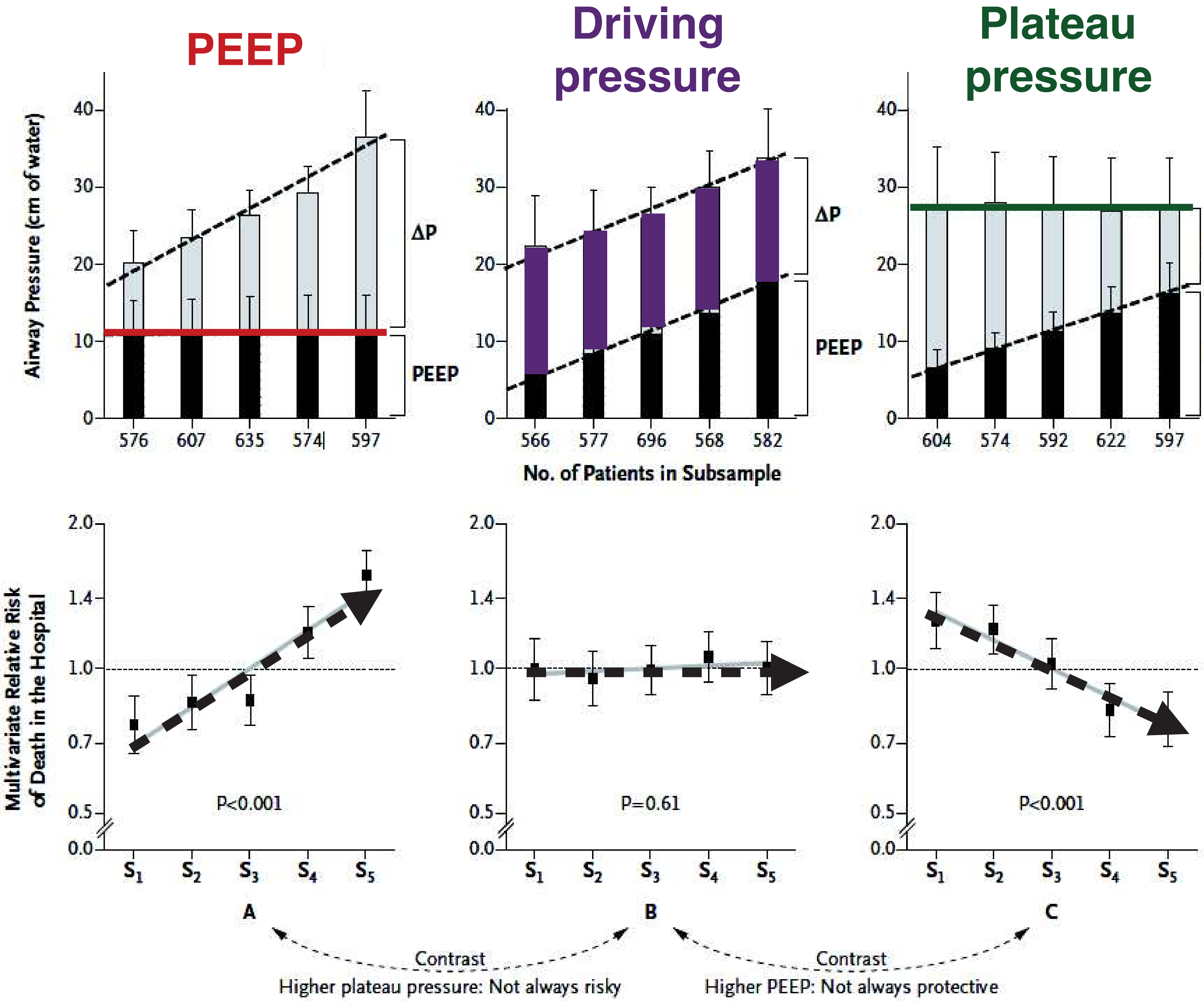
N Engl J Med 2015;372:747-55

PEEP



PEEP (cmH_2O)	10	10	10	10	10
P Plat (cmH_2O)	20	24	28	30	35
ΔP (cmH_2O)	10	14	18	20	25

N Engl J Med 2015;372:747-55

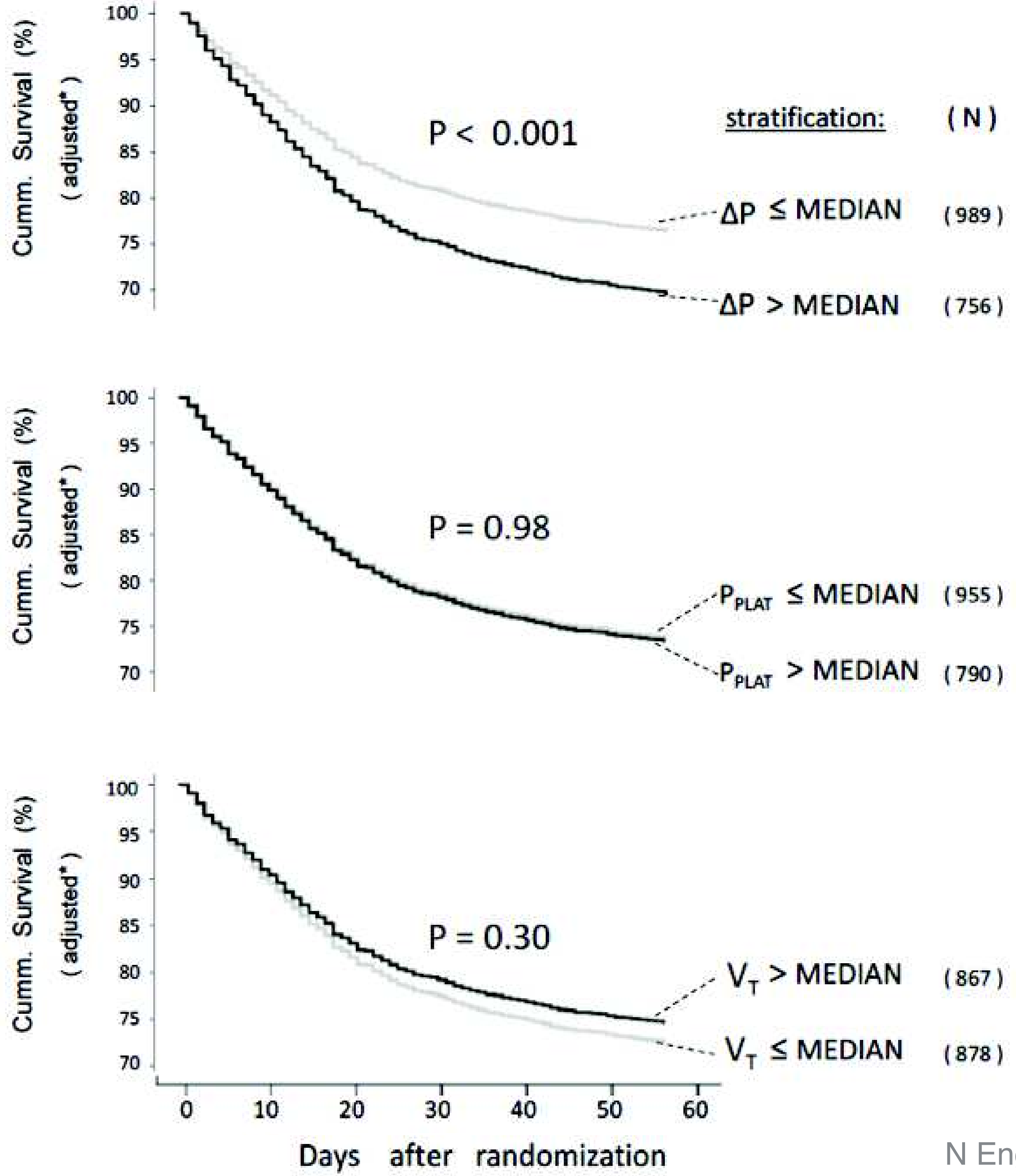


N Engl J Med 2015;372:747-55

Survival in patients under "protective" ventilator settings

(All with Plateau-pressure ≤ 30 cmH_2O and VT ≤ 7 mL/Kg IBW), N=1745

* : survival adjusted for
Age, APACHE/SAPS risk, Arterial-pH, P/F ratio, and Trial

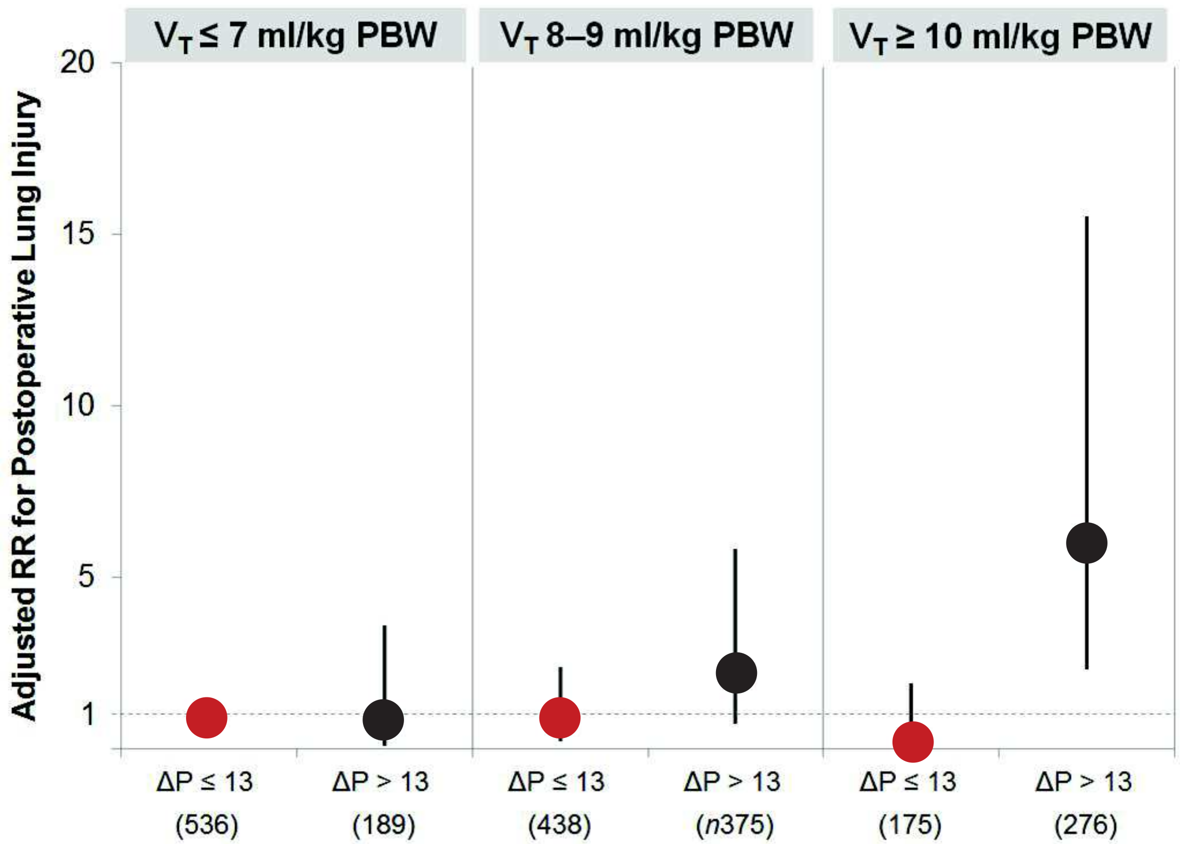


N Engl J Med 2015;372:747-55

Dose-Response Relationship Between PPC and Driving Pressure

Data from 17 randomized controlled trials, including 2250 patients

Lower VT and Driving Pressure reduce PPCs

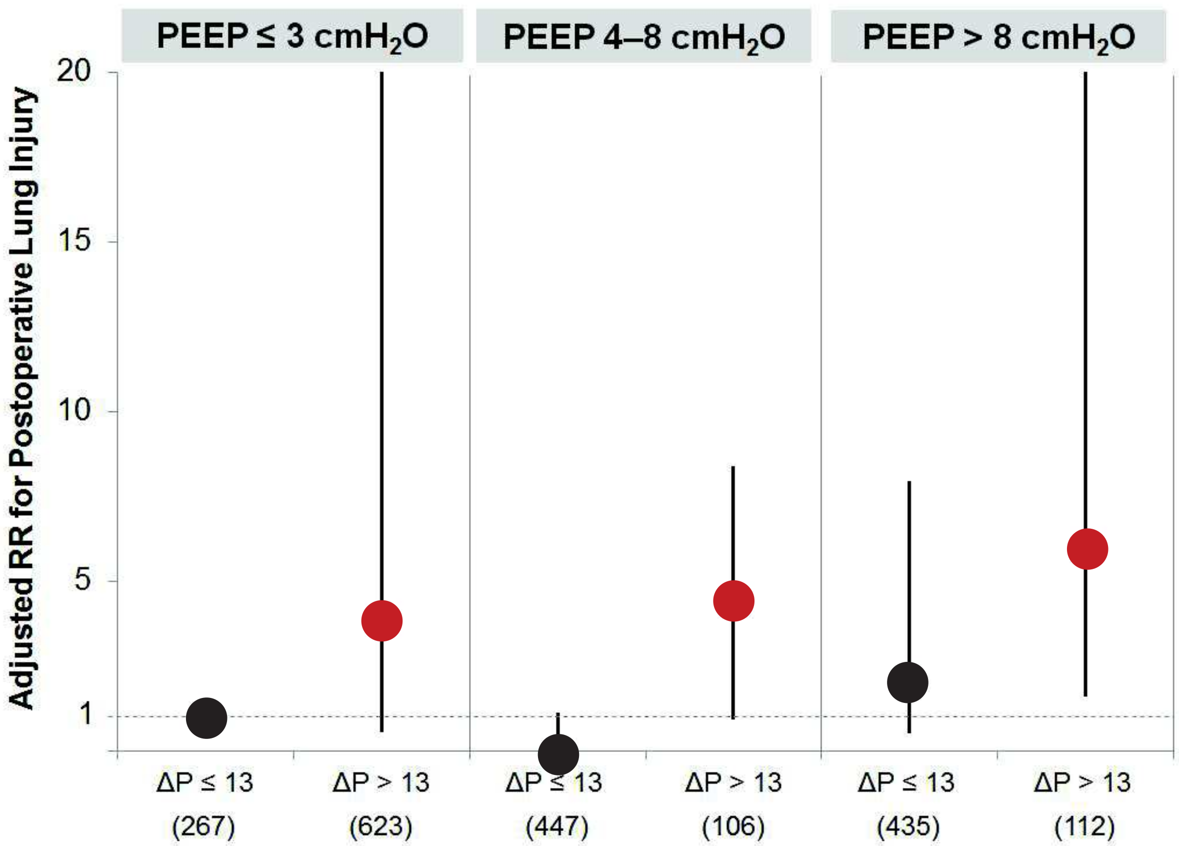


PROVE Network. Lancet Respir Med 2016, pii: S2213-2600(16)00057-6

Dose-Response Relationship Between PPC and Driving Pressure

Data from 17 randomized controlled trials, including 2250 patients

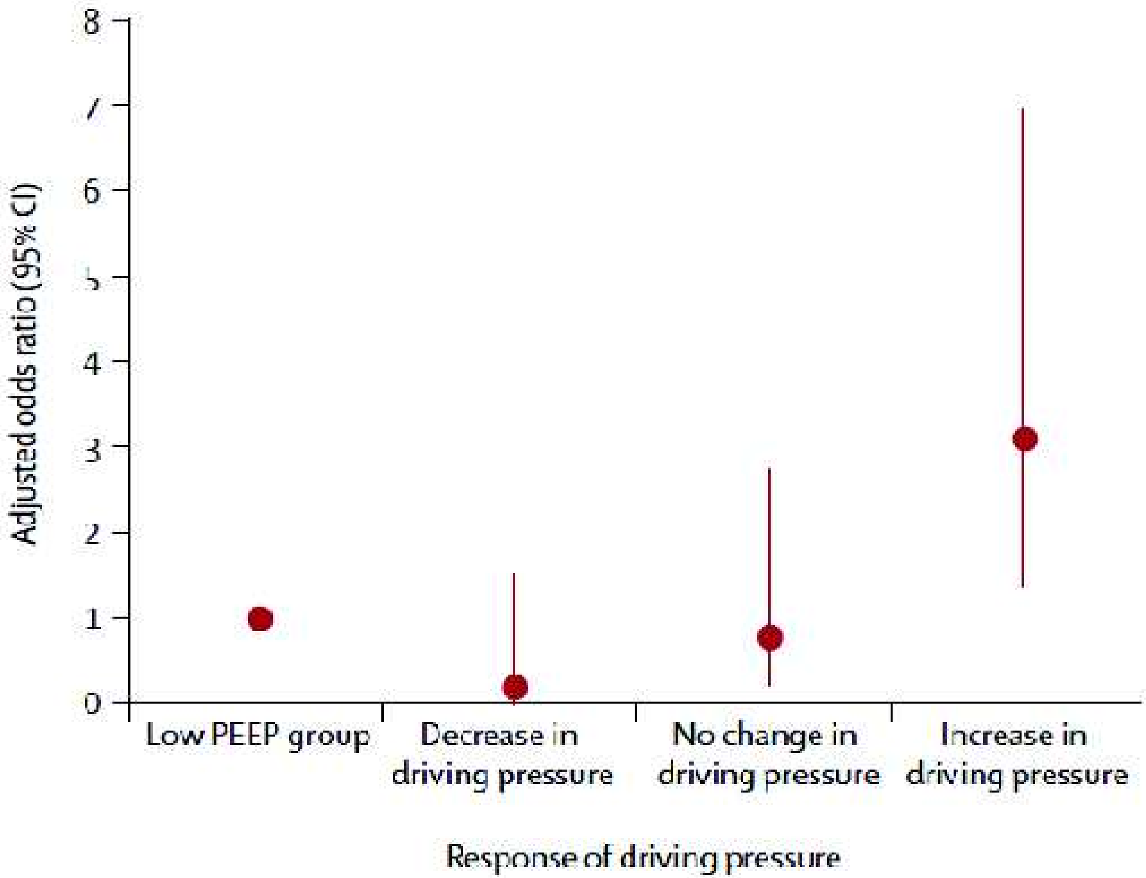
Higher Driving Pressure and PEEP increase PPCs



PROVE Network. Lancet Respir Med 2016, pii: S2213-2600(16)00057-6

Dose-Response Relationship Between PPC and Driving Pressure

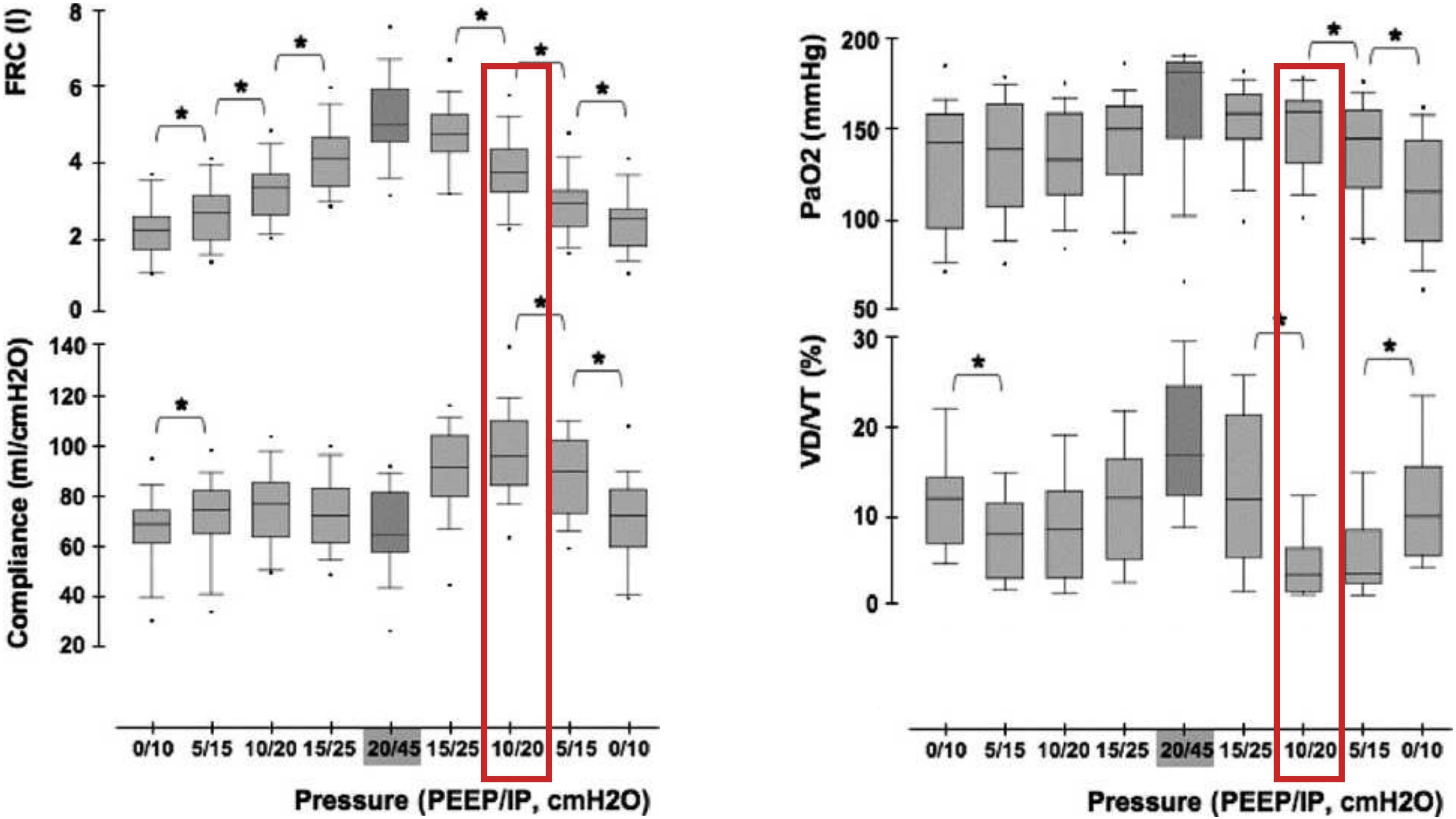
Postoperative pulmonary complications according to response of driving pressure after increase of PEEP



PROVE Network. Lancet Respir Med 2016, pii: S2213-2600(16)00057-6

Optimal PEEP setting after recruitment?

A Multimodal approach



Anesth Analg 2008;106:175–81


22:14
Audio Pause
Alarm Setup
System Setup
Next Page
Trends
Spirometry
Procedures
Start 00:00:00
End Case
Compl
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30 min
l/min
O2
Air
0.11
0.90
Paw
Flow
CO2
Paw cmH2O
Ppeak
15
Pmean
7
PEEP
2
Flow l/min
MV
6.0
TVexp ml
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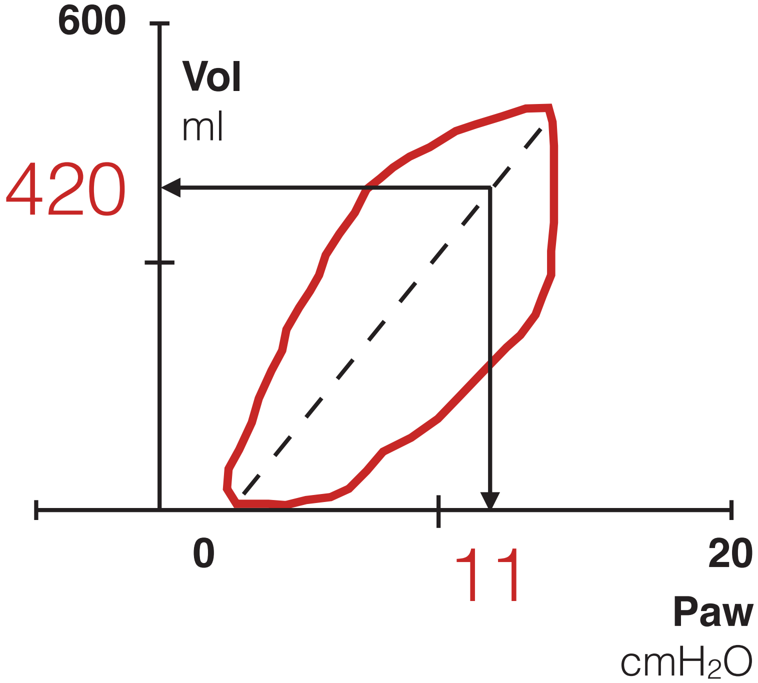
CO2 mmHg
Et
3
Fi
3
Vol ml
Paw cmH2O
Resp
RR /min
12
Compl ml/cmH2O
39
Agent %
Agent
MAC 40 y
Gases %
O2
37
37
N2O
1
1
Fresh Gas: O2+Air
O2
30
%
Total Flow
1.00
l/min
Gas Setup
Ventilator On: Pressure Control
Mode
PCV
TV
420
ml
RR
12
/min
I:E
1:2
PEEP
5
cmH2O
Pmax
40
cmH2O
More Settings

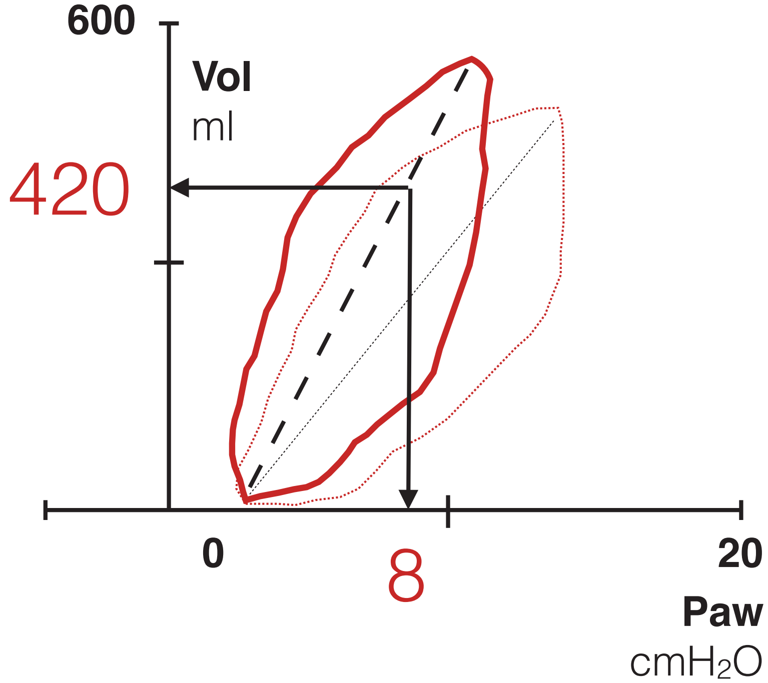
Compliance = **V** (ml) / **P** (cmH_2O)

Avant MRA



Compliance = **39** ml/cmH_2O

Après MRA



Compliance = **50** ml/cmH_2O

The P.O.P® Ventilation concept

3

Postoperative NIV

Conclusion

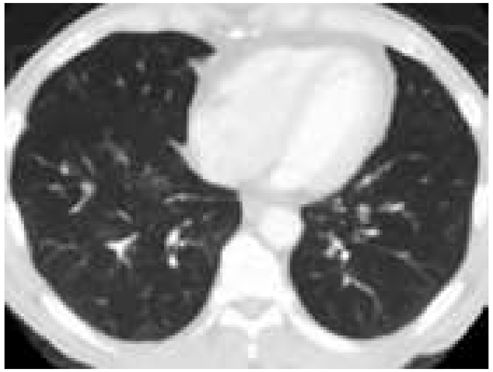
Take Home Messages

- Changement de paradigme: prévention plutôt que traitement des complications postopératoire

- Une stratégie de ventilation protectrice améliore le pronostic postopératoire des patients chirurgicaux

Objectives in volume-controlled mode (VC)

A Healthy lungs



Initial settings

6 < **VT** < 8 ml/kg PBW
6 < **PEEP** < 8 cmH_2O
Recruitment maneuvers

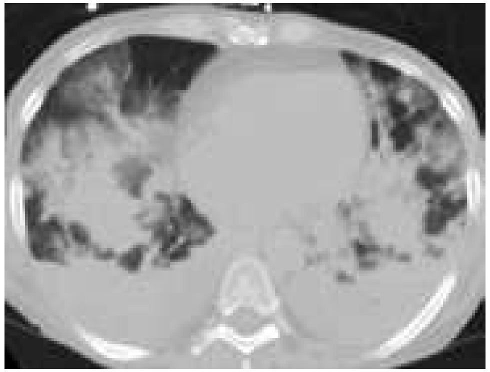
12 < **RR** < 25 breath/min
30 < **FiO_2** < 50%

Target values and monitoring

Plateau pressure < 25 cmH_2O
35 < **E_TCO_2** < 45 mmHg

SpO_2 > 95 %

B Injured lungs



Initial settings

4 < **VT** < 6 ml/kg PBW
8 < **PEEP** < 15 cmH_2O
Recruitment maneuvers (in selected patients)

15 < **RR** < 35 breath/min
50 < **FiO_2** < 80%

Target values and monitoring

Plateau pressure < 30 cmH_2O
40 < **E_TCO_2** < 60 mmHg
(7.30 < **pH** < 7.40)
SpO_2 > 92 %

Futier E et al. Anesthesiology 2014; 121:400–8

Take Home Messages

- Changement de paradigme: prévention plutôt que traitement des complications postopératoire

- Une stratégie de ventilation protectrice améliore le pronostic postopératoire des patients chirurgicaux

- Approche de POP® ventilation
  1. VNI preox
  2. VT (max 8 ml/kg IBW), PEEP (5-10 cmH_2O) et MRA
  3. VNI postop