Rencontres d'Anesthésie SANOFI 2014

Ventilation Mécanique Periopératoire

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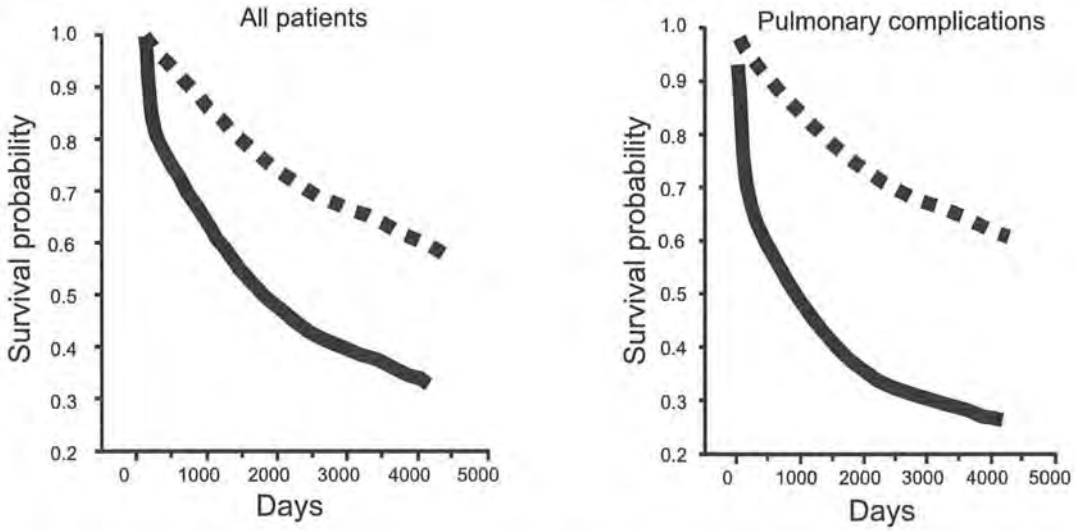
Biarritz - 14&15 Juin 2014

Déclaration de liens d'intérêts

General Electric Medical System
Drager
Fresenius Kabi
Baxter
Fisher & Paykel Healthcare

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

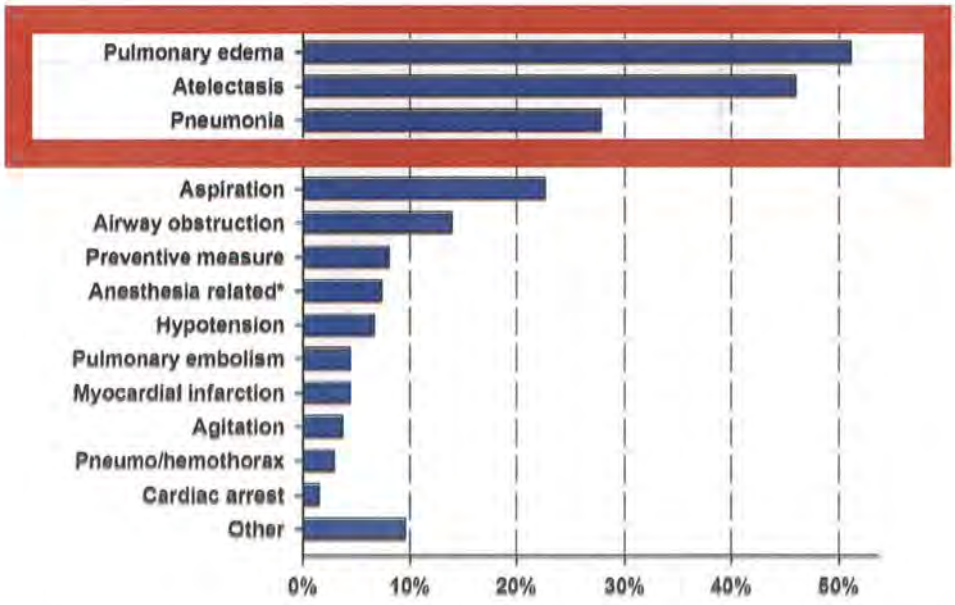


Conclusions: The occurrence of a 30-day postoperative complication is more important than preoperative patient risk and intraoperative factors in determining the survival after major surgery

····· **Patients with no complications**
—— **Patients with 1 or more 30-day complications**

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

Unplanned reintubation for postoperative respiratory failure



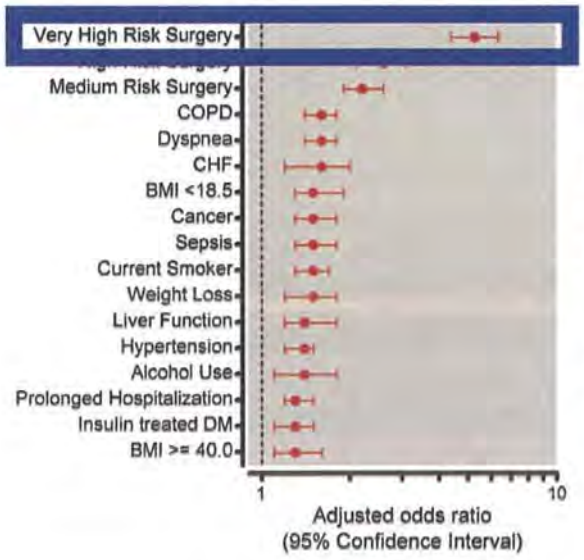
Unplanned reintubation for ARF within the first 3 postoperative days is highly associated with increased risk (72-fold) for in-hospital death:

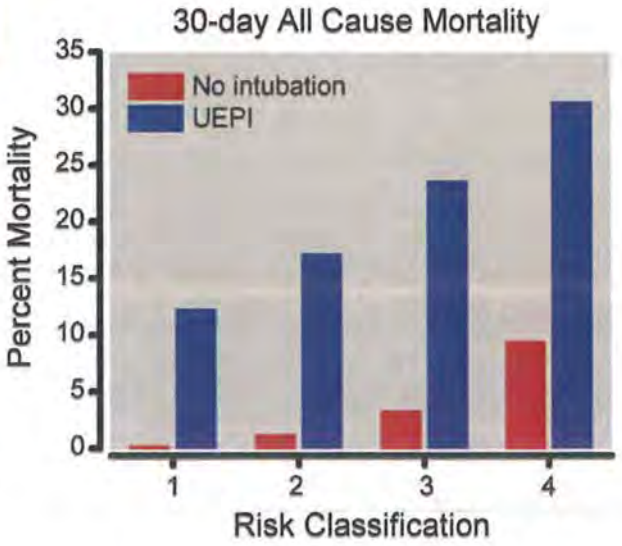
Postoperative mortality 16% *versus* 0,26%

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

Independent Predictors and Outcomes of Unanticipated Early Postoperative Tracheal Intubation after Nonemergent, Noncardiac Surgery

Satya Krishna Ramachandran, M.D., F.R.C.A.,* Olubukola O. Nafiu, M.D.,* Amir Ghaferi, M.D.,‡ Kevin K. Tremper, M.D., Ph.D.,† Amy Shanks, M.S.,§ Sachin Kheterpal, M.D., M.B.A.*





Anesthesiology 2011;115:44–53

PAPER

Temporal Patterns of Postoperative Complications

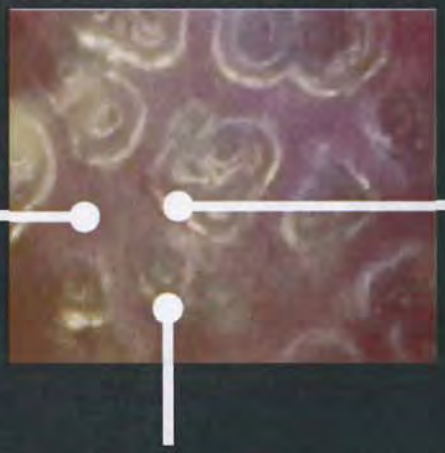
Jon S. Thompson, MD; B. Timothy Baxter, MD; John G. Allison, MD; Frank E. Johnson, MD; Kelvin K. Lee, PhD; Woo Young Park, MD

A prospective multicenter observational study in 1021 patients undergoing intraabdominal surgery. Postoperative morbidity = 42% (435/1021)

Variable	Day 1	Day 1-3	Day 4-7	Day 8-30
Cardiac complications				
Myocardial infarction	21 (47)	17 (38)	5 (11)	2 (4)
Congestive heart failure	6 (17)	16 (46)	6 (17)	7 (20)
Hypotension	13 (43)	5 (17)	4 (13)	8 (27)
Cardiac arrhythmia	7 (33)	7 (33)	3 (14)	4 (19)
Angina	1 (20)	2 (40)	2 (40)	0
Pulmonary complications				
Respiratory failure	8 (7)	94 (76)	9 (7)	12 (10)
Pneumonia	2 (29)	24 (35)	26 (38)	16 (24)
Respiratory depression	11 (55)	2 (10)	2 (10)	5 (25)
Others				
Sepsis	0	4 (11)	7 (18)	27 (71)
Renal failure	2 (13)	5 (31)	0	9 (56)
Cardiovascular accident	0	4 (24)	4 (24)	9 (52)
Total	74 (17)	185 (43)	72 (17)	104 (24)

Arch Surg 2003;138:596-603

Mechanical Ventilation can damage the lungs



Collapsed lung

Shear forces at the junction of opened (aerated) and closed (poorly and non-aerated) alveoli

"Tidal recruitment"
Opening–Closing of lung units

The NEW ENGLAND JOURNAL of MEDICINE

REVIEW ARTICLE

N Engl J Med 2013;369:2126-36.

CRITICAL CARE MEDICINE

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

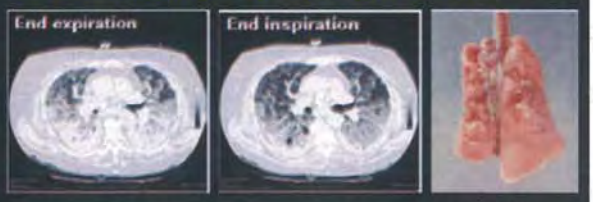
Ventilator-Induced Lung Injury

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

A. Ventilation at HIGH Lung Volume

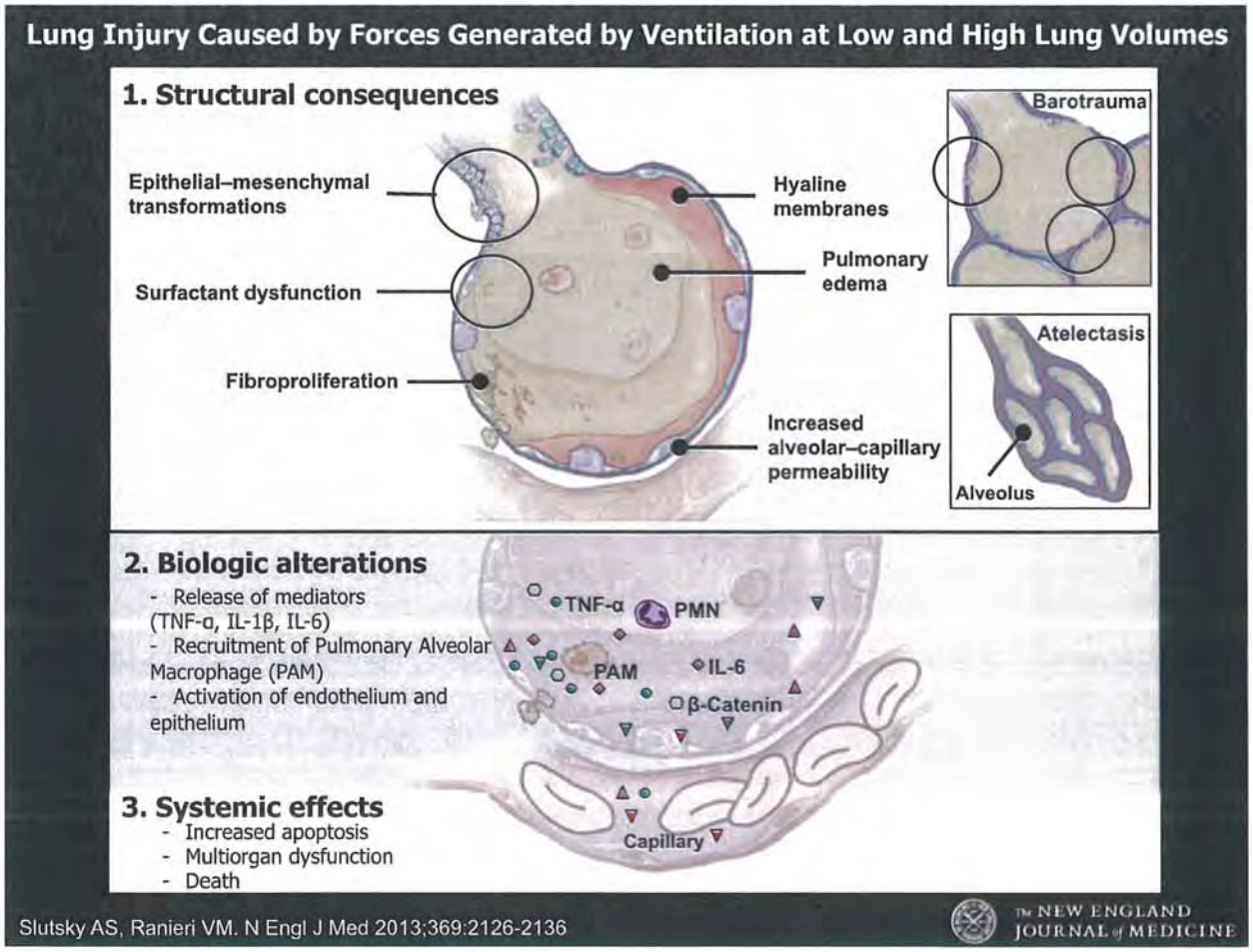
Overdistention

B. Ventilation at LOW Lung Volume



Atelectrauma

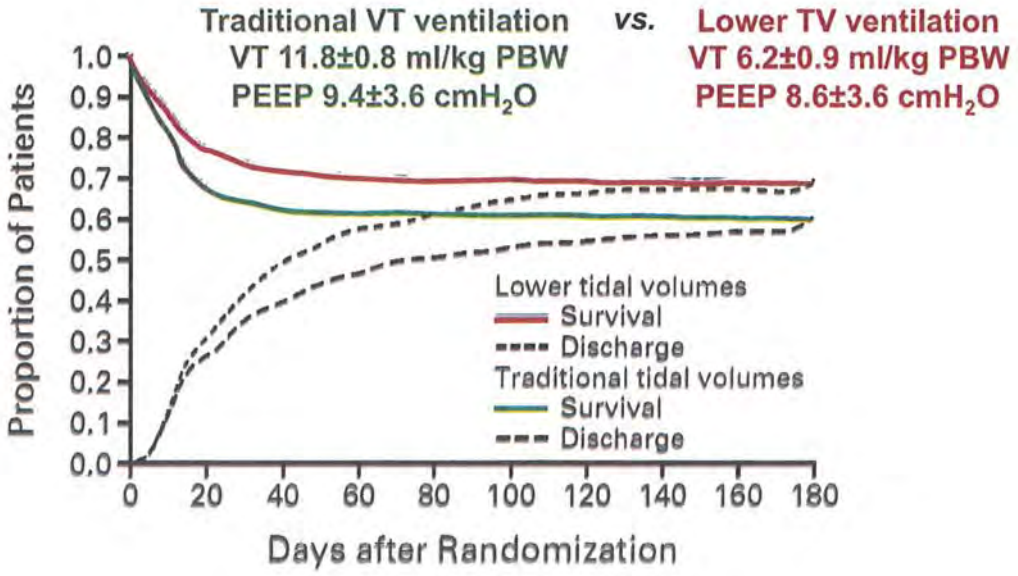
Lung inhomogeneity



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*



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

Petrucci N, De Feo C

Outcome: 2 Mortality at day 28

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 of acute respiratory distress syndrome and acute lung injury.

Cochrane Database Syst Rev. 2013

A **Lung Protective Ventilation** strategy should be composed of:

- **Low Tidal Volume** (calculated using PBW)
- **PEEP**

To protect the lungs against physical (mechanical) forces associated with:

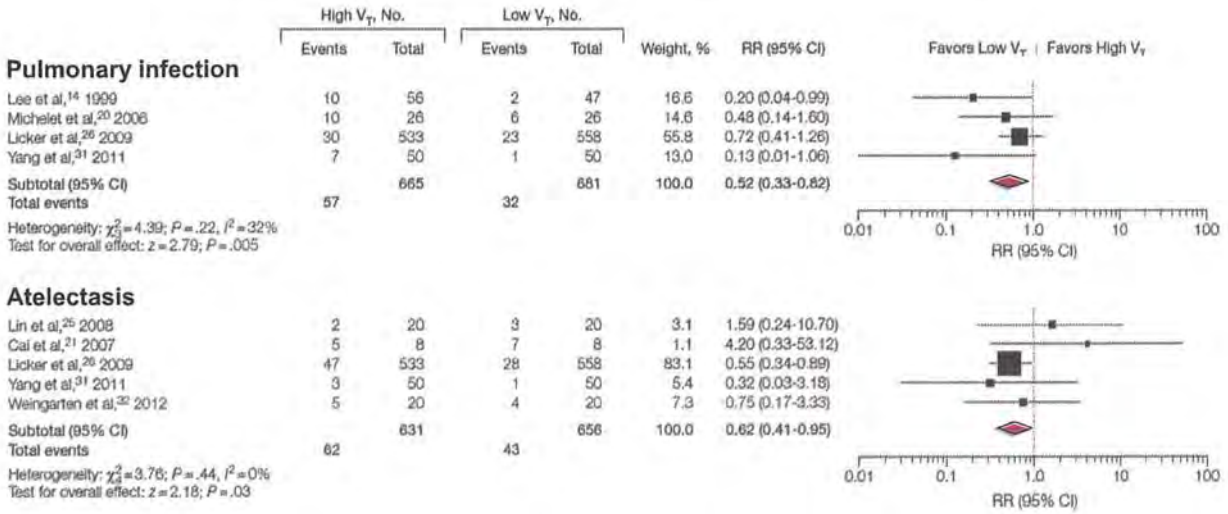
- Lung overdistension
- Repetitive opening and closing of lung units

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
The Journal of the American Medical Association

	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



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

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

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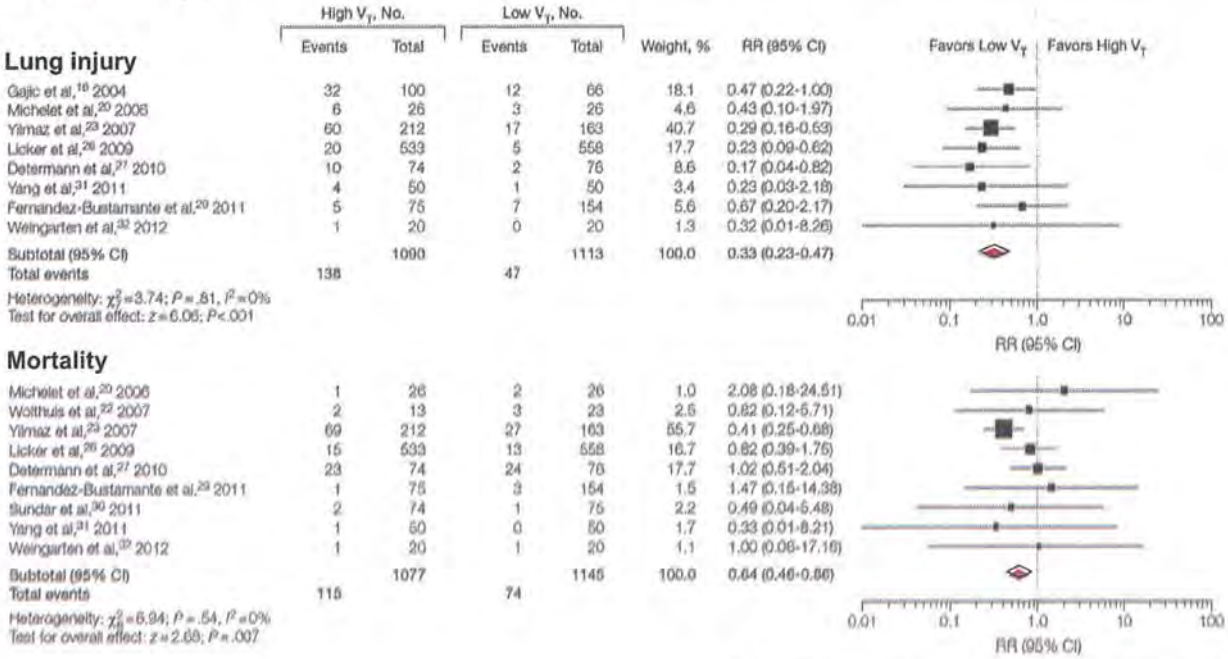
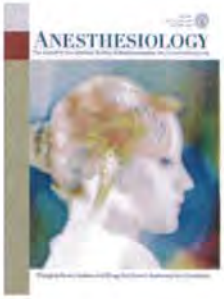


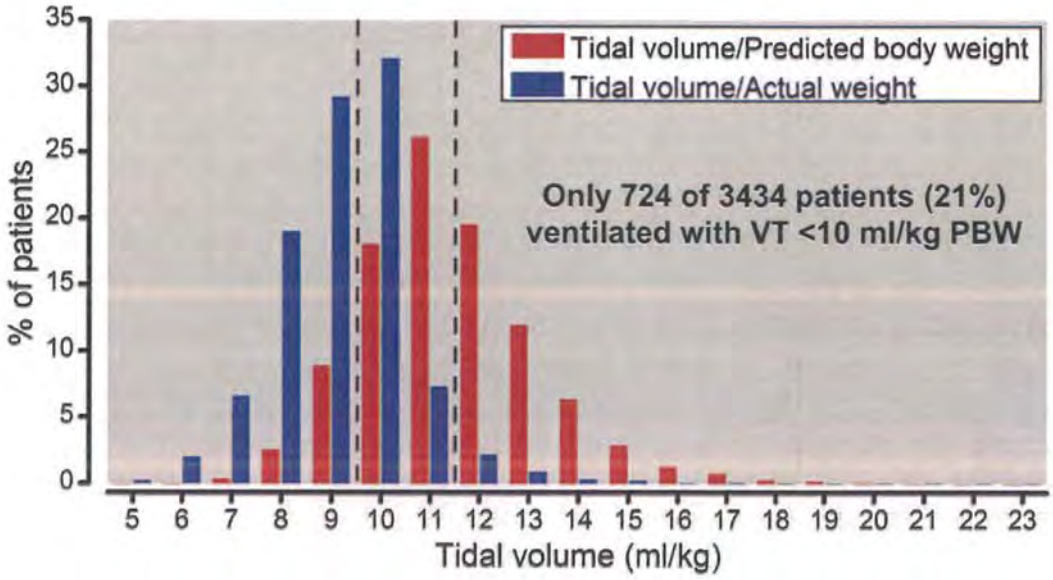
Serpa Neto A et al. JAMA 2012;308:1651-1659

High Tidal Volumes in Mechanically Ventilated Patients Increase Organ Dysfunction after Cardiac Surgery

Francois Lellouche, M.D., Ph.D., Stephanie Dionne, Serge Simard, M.Sc., Jean Bussieres, M.D., Francois Dagenais, M.D.

Anesthesiology 2012;116:1072-82





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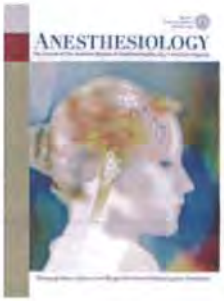
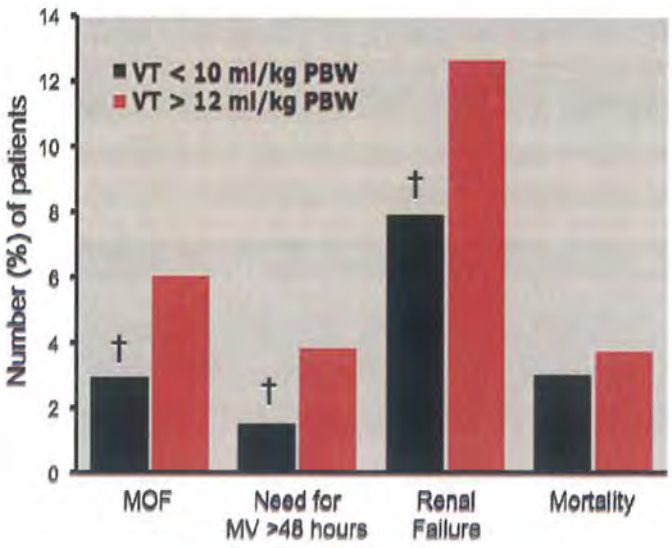
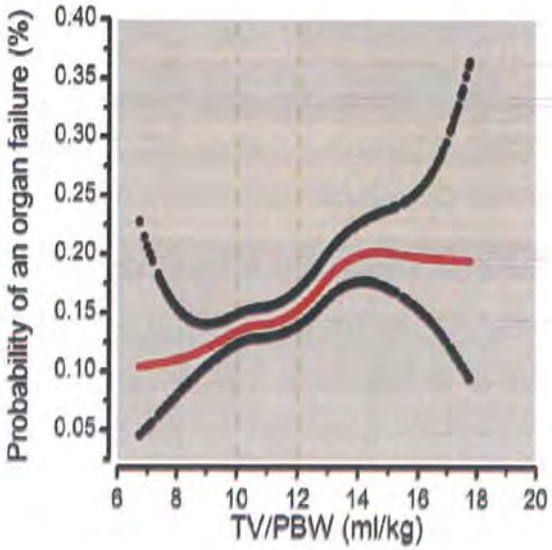






Existe t'il un rationnel à utiliser une ventilation protectrice chez des patients ayant des poumons sains

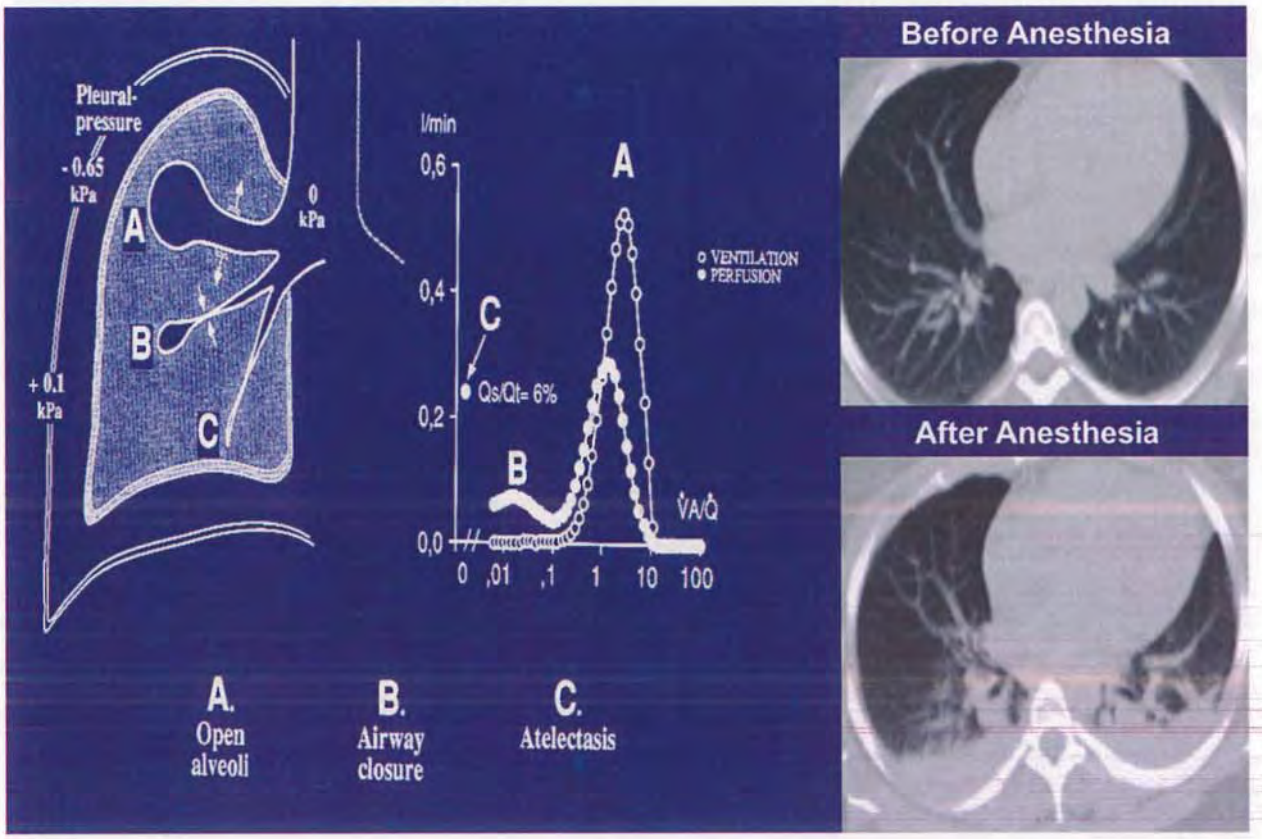
… au bloc opératoire ?

Rationnel physiologique en faveur de l'application d'une stratégie de ventilation protectice au bloc :

1. Une anesthésie générale est associée à une réduction des volumes pulmonaires et à la formation d'atélectasies

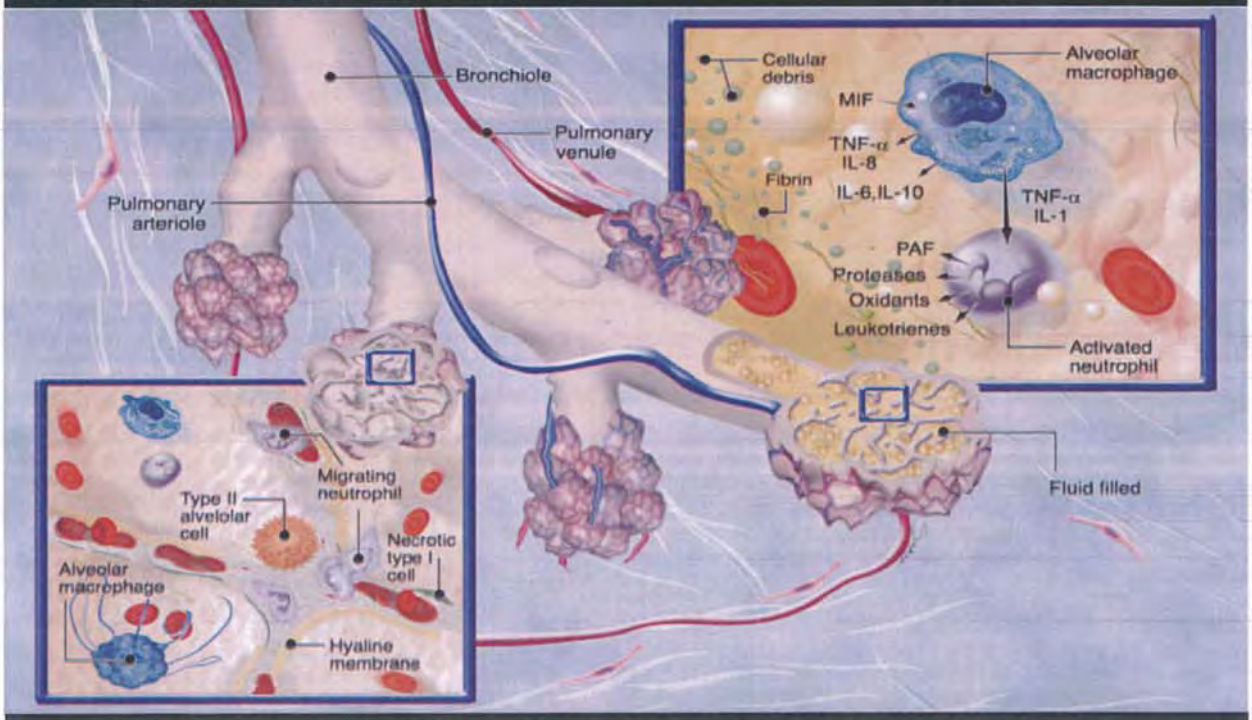
Airway Closure: the silent killer of peripheral airways

Paolo Pelosi and Patricia RM Rocco *Crit Care 2007, 11:114*



Pulmonary Atelectasis:

A Pathogenic Perioperative Entity



Initial injury is simple collapse of alveoli. However, with time, this leads to an inflammatory reaction. The derecruited lungs cause **epithelial injury** and **loss of epithelial integrity**

Duggan M. **Anesthesiology** 2005

Rationnel physiologique en faveur de l'application d'une stratégie de ventilation protectice au bloc :

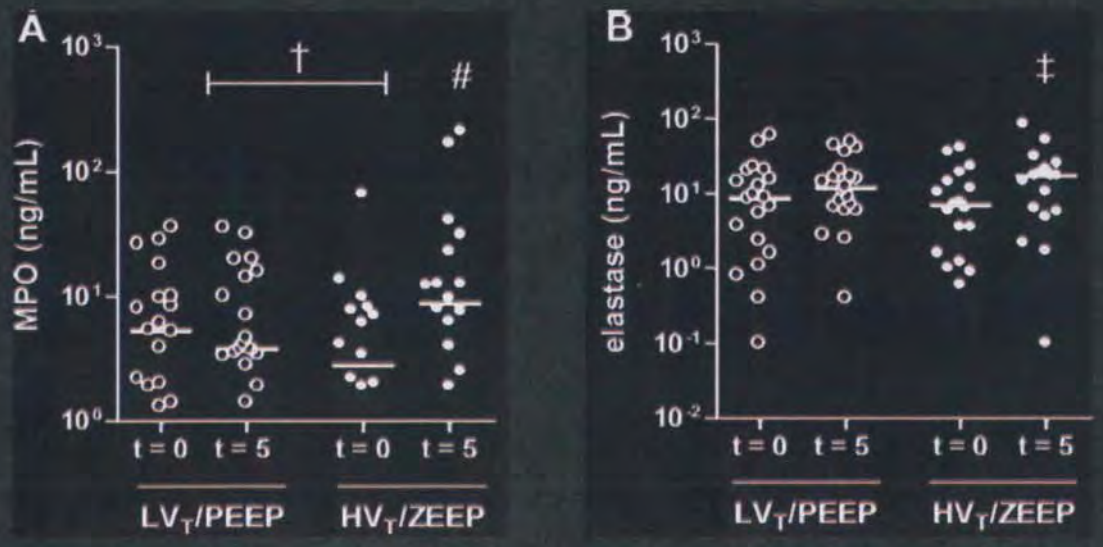
1. Une anesthésie générale est associée à une réduction des volumes pulmonaires et à la formation d'atélectasies
2. Même une courte période de ventilation peut être responsable de phénomènes inflammatoires pulmonaires

Anesthesiology 2008; 108:46–54

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.

6 hours



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

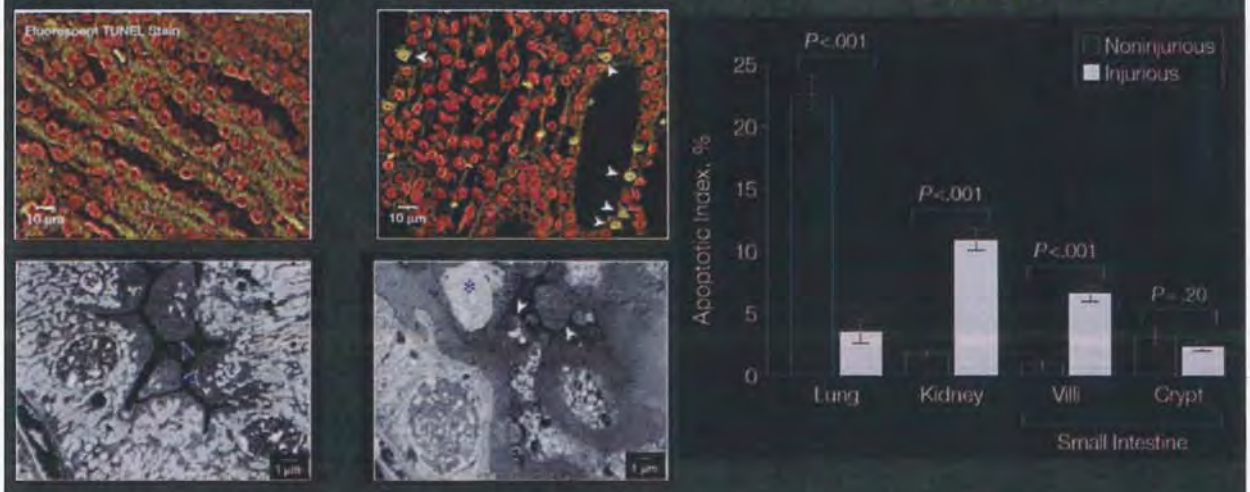
JAMA®
The Journal of the American Medical Association

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

Non-Injurious Ventilation
TV 5-7 ml/kg, PEEP 9-12 cmH_2O

Injurious Ventilation
TV 15-17 ml/kg, PEEP 0-3 cmH_2O

8 hours

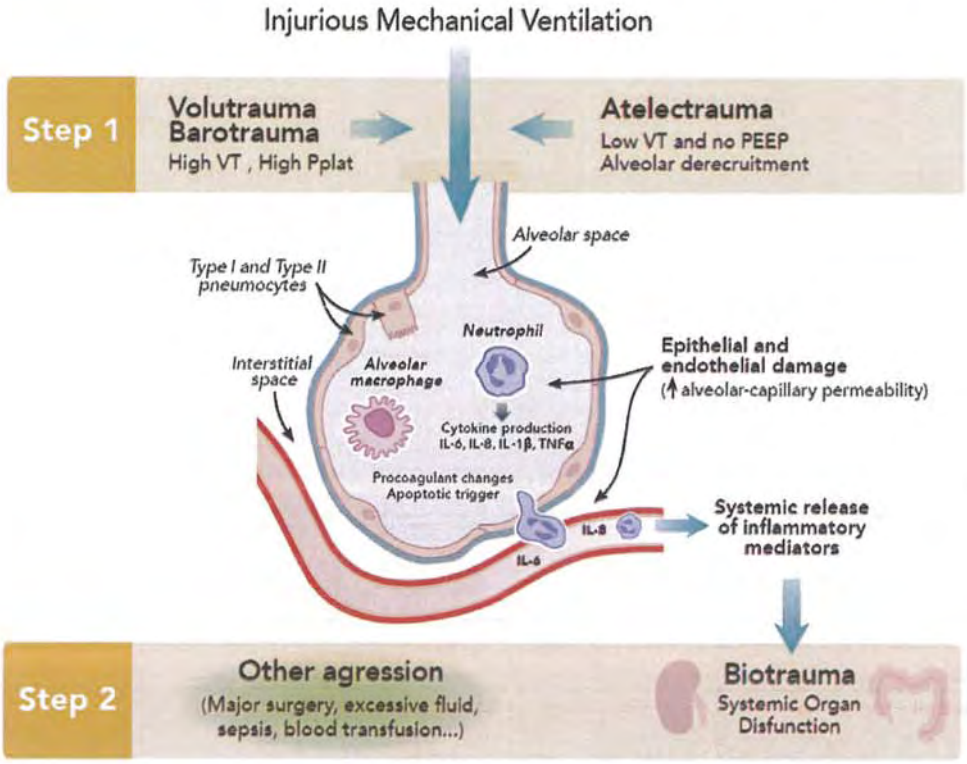


- **Even short-term injurious ventilation can produce lung damage**
- **Injurious mechanical ventilation can lead to epithelial cell apoptosis (kidney, small intestine)**
- **This effect could be mediated by solube factors (Fas-Fas ligand system)**

Rationnel physiologique en faveur de l'application d'une stratégie de ventilation protectice au bloc :

1. Une anesthésie générale est associée à une réduction des volumes pulmonaires et à la formation d'atélectasies
2. Même une courte période de ventilation peut être responsable de phénomènes inflammatoires pulmonaires
3. Dans le contexte d'une chirurgie majeure, une ventilation agressive peut créer les conditions de lésions pulmonaires secondaires

The "Multiple hits" hypothesis



Futier E et al. Anesthesiology 2014 (*In PRESS*)

Comment protéger les poumons au bloc opératoire ?

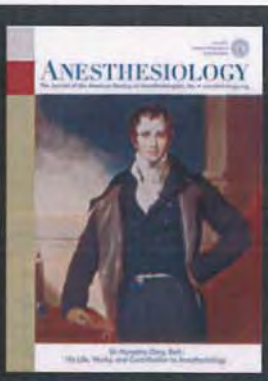
Ventilation Protectrice Prophylactique au bloc :

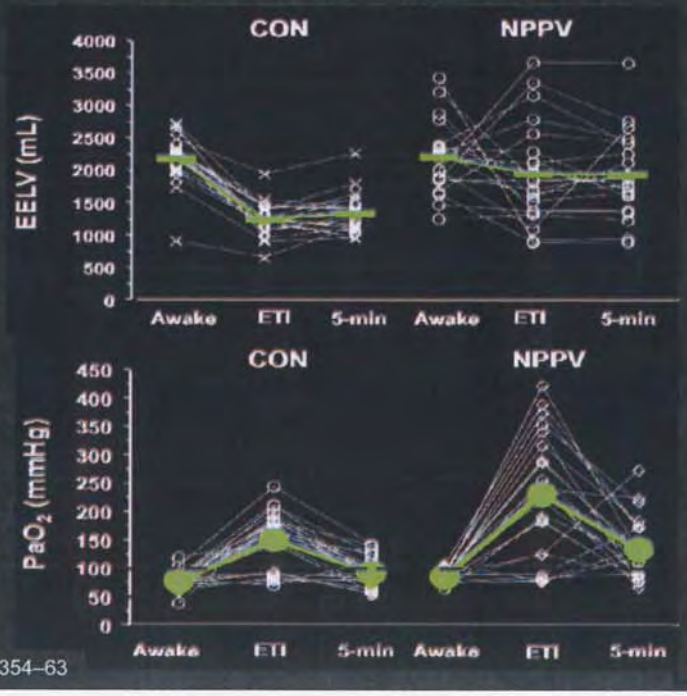
1. Prévenir le collapsus pulmonaire dès que possible

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

Ventilation Protectrice Prophylactique au bloc :

1. Prévenir le collapsus pulmonaire dès que possible
2. Régler le volume courant (VT) sur le poids idéal et pas sur le poids réel

Should we use actual or predicted body weight to set tidal volume?

Patient #1
53 years
162 cm 132 kgs

Patient #2
46 years
161cm 47 kgs

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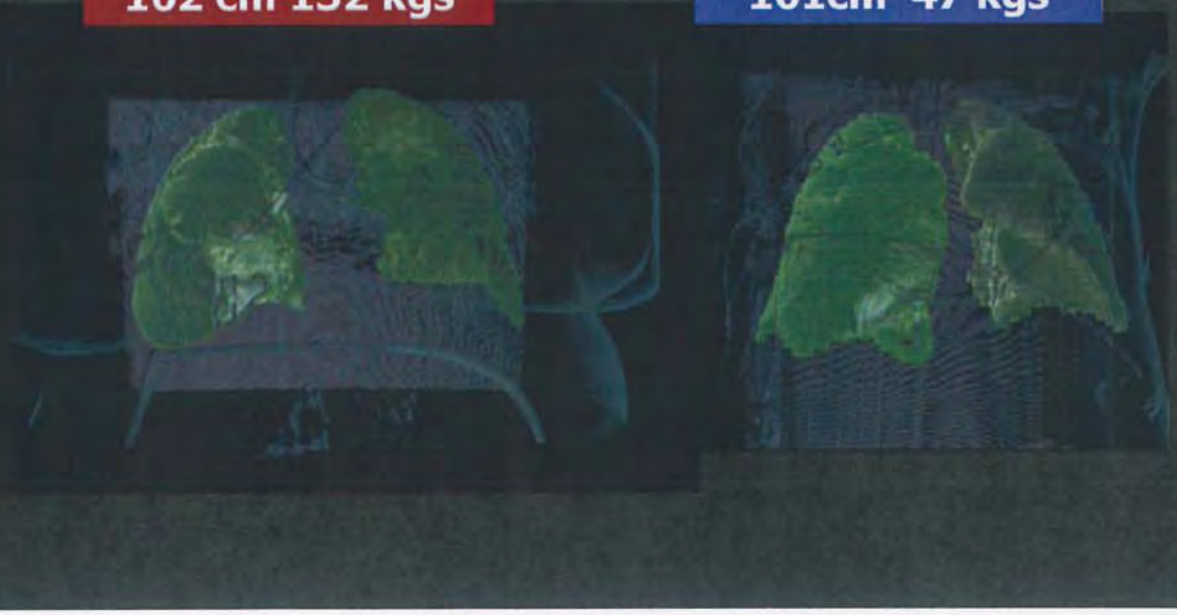

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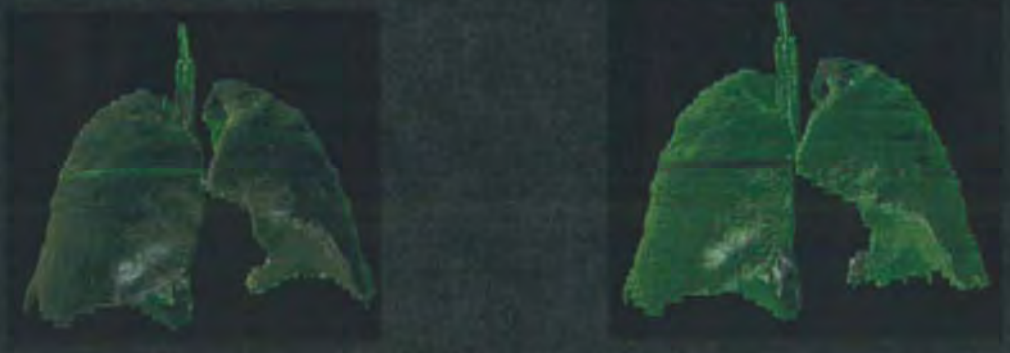


Should we use actual or predicted body weight to set tidal volume?

Patient #1
53 years
162 cm 132 kgs

Patient #2
46 years
161cm 47 kgs

Tidal volume should be set on
PREDICTED BODY WEIGHT (PBW)

Taille (cm) – 100 in men
Taille (cm) – 110 in women

Ventilation Protectrice Prophylactique au bloc :

1. Prévenir le collapsus pulmonaire dès que possible
2. Régler le volume courant (VT) sur le poids idéal et pas sur le poids réel
3. Le mode de ventilation (VVC ou VPC) utilisé n'est pas déterminant

REVIEW ARTICLES

Ventilation strategies in obese patients undergoing surgery: a quantitative systematic review and meta-analysis†

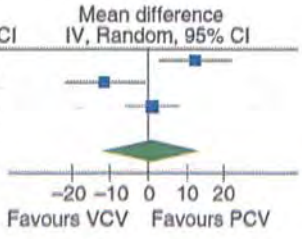
M. Aldenkortt[1*], C. Lysakowski[1], N. Elia[1,3], L. Brochard[2,4] and M. R. Tramèr[1,4]

VVC ou VPC

Intraoperative PaO_2/FiO_2 (kPa)

Study or Subgroup	PCV Mean	PCV SD	PCV Total	VCV Mean	VCV SD	VCV Total	Weight	Mean difference IV, Random, 95% CI
Cadi 2008	37.5	14.3	18	26.5	10.3	18	32.8%	11.00 [2.86, 19.14]
De Baerdemaeker 2007	31.6	10.5	12	41.7	11.9	12	31.5%	−10.10 [−19.08, −1.12]
Hans 2007	36.4	13.5	39	35.5	14.4	40	35.7%	0.90 [−5.25, 7.05]
Total (95% CI)			69			70	100.0%	0.75 [−9.99, 11.48]

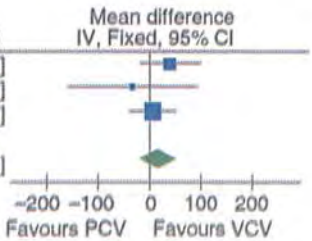
Heterogeneity: $\tau^2 = 74.21$; $\chi^2 = 11.66$, df = 2 ($P = 0.003$); $I^2 = 83\%$
Test for overall effect: $Z = 0.14$ ($P = 0.89$)



Intraoperative tidal volume (ml)

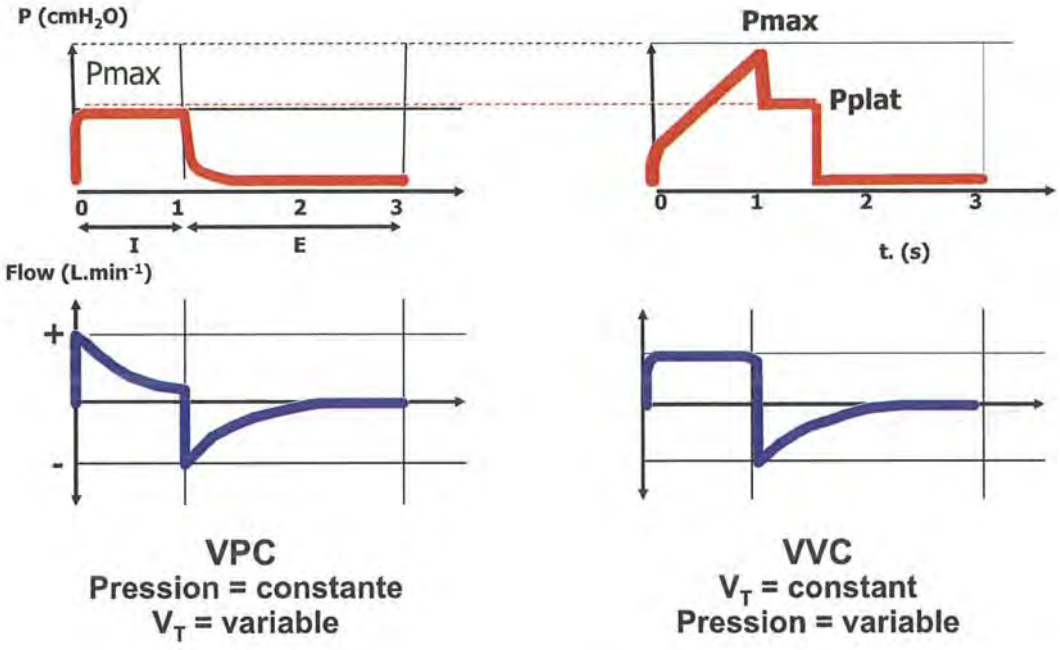
Study or Subgroup	PCV Mean	PCV SD	PCV Total	VCV Mean	VCV SD	VCV Total	Weight	Mean difference IV, Fixed, 95% CI
Cadi 2008	613	91	18	573	81	18	36.1%	40.00 [−16.28, 96.28]
De Baerdemaeker 2007	612	170	12	645	138	12	7.5%	−33.00 [−156.89, 90.89]
Hans 2007	650	104	39	643	100	40	56.4%	7.00 [−38.01, 52.01]
Total (95% CI)			69			70	100.0%	15.93 [−17.88, 49.75]

Heterogeneity: $\chi^2 = 1.45$, df = 2 ($P = 0.48$); $I^2 = 0\%$
Test for overall effect: $Z = 0.92$ ($P = 0.36$)



Br J Anaesth 2012; 109: 493–502

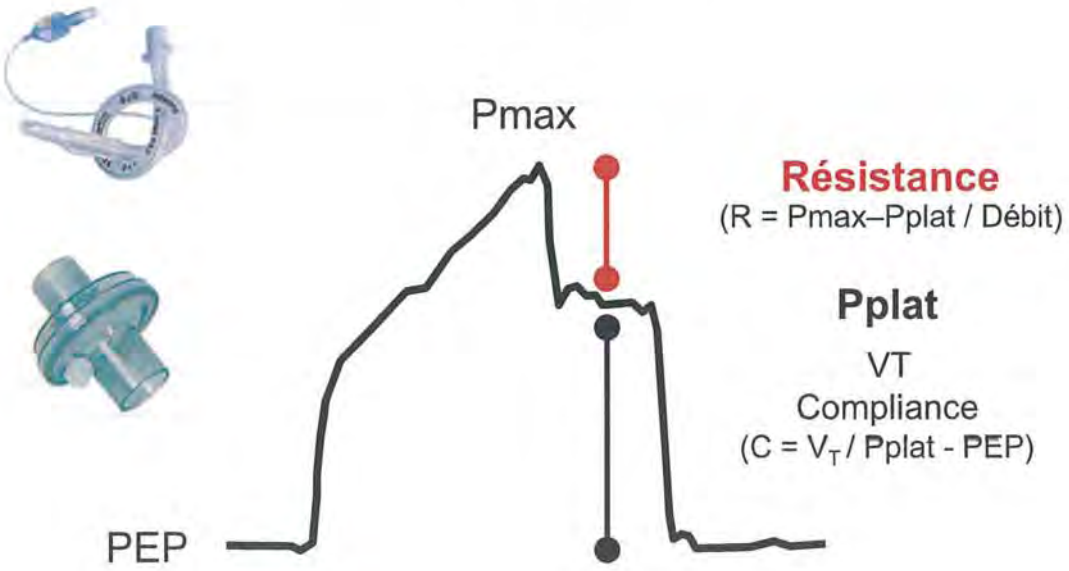
VVC versus **VPC**



VPC
Pression = constante
V_T = variable

VVC
V_T = constant
Pression = variable

Airway Pressures



Ventilation Protectrice Prophylactique au bloc :

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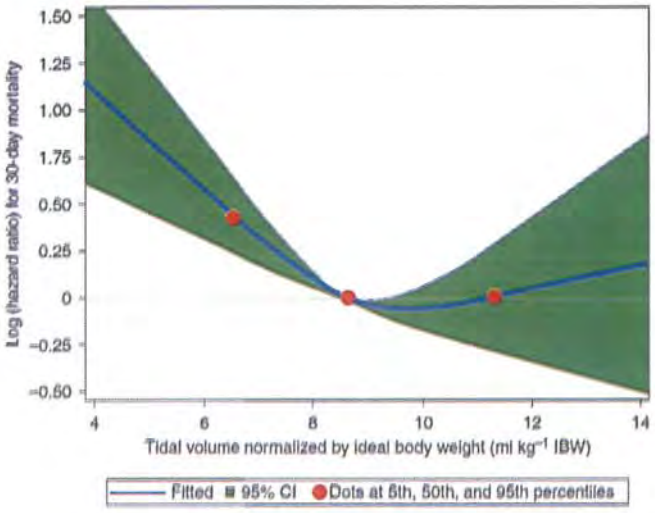
2. Régler le volume courant (VT) sur le poids idéal et pas sur le poids réel
3. Le mode de ventilation (VVC ou VPC) utilisé n'est pas déterminant
4. Un objectif de volume courant bas (VT <8 ml/kg PBW) NE SUFFIT PAS !

BJA British Journal of Anaesthesia

Low intraoperative tidal volume ventilation with minimal PEEP is associated with increased mortality

M. A. Levin[1], P. J. McCormick[1], H. M. Lin[1,2], L. Hosseinian[1] and G.W. Fischer[1,3*]

Br J Anaesth 2014 Mar 12. [Epub ahead of print]



- Retrospective analysis of data from 29 343 patients between 2008 and 2011 at Mount Sinai (NY, USA)

  Patients with VT of 6-8 ml/kg IBW
  - **2008: 22.7%**
  - **2011: 37.7%**
- **Median PEEP=4 [2.2-5] cmH_2O**

Conclusions. Use of low intraoperative TV (≤ 8 ml/kg PBW) with minimal PEEP is associated with an increased risk of 30-day mortality.

Ventilation Protectrice Prophylactique au bloc :

1. Prévenir le collapsus pulmonaire dès que possible
2. Régler le volume courant (VT) sur le poids idéal et pas sur le poids réel
3. Le mode de ventilation (VVC ou VPC) utilisé n'est pas déterminant
4. Un objectif de volume courant bas (VT <8 ml/kg PBW) NE SUFFIT PAS !
5. Une PEEP et des manoeuvres de recrutement alvéolaire sont nécessaires

Editorial

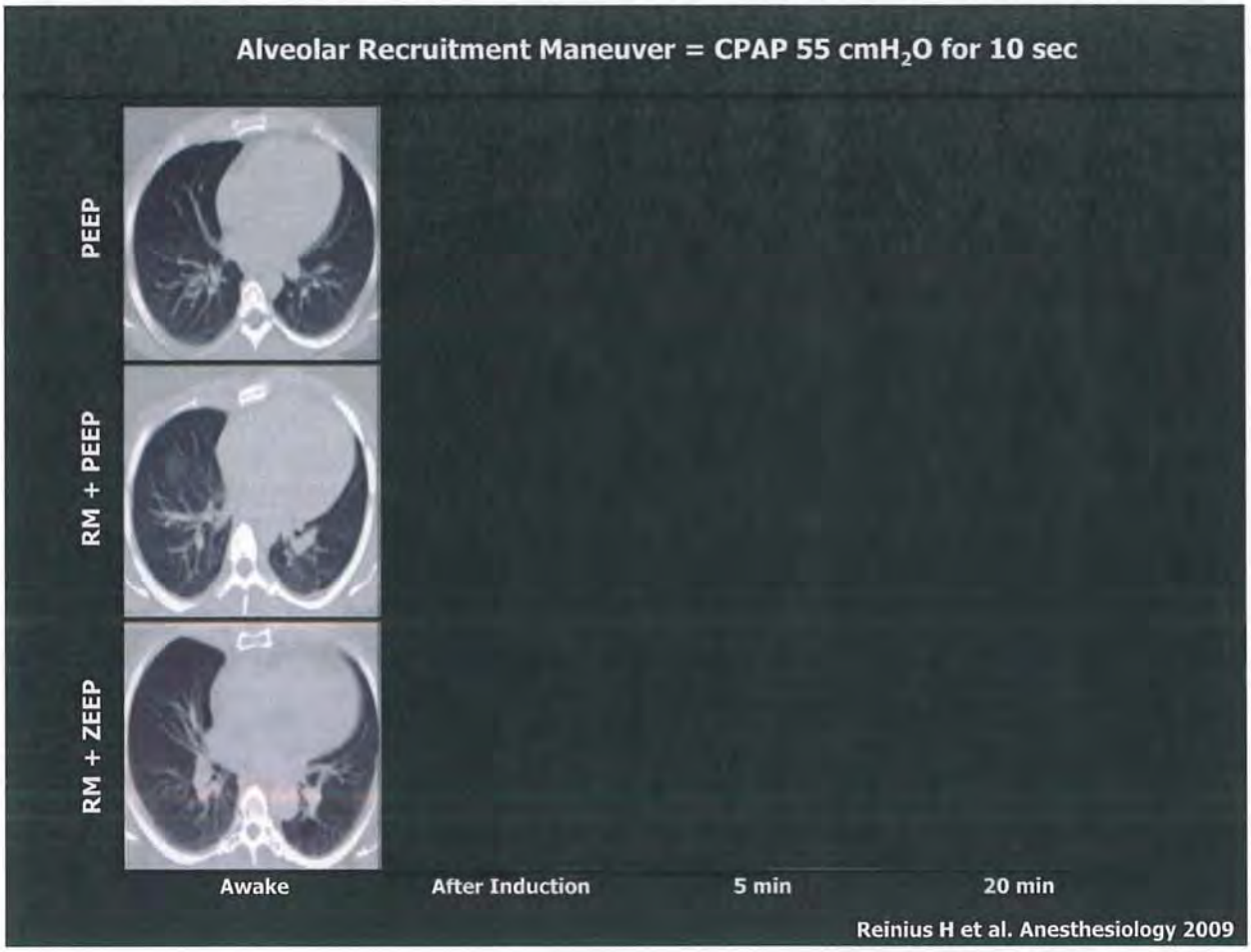
Open up the lung and keep the lung open

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."

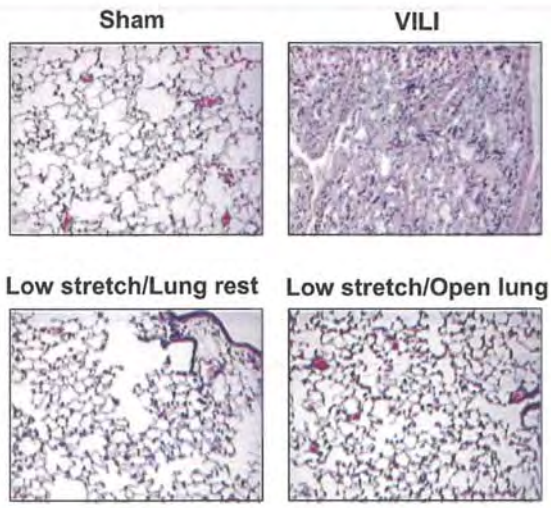
Intensive Care Med **1992**; 18: 319-21

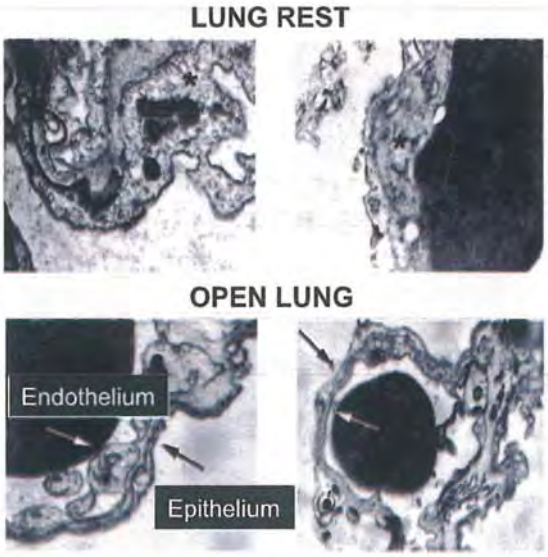


Pulmonary atelectasis during low stretch ventilation: "Open lung" versus "lung rest" strategy*

Vito Fanelli, MD; Luciana Mascia, MD, PhD; Valeria Puntorieri, MSc; Barbara Assenzio, MSc; Vincenzo Elia, MSc; Giancarlo Fornaro, MD; Erica L. Martin, PhD; Martino Bosco, MD; Luisa Delsedime, MD; Tommaso Fiore, MD; Salvatore Grasso, MD; V. Marco Ranieri, MD

Crit Care Med 2009; 37:1046 –1053





- Both low stretch strategies provide similar attenuation of VILI
- But the presence of atelectasis during the low stretch/lung rest strategy was associated with ultrastructural damage of the alveolar wal

Quelles données au bloc opératoire ?

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*

N Engl J Med 2013;369:428-37

Study design

Intraoperative PROtective VEntilation in abdominal surgery

The *IMPROVE* Trial

A pragmatic multicenter, double-blinded, randomized controlled trial

Lung-Protective Ventilation
N=200

VT 6 to 8 ml/kg PBW
PEEP 6 to 8 cmH_2O
Recruitment Maneuver

Recruitment maneuver=CPAP 30 cmH_2O during 30 sec
After intubation and every 30min thereafter

VS.

Non-Protective Ventilation
N=200

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

How do it in practice?

Laparoscopic abdominal surgery
Height: 170 cm, Weight: 75 kg, IBW=[(170-152.4)×0.91]+50=66 kg

Non-protective ventilation
VT 750 ml (11 ml/kg PBW)
No PEEP
No Recruitment Maneuver

Lung-protective ventilation
VT 480 (7 ml/kg IBW)
PEEP 8 cmH_2O
Repeated Recruitment Maneuver

Primary outcome measure

A composite of major pulmonary and extra-pulmonary complications to postoperative Day 7

- **Pulmonary:** **Postoperative pneumonia**
  Need for NIV or tracheal intubation for ARF
- **Extra-pulmonary:** **Sepsis, Severe sepsis and septic shock**
  Postoperative Death

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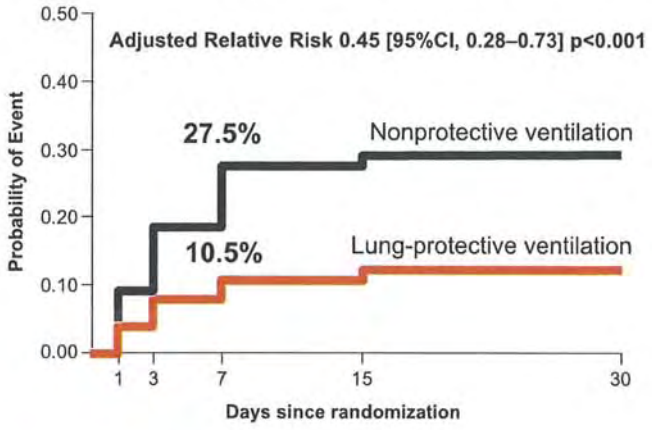
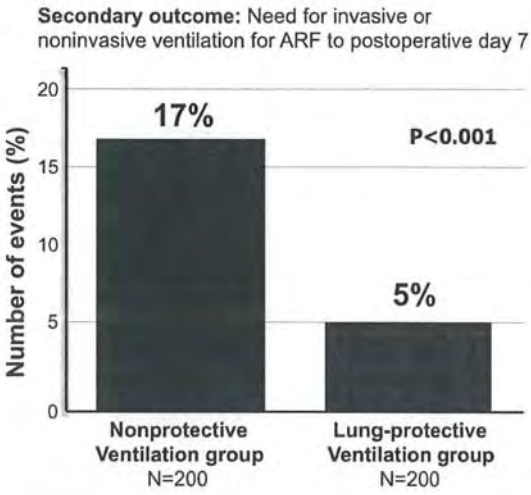


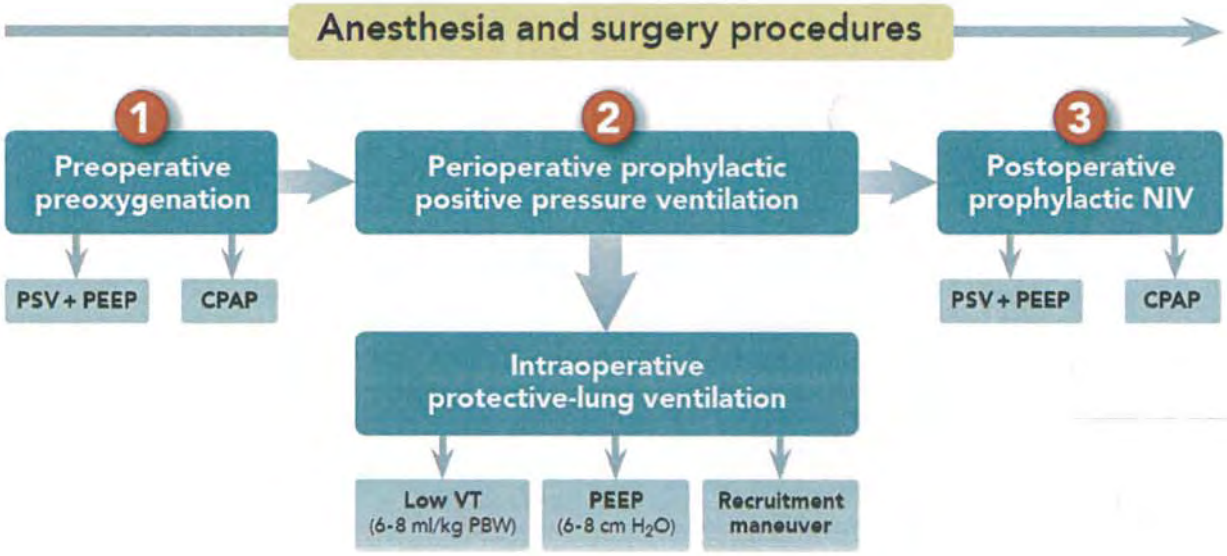


CONCLUSIONS

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

Est-il possible de faire encore mieux ?

The «P.O.P» Ventilation concept



Futier E et al. Anesthesiology 2014 (*In PRESS*)

Conclusion

- Les complications pulmonaires postopératoires sont responsables d'une morbidité et d'une mortalité postopératoires importantes

- La ventilation mécanique ne devrait plus être considérée uniquement comme un moyen pour administrer des agents halogénés pendant la chirurgie

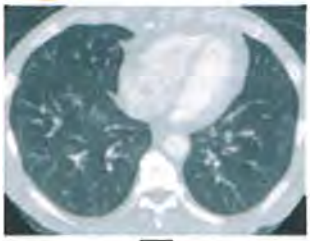
- Stratégie prophylactique de ventilation protectrice composée de :

  VT de 6 à 8 ml/kg PBW
  Une PEEP modérée (6 à 8 cmH_2O)
  Maneurvres de recrutement répétées

1. Applicable en routine clinique
2. Avec tous les ventilateurs
3. Améliorer le pronostic clinique des patients opérés d'une chirurgie abdominale

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 %

FIN

Merci de votre attention