



Ventilation Protectrice en dehors du SDRA et de l'ALI

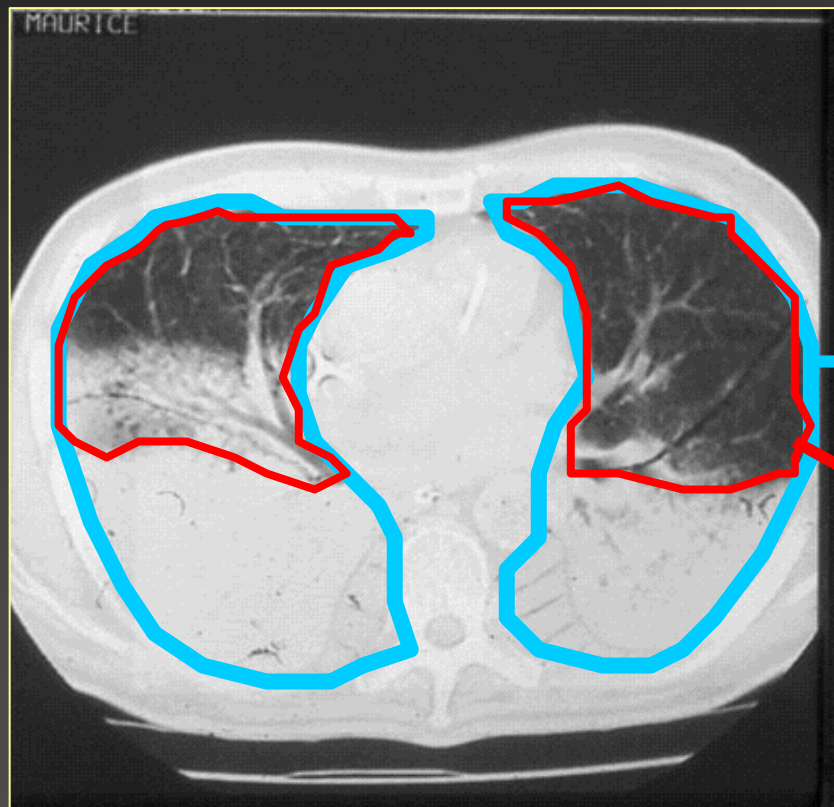
Pierre Michelet
Réanimation des Urgences

Objectifs Pédagogiques

- Ventilation « protectrice »
 - Arguments en faveur de lésions induites par la ventilation mécanique sur poumon sains
 - Arguments en faveur de l'amélioration de cette dysfonction par une stratégie de ventilation protectrice
-

Luciano Gattinoni
Antonio Pesenti

The concept of “baby lung”



Vt de 9 ml/kg

Vt de 6 ml/kg

Ventilation protectrice,
vous avez dit ventilation protectrice !

The New England
Journal of Medicine

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NUMBER 18



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*

Intérêt lors du SDRA et ALI

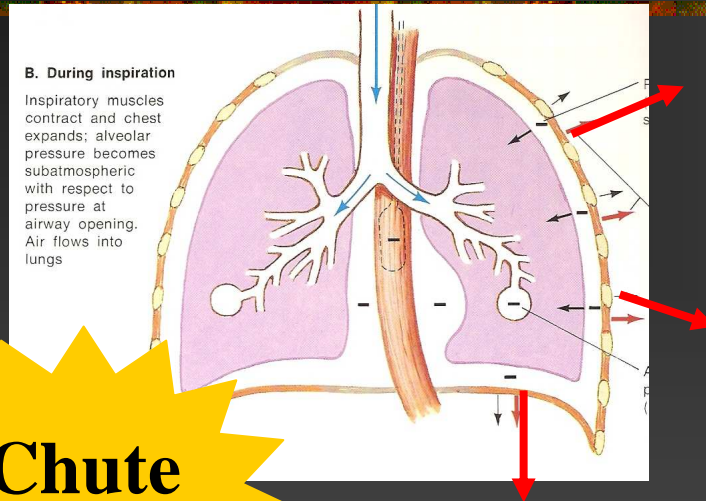


Arguments en faveur de lésions induites par la ventilation mécanique sur poumon sains

Arguments

- Physiologiques
- Expérimentaux
- Cliniques

Arguments Physiologiques



INSPIRATION (active)

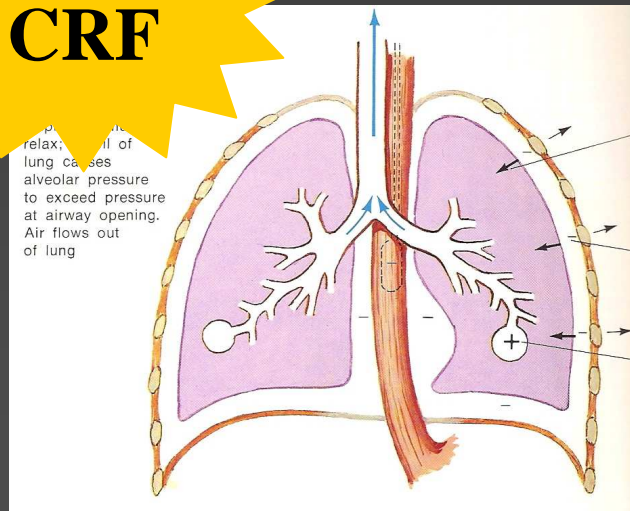
Expansion thoracique

↘ Ppl

$P_{alv} < P_{atm}$

Afflux passif d'air dans le poumon

**Chute
CRF**



EXPIRATION (passive)

Force de rétraction élastique

↗ Ppl

$P_{alv} > P_{atm}$

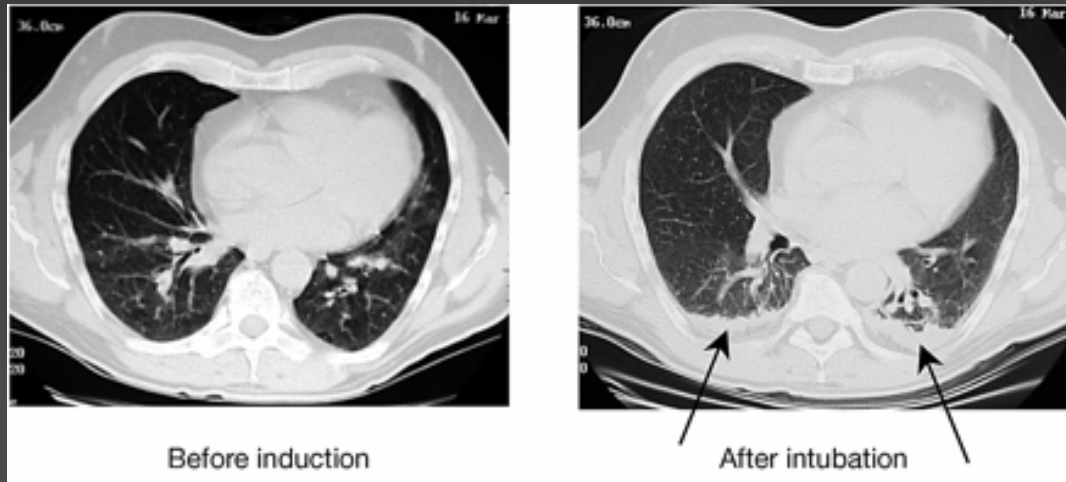
Expulsion d'air du poumon

Arguments Physiologiques : les atélectasies

- Autres facteurs en cause
 - Les hauts niveaux de FiO_2
 - L'altération du surfactant
 - Les phénomènes d'ouvertures fermetures
 - La position
 - Les débranchements itératifs
 - Obésité ou l'HPIA ...
-

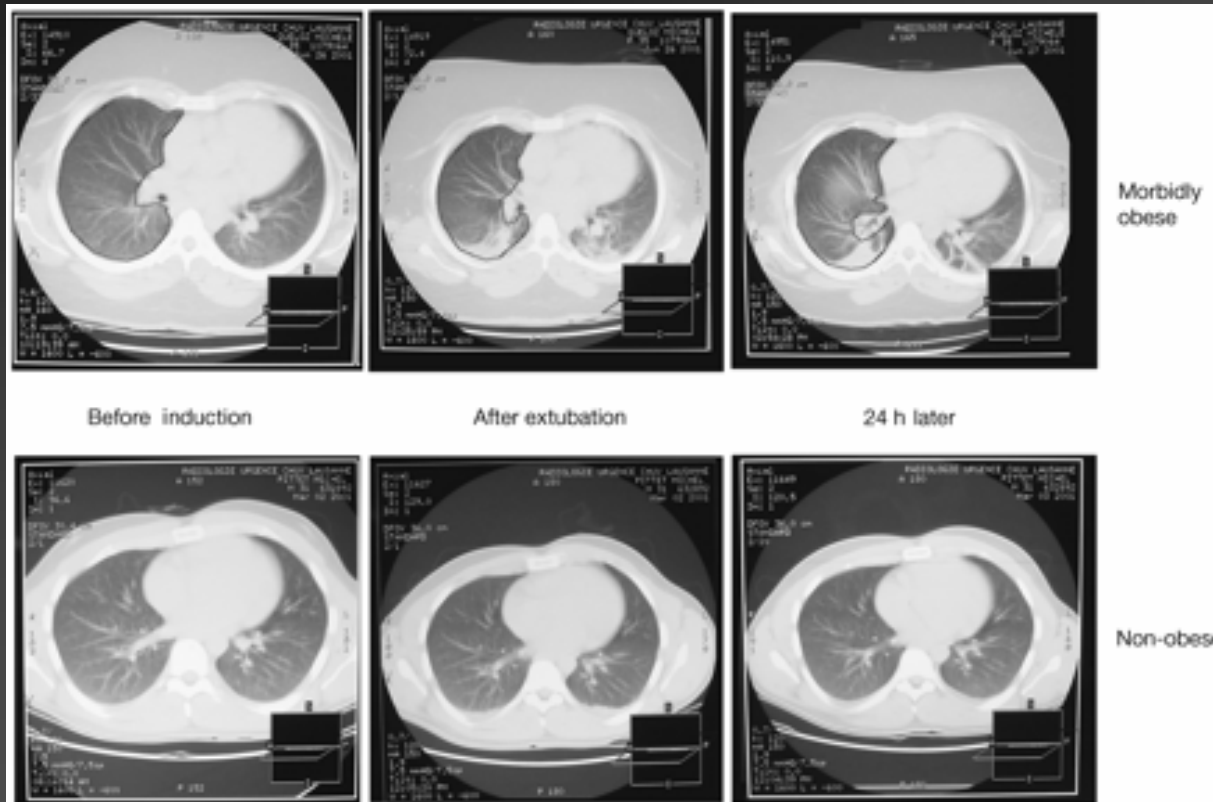
Arguments Physiologiques : les atélectasies

Réduction du volume pulmonaire
« ventilable »



Arguments Physiologiques : les atélectasies

Réduction plus marquée



Chirurgie

- Thoracique
- Cardiaque
- Abdominale
- Obèse

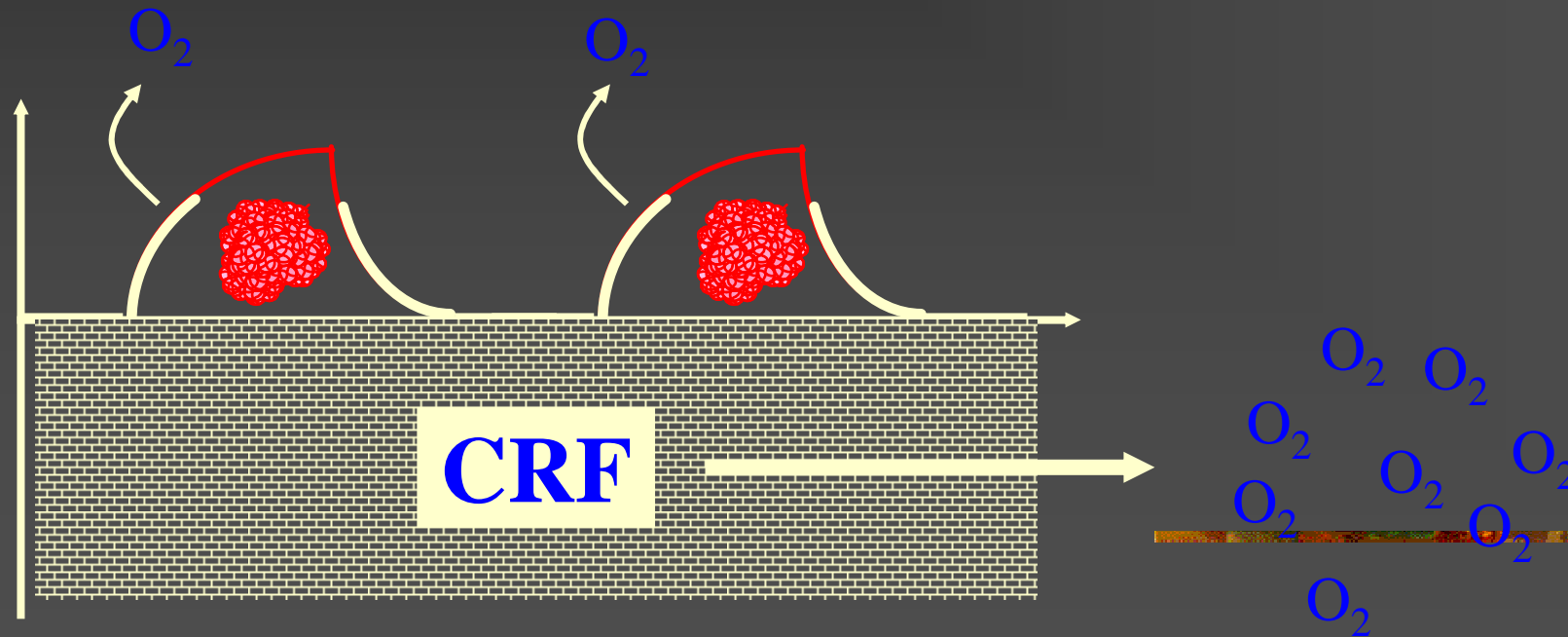
Atélectasies : première conséquence

Hypoxémie

Corrélation atélectasies – shunt intrapulmonaire $r = 0,93$

Corrélation atélectasies – hypoxémie $r = 0,99$

Hedenstierna G et al Acta Anaesthesiol Scand 1986



Pulmonary Atelectasis

A Pathogenic Perioperative Entity

Michelle Duggan, M.B.,* Brian P. Kavanagh, M.B.†

Une entité pathologique

- Périopératoire

- Ventilatoire aussi

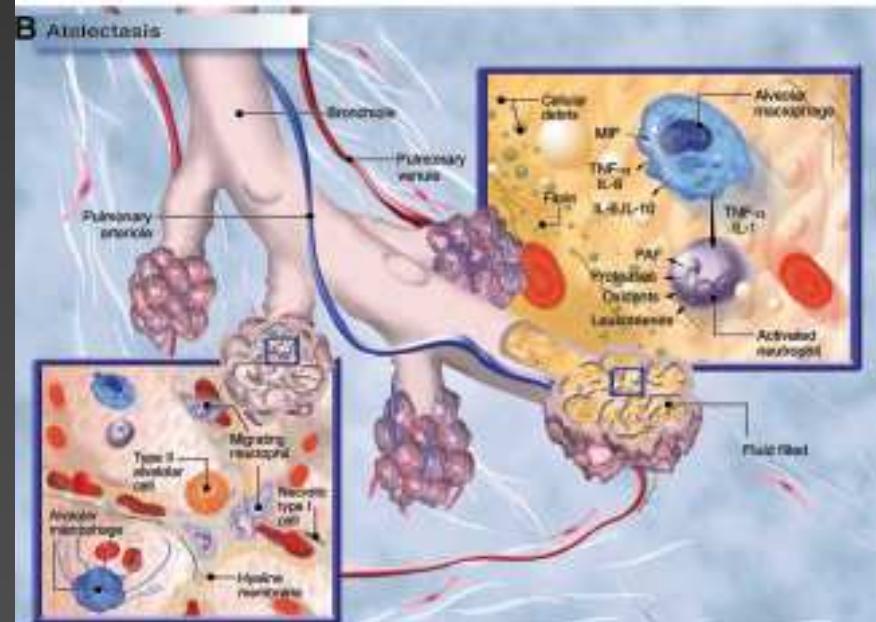
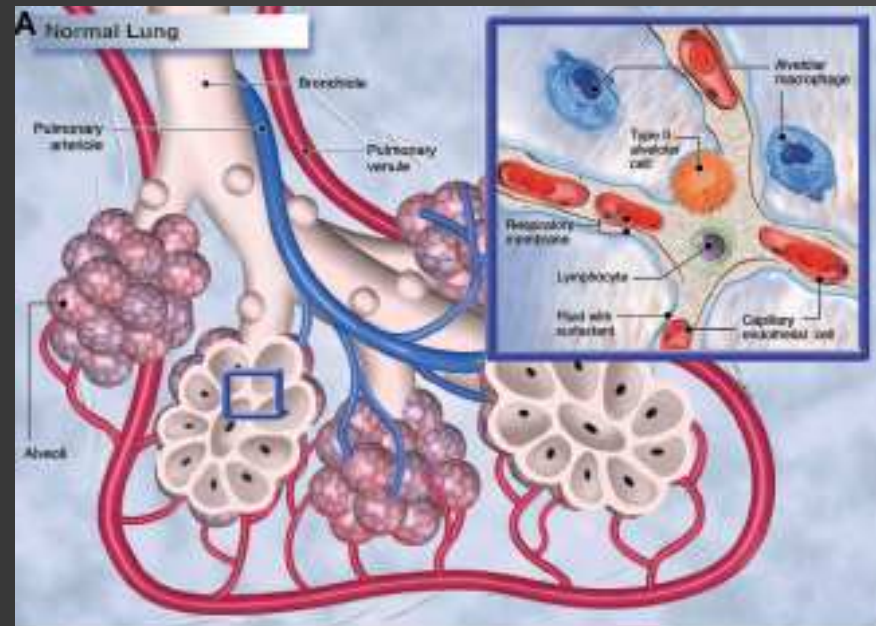
Une entité pathologique

- Hypoxémie

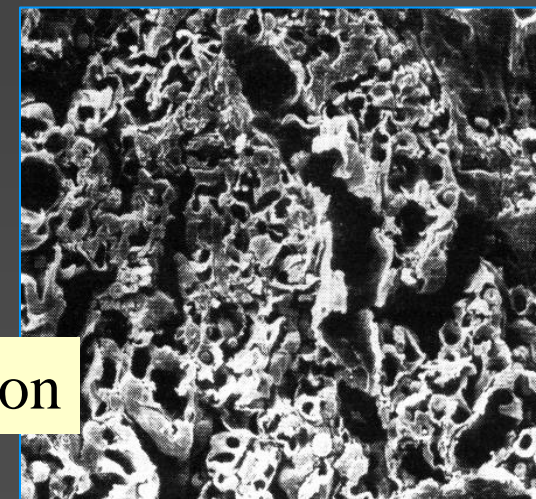
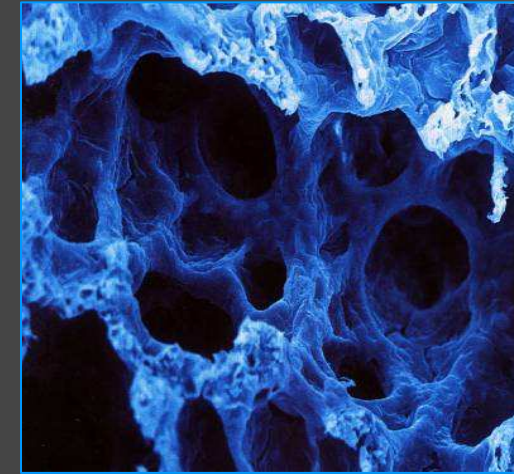
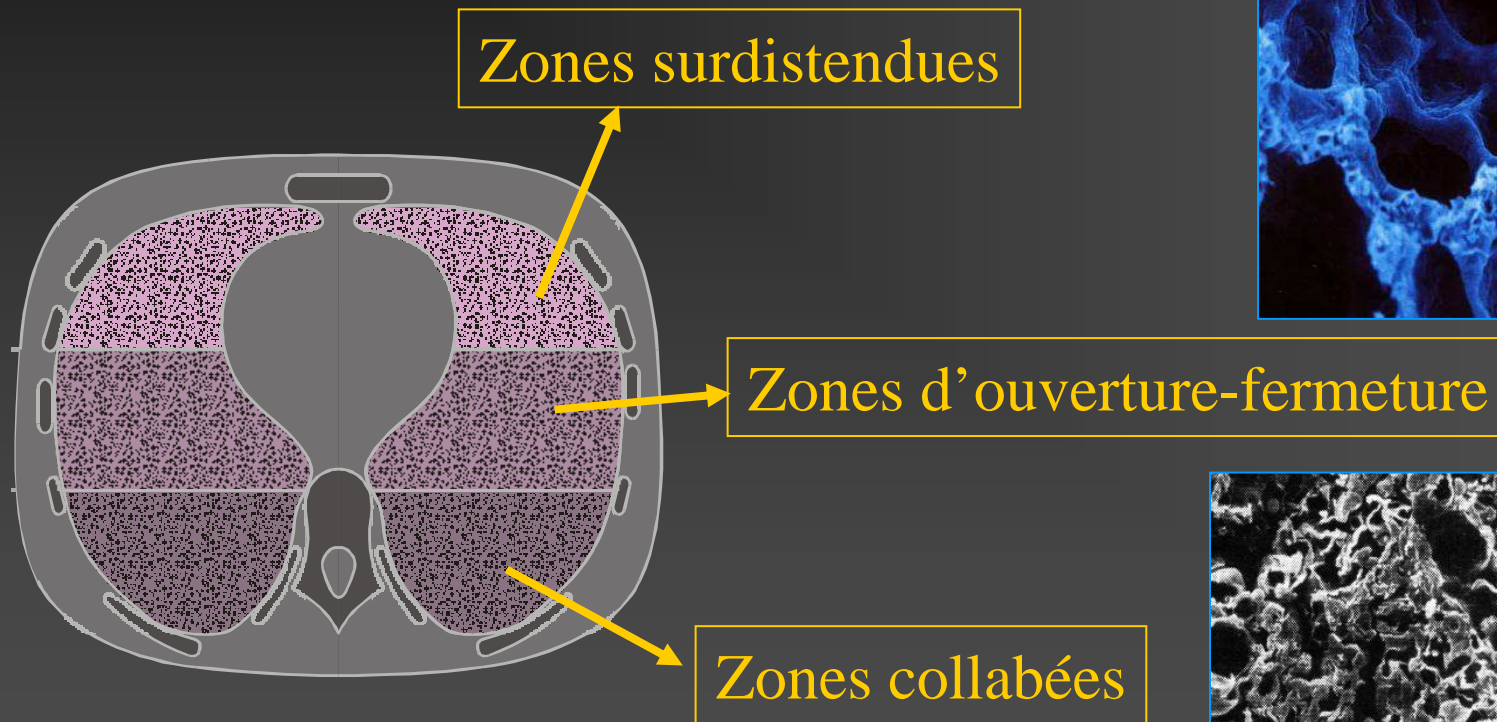
- Lésions induites

Alvéolaires

Et au delà ...



De l'atélectasie aux lésions induites



Une inhomogénéité de répartition de la ventilation

L'inhomogénéité de répartition de la ventilation peut-elle induire des lésions pulmonaires ?

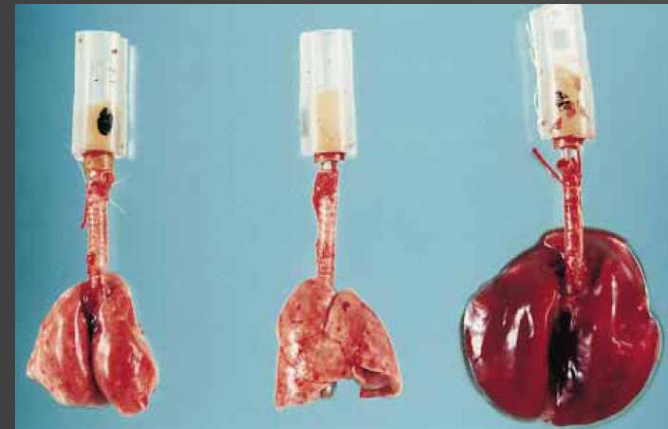
Inflammatoires

Brégeon F, Roch A et al
Respir Physiol Neurobiol 2002

10 ml/kg sans PEP sur des lapins

- Œdème pulmonaire
- Augmentation des macrophages alv.
- Augmentation de la transcription des gènes pro inflammatoires

Structurelles



Injurious Ventilatory Strategies Increase Cytokines and c-fos m-RNA Expression in an Isolated Rat Lung Model

Lorraine Tremblay,* Franco Valenza,[‡] Sergio P. Ribeiro,[‡] Jingfang Li,[‡] and Arthur S. Slutsky[‡]

**Division of General Surgery and Division of Thoracic Surgery, The Toronto Hospital, Toronto, M5G 1L7; and [‡]Division of Respiratory Medicine, Mount Sinai Hospital, Samuel Lunenfeld Research Institute, University of Toronto, Toronto, M5G 1X5 Canada*

J Clin Invest 1997; 99:944-52

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

Am J Respir Crit Care Med Vol 174. pp 279–289, 2006



Modèle animal de déplétion du surfactant

- Atélectasies = Z dépendantes
- Lésions prédominantes dans les zones non atélectasiées
- Réduction des lésions observées lors d'une stratégie de réduction du V_t + PEP

region	non-dependent (non-atelectatic)	
	airway	alveolus
end-expiration		
end-inspiration		
injury	+++	+++
region	dependent (atelectatic)	
	airway	alveolus
end-expiration		
end-inspiration		
injury	+++	+

Atelectasis Causes Vascular Leak and Lethal Right Ventricular Failure in Uninjured Rat Lungs

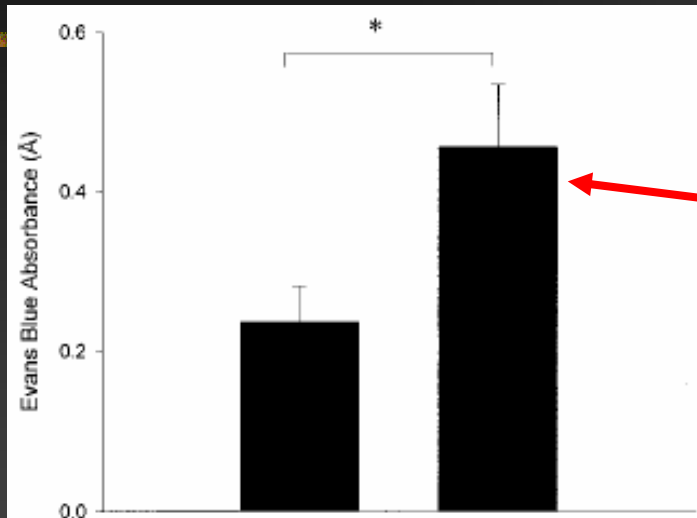
Michelle Duggan, Conán L. McCaul, Patrick J. McNamara, Doreen Engelberts, Cameron Ackerley, and Brian P. Kavanagh

Am J Respir Crit Care Med Vol 167. pp 1633–1640, 2003

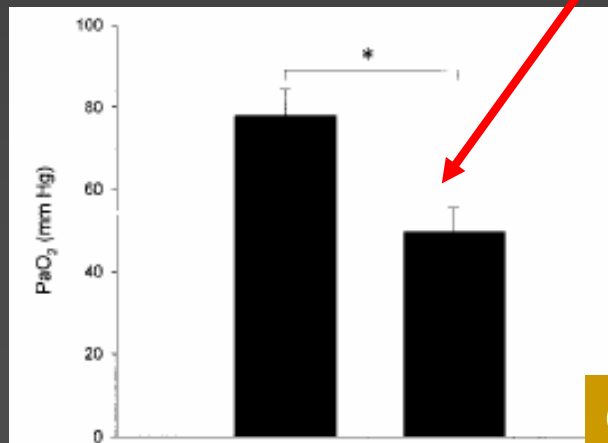


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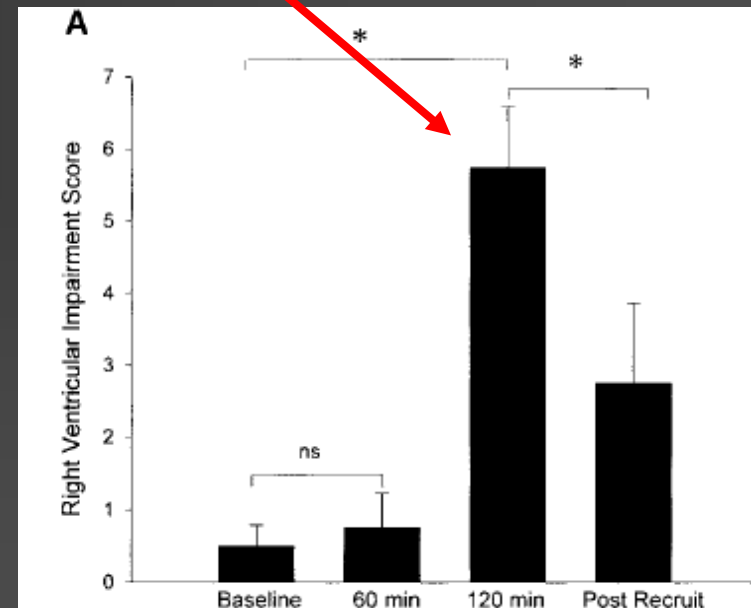


Fuite capillaire



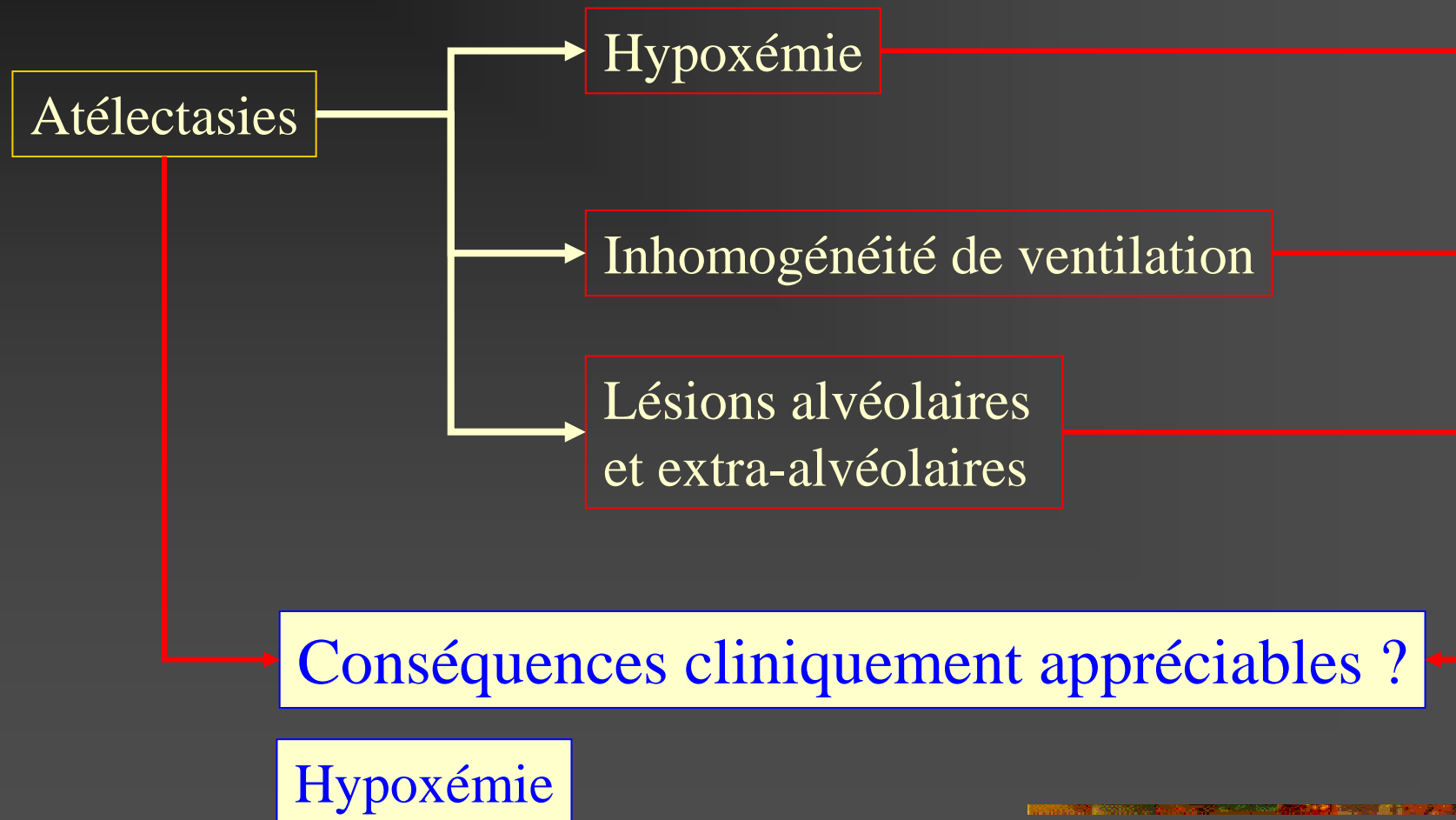
Oxygénation

Atélectasie



Dysfonction cardiaque Dte

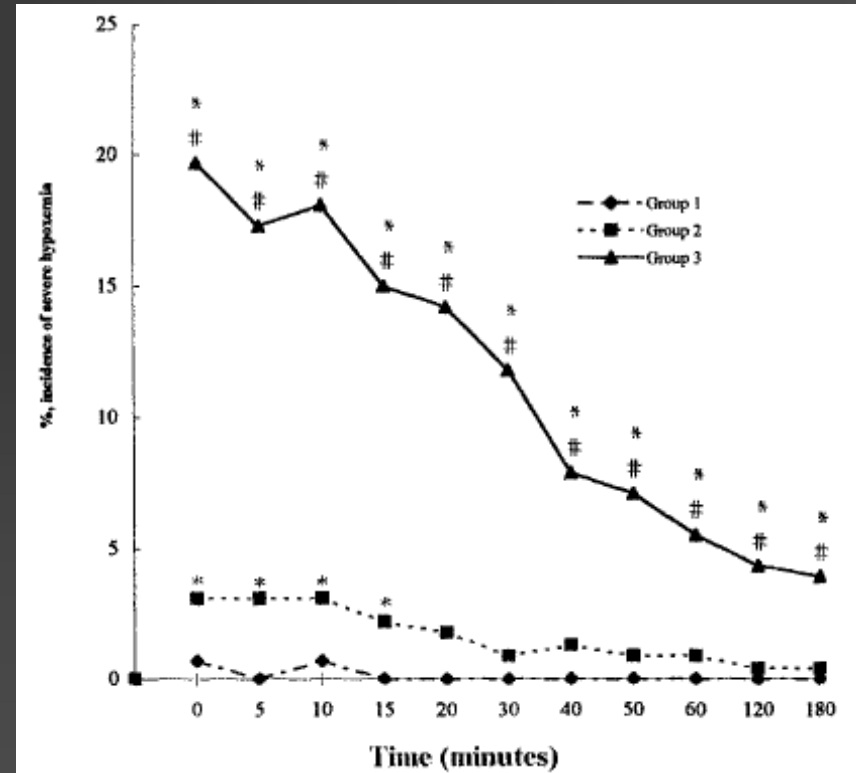
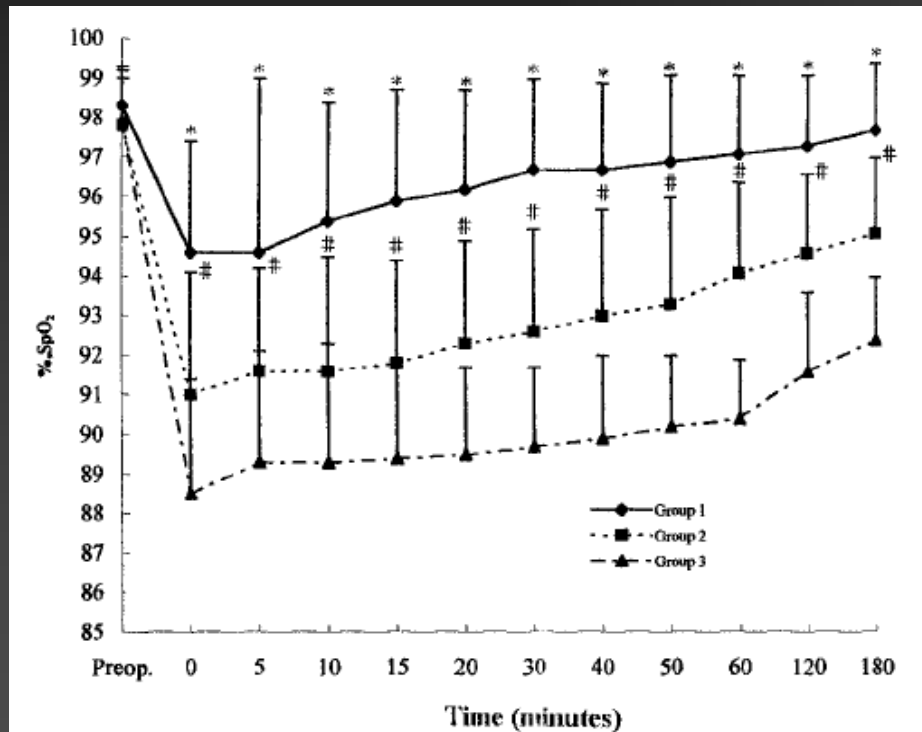
De l'atélectasie aux lésions induites



The Influence of Surgical Sites on Early Postoperative Hypoxemia in Adults Undergoing Elective Surgery

Fu S. Xue, MD*, Bai W. Li, MB†, Guo S. Zhang, MB†, Xu Liao, MD*, Yan M. Zhang, MD*, Jian H. Liu, MD*, Gang An, MD*, and Lai K. Luo, MD*

(Anesth Analg 1999;88:213-9)



Désaturation < 85 %



(CHEST 2005; 128:1564–1570)

The Effect of Thoracic Epidural Analgesia on the Occurrence of Late Postoperative Hypoxemia in Patients Undergoing Elective Coronary Bypass Surgery*

A Randomized Controlled Trial

Lars Hyldborg Lundstrøm, MD; Eigil Nygård, MD; Lamia Bada Hviid, MD; Finn Møller Pedersen, MD; Jesper Ravn, MD; Jan Aldershvile, MD, DSc;† and Jacob Rosenberg, MD, DSc

Fonction pulmonaire pré-opératoire normale dans 95% des cas

Table 4—The Incidence of Late Postoperative Hypoxemia for All Patients*

Variables	2nd PO Night (n = 50)	3rd PO Night (n = 46)
Patients with episodic hypoxemia, No.	28 (56)	41 (89)
Patients with more than 30 episodes, No.	11 (22)	14 (30)
Patients with constant hypoxemia, No.	0 (0)	3 (7)

*Values given as No. of patients (%). See Table 2 for abbreviation not used in the text.

Are Low Tidal Volumes Safe?*

Patrick C. Lee, M.D.; Cathleen M. Helmsmoortel, R.N.;
Stephen M. Cohn, M.D.; and Mitchell P. Fink, M.D., F.C.C.P.

(*Chest* 1990; 97:425-29)



103 patients chirurgicaux

- Pas de dysfonction respiratoire
- Durée d'intubation de 3 jours

	Group 1	Group 2
Total patients	56	47
Pneumonia	6	1
Tracheobronchitis	4	1
Total infections	10	2
Incidence of infections	17.9%	4.3%*

*p = 0.061, Mann-Whitney U test.

	Group 1 (12 ml/kg)	Group 2 (6 ml/kg)	Significance
Maximum peak airway pressure, cm H ₂ O			
Mean ± SD	38.8 ± 11.9	28.9 ± 8.9	<.001
Median	36.0	28.0	
Range	22.0-76.0	12.0-51.0	
Average peak airway pressure, cm H ₂ O			
Mean ± SD	35.1 ± 8.7	26.0 ± 7.3	<.001
Median	34.0	25.7	
Range	17.0-60.0	10.0-42.0	
Maximum PEEP used, cm H ₂ O			
Mean ± SD	6.8 ± 6.7	7.2 ± 4.3	.18
Median	5.0	5.0	
Range	5.0-20.0	5.0-20.0	
Average PEEP used, cm H ₂ O			
Mean ± SD	5.4 ± 2.3	6.0 ± 2.5	.20
Median	5.0	5.0	
Range	5.0-14.3	5.0-16.4	
Maximum PaO ₂ /FIO ₂			
Mean ± SD	328 ± 86	284 ± 75	.009
Median	326	255	
Range	174-530	148-460	
Average PaO ₂ /FIO ₂			
Mean ± SD	294 ± 86	260 ± 78	.031
Median	278	240	
Range	168-530	131-460	
Minimum PaO ₂ /FIO ₂			
Mean ± SD	266 ± 102	241 ± 91	.191
Median	255	233	
Range	70-530	105-460	

Characteristics and Outcomes in Adult Patients Receiving Mechanical Ventilation

A 28-Day International Study

JAMA. 2002;287:345-355

Andrés Esteban, MD, PhD
 Antonio Anzueto, MD
 Fernando Frutos, MD
 Inmaculada Alía, MD
 Laurent Brochard, MD
 Thomas E. Stewart, MD
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 Peter Nightingale, MD
 Alejandro C. Arroliga, MD
 Martin J. Tobin, MD
 for the Mechanical Ventilation
 International Study Group

Plus de 15000 patients étudiés avec plus de 33% de VM

	Factors Related to Patient Management				
Successful noninvasive ventilation	14 (10-21)	0.46 (0.32-0.66)	<.001		
Use of vasoactive drugs	48 (46-50)	2.41 (2.22-2.63)	<.001	1.77 (1.50-2.08)	<.001
Use of sedatives	33 (31-35)	1.22 (1.13-1.34)	<.001		
Use of neuromuscular blockers	50 (46-55)	1.75 (1.58-1.94)	<.001	1.39 (1.08-1.79)	<.001
Tidal volume, mL/kg					
<6	32 (28-41)	1.23 (0.91-1.63)]	.09	
6-10	30 (28-31)	1.00			
>10	33 (30-35)	1.14 (0.99-1.31)			
PEEP, cm H ₂ O					
<5	28 (26-30)	1.00]	<.001	
5-10	31 (29-33)	1.15 (1.02-1.30)			
>10	50 (44-56)	2.52 (1.96-3.24)			
Peak pressure >50 cm H ₂ O	65 (53-74)	2.15 (1.83-2.52)	<.001	2.67 (1.50-4.72)	<.001
Plateau pressure >35 cm H ₂ O	78 (69-86)	2.64 (2.36-2.95)	<.001	3.67 (2.02-6.66)	<.001
Tracheostomy	20 (17-23)	0.62 (0.52-0.74)	<.001	0.45 (0.35-0.58)	<.001

Characteristics and Outcomes in Adult Patients Receiving Mechanical Ventilation

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P _a O ₂ /F _i O ₂ ratio					
>300	24 (21-26)	1.00] <.001	1.00] <.001
200-300	25 (23-28)	1.10 (0.92-1.33)		0.91 (0.74-1.13)	
150-199	31 (28-35)	1.36 (1.16-1.61)		1.30 (1.08-1.58)	
100-149	47 (42-51)	2.29 (2.26-3.54)		2.15 (1.64-2.82)	
<100	83 (77-88)	15.73 (10.45-23.69)		8.71 (5.44-13.94)	

Mais > 50 % des patients avec une affection pulmonaire lors de l'inclusion !

Quid des patients à fonction pulmonaire saine ?

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

Crit Care Med 2004; 32:1817-1824

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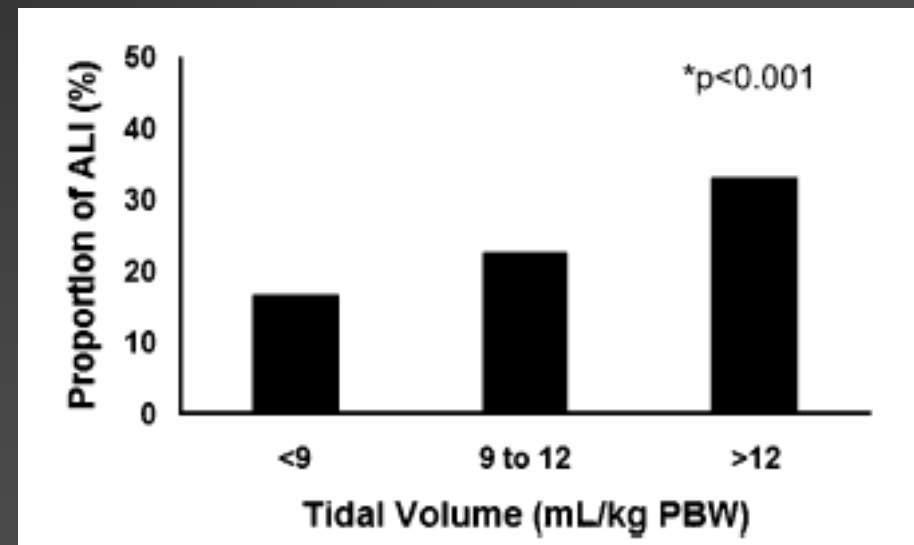
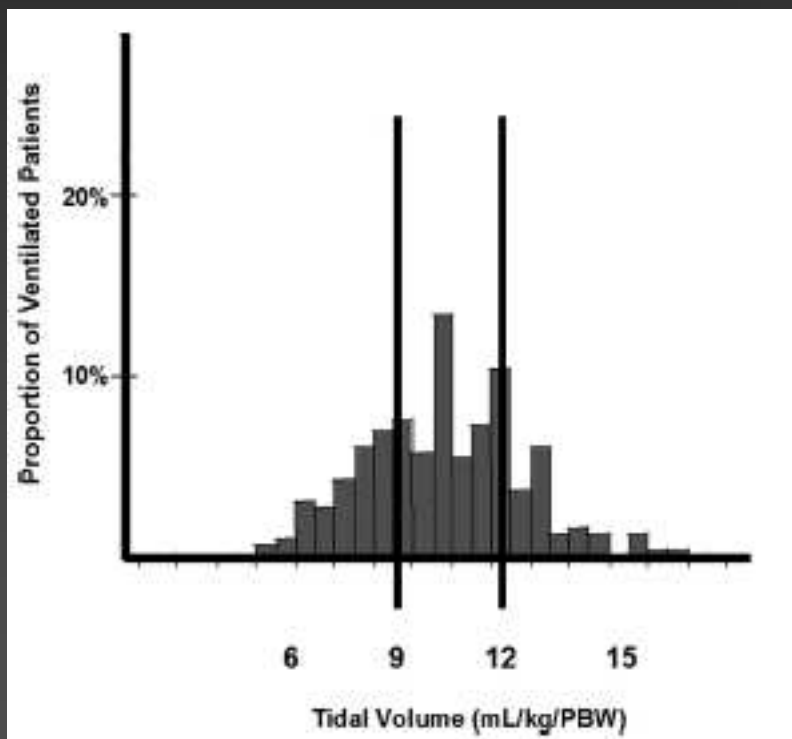
- Cohorte de 447 patients dans 4 Réa.
 - 115 éliminés car ALI lors du screening
- 332 patients étudiés
- Ventilation mécanique de plus de 48 H
- 24 % ont développé un ALI dans les 5 jours

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

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

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Crit Care Med 2004; 32:1817-1824



	Medical (n = 80)	Surgical 1 ^d (n = 84)	Surgical 2 ^b (n = 112)	Medical/Surgical ^f (n = 56)	p Value
Tidal volume, mL/kg/PEW	9.6 (8.5–11.5)	11.3 (10.1–12.4) ^d	11.0 (9.9–12.8) ^d	10.5 (8.8–11.8)	<.001
Blood product transfusion, n (%)	31 (40)	62 (80) ^d	60 (59)	39 (75) ^d	<.001
Acidosis, pH <7.35, n (%)	29 (37)	32 (38)	48 (43)	18 (32)	.533
Restrictive lung disease, n (%)	8 (11)	4 (5)	3 (3)	1 (2)	.052
ALI, n (%)	19 (25)	27 (33)	20 (18)	14 (25)	.142
Predicted hospital mortality	0.42 (0.2–0.7)	0.13 (0.05–0.3) ^{d,e}	0.15 (0.06–0.4) ^{d,e}	0.81 (0.4–0.9) ^d	<.001
Observed hospital mortality, n (%)	29 (38)	16 (19) ^e	16 (14) ^{d,e}	24 (44)	<.001

PEW, predicted body weight.

^aPredominantly vascular and thoracic surgery patients; ^bpredominantly general surgery and trauma patients; ^cmixed medical/surgical unit patients with hematologic malignancies, orthopedic surgery, bone marrow, and solid organ transplant; ^dp < .01 vs. medical ICU; ^ep < .01 vs. medical/surgical ICU.

VALI (haut niveau de Vt)



ALI

High tidal volume is associated with the development of acute lung injury after severe brain injury: An international observational study*

Luciana Mascia, MD, PhD; Elisabeth Zavala, MD; Karen Bosma, MD; Daniela Pasero, MD; Daniela Decaroli, MD; Peter Andrews, MD; Donatella Isnardi, MD; Alessandra Davi, MD; Maria Jose Arguis, MD; Maurizio Berardino, MD; Alessandro Ducati, MD; on behalf of the Brain IT group

Crit Care Med 2007; 35:1815-1820

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

- 82 patients traumatisés crâniens au sein de 4 unités européennes sans ALI / SDRA
- 22 % d'ALI / SDRA durant le séjour
- Étude des facteurs prédictifs d'ALI / SDRA

High tidal volume is associated with the development of acute lung injury after severe brain injury: An international observational study*

Luciana Mascia, MD, PhD; Elisabeth Zavala, MD; Karen Bosma, MD; Daniela Pasero, MD; Daniela Decaroli, MD; Peter Andrews, MD; Donatella Isnardi, MD; Alessandra Davi, MD; Maria Jose Arguis, MD; Maurizio Berardino, MD; Alessandro Ducati, MD; on behalf of the Brain IT group

Crit Care Med 2007; 35:1815-1820

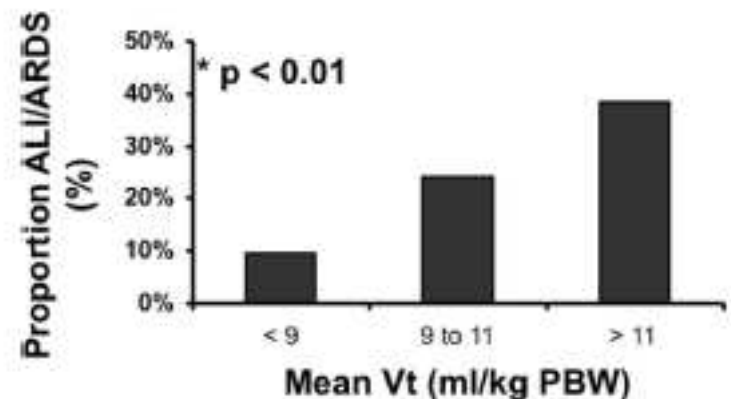


Variable	p Value	Odds Ratio	95% CI
Mean V _T /PBW	.008	5.45	1.54-19.24
RR	.013	1.80	1.13-2.86
Pao ₂ /Fio ₂	.004	0.98	0.98-0.99

CI, confidence interval; V_T/PBW, tidal volume per ideal body weight; RR, respiratory rate. The OR for V_T/PBW is per unit increase.

- De hauts niveaux de V_t
- Une fréquence respiratoire élevée

FDR de lésions induites



Multiple System Organ Failure

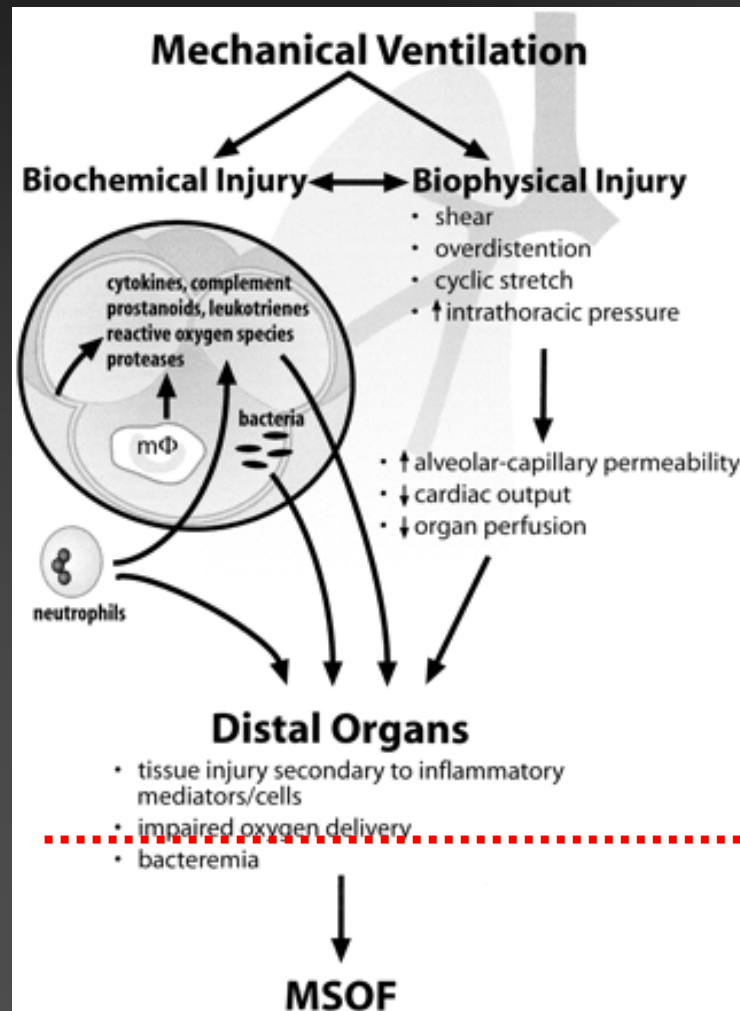
Is Mechanical Ventilation a Contributing Factor?

ARTHUR S. SLUTSKY and LORRAINE N. TREMBLAY



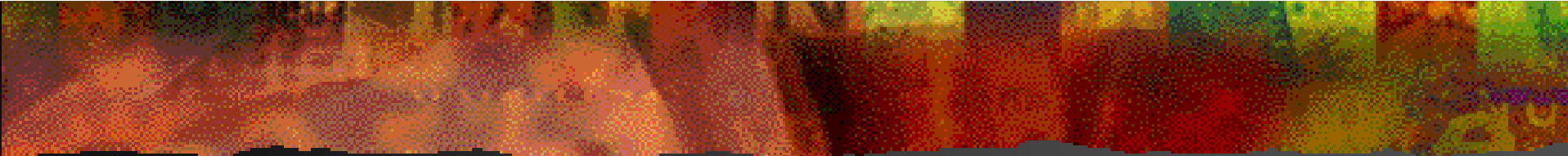
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ALI /SDRA

Poumons
Sains



Arguments en faveur de l'amélioration de cette dysfonction par une stratégie de ventilation protectrice

- Les moyens
- Peropératoire
- Postopératoire ou sans chirurgie

Les moyens

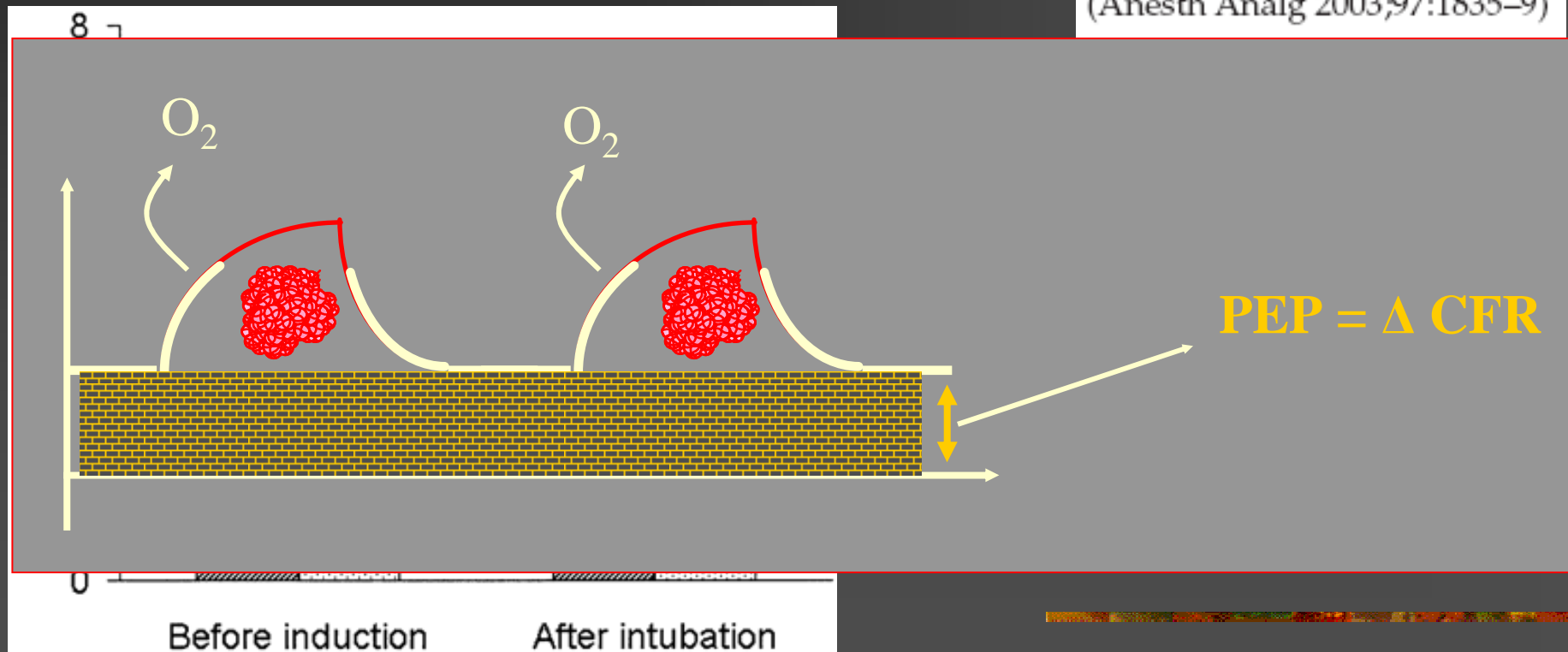
- Objectifs
 - Limiter le dérecrutement alvéolaire
 - Limiter l'apparition des lésions associées à la ventilation mécanique (VALI)
 - Atélectasies, réaction inflammatoire
 - Pneumopathies ALI et SDRA
 - Mesures de recrutement alvéolaire
 - Ventilation protectrice
 - Réduction du volume courant
 - Pression expiratoire positive
-

Mesures de recrutement alvéolaire

Prevention of Atelectasis Formation During Induction of General Anesthesia

Marco Rusca, MD*, Stefania Proietti, MD†, Pierre Schnyder, MD†, Philippe Frascarolo, PhD*, Göran Hedenstierna, MD, PhD‡, Donat R. Spahn, MD*, and Lennart Magnusson, MD, PhD*

(Anesth Analg 2003;97:1835-9)

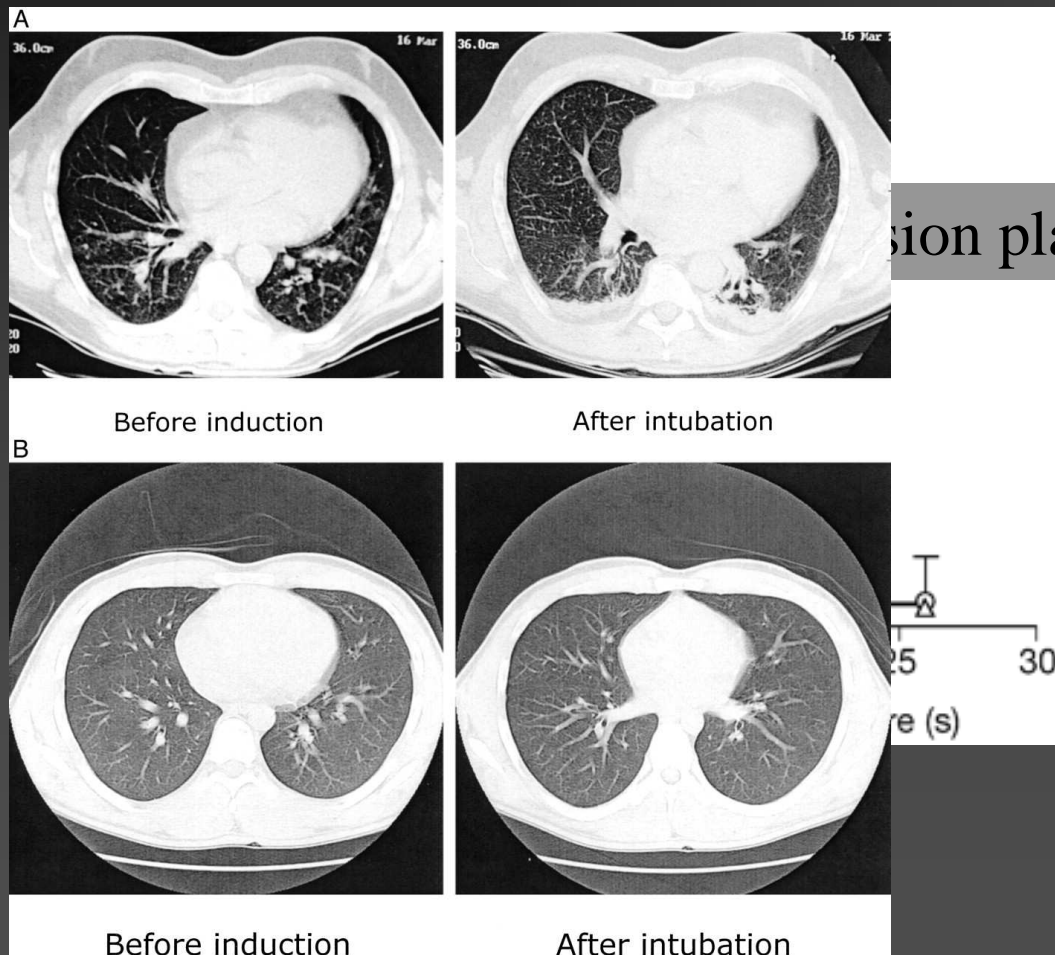


Mesures de recrutement alvéolaire

Rothen HU. et al
BJA 1999; 82: 551-6

Position plateau de 40 cm H₂O – 15 s

PaO₂ avant-après
17 ± 4 kpa vs 22 ± 6 kpa

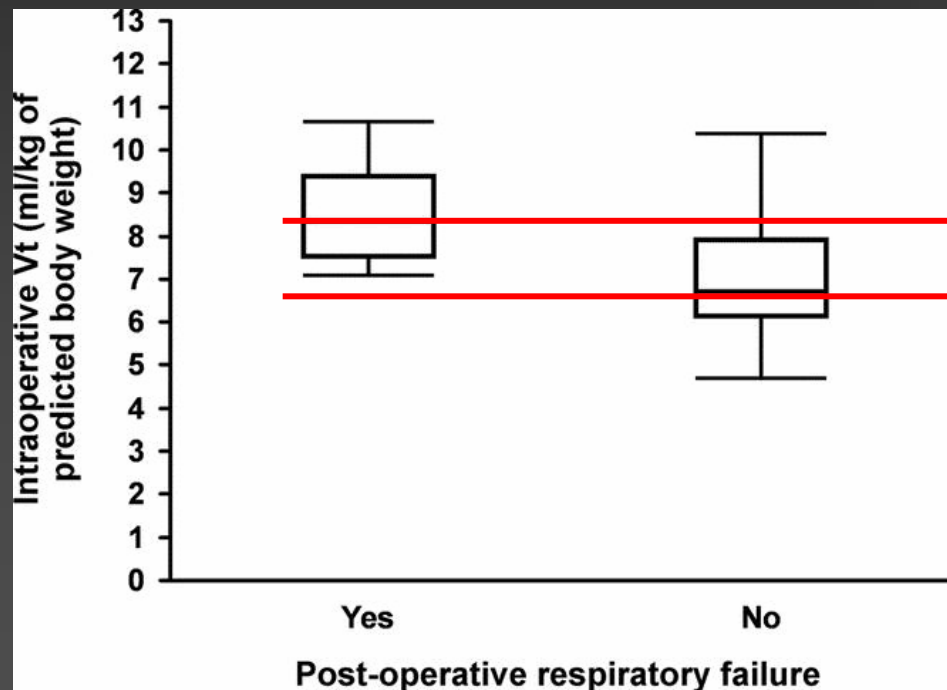


Ventilation protectrice

- Résultats contradictoires en anesthésie
 - Ventilation bipulmonaire : réduction Vt et PEP
 - Pas de réduction significative des VALI
 - Wrigge H et al Intensive Care Med 2005
 - Wrigge H et al Anesth Analg 2004;98:775-781
 - Réduction du shunt, amélioration de la PaO₂ et de la mécanique pulmonaire
 - Koner O et al Intensive Care Med 2004;30:620-626
 - Chaney M et al J Cardiothorac Vasc Anesth 2000;14:514-518
 - Réduction des VALI
 - Choi G et al Anesthesiology 2006;105:689-695

Ventilation protectrice

- Résultats contradictoires en anesthésie
 - Ventilation monopulmonaire



Étude sur les détresses
Respiratoires postopératoires
(80 % de la mortalité)
Le volume courant
Facteur indépendant
8,3 vs 6,7 ml / kg

Fernandez-Perez ER et al
Anesthesiology 2006; 105:14-8

Ventilation protectrice

- Résultats contradictoires en anesthésie
 - Ventilation monopulmonaire
 - Réduction du V_t lors de la période de VMP
 - Adjonction d'une PEP 5 cmH₂O
 - Amélioration de l'oxygénation
 - Réduction de la réaction inflammatoire
 - Réduction de l'EPEV

Michelet P, Roch A et al
Anesthesiology 2006; 105:911-9

En réanimation

Are Low Tidal Volumes Safe?*

Patrick C. Lee, M.D.; Cathleen M. Helmsmoortel, R.N.;
Stephen M. Cohn, M.D.; and Mitchell P. Fink, M.D., F.C.C.P.

(*Chest* 1990; 97:425-29)

	Group 1	Group 2
Total patients	56	47
Pneumonia	6	1
Tracheobronchitis	4	1
Total infections	10	2
Incidence of infections	17.9%	4.3%*

*p = 0.061, Mann-Whitney U test.

Oui pour la réduction du Vt

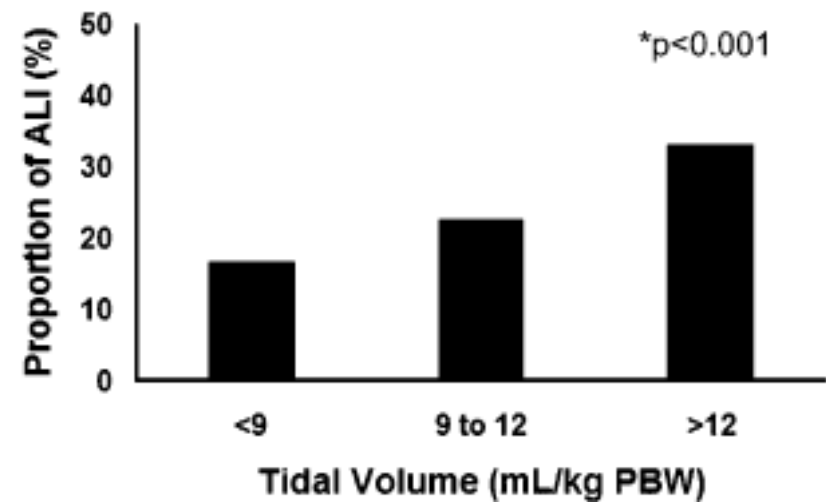
	Group 1 (12 ml/kg)	Group 2 (6 ml/kg)	Significance
Maximum peak airway pressure, cm H ₂ O			
Mean ± SD	38.8 ± 11.9	28.9 ± 8.9	<.001
Median	36.0	28.0	
Range	22.0-76.0	12.0-51.0	
Average peak airway pressure, cm H ₂ O			
Mean ± SD	35.1 ± 8.7	26.0 ± 7.3	<.001
Median	34.0	25.7	
Range	17.0-60.0	10.0-42.0	
Maximum PEEP used, cm H ₂ O			
Mean ± SD	6.8 ± 6.7	7.2 ± 4.3	.18
Median	5.0	5.0	
Range	5.0-20.0	5.0-20.0	
Average PEEP used, cm H ₂ O			
Mean ± SD	5.4 ± 2.3	6.0 ± 2.5	.20
Median	5.0	5.0	
Range	5.0-14.3	5.0-16.4	
Maximum PaO ₂ /Fio ₂			
Mean ± SD	328 ± 86	284 ± 75	.009
Median	326	255	
Range	174-530	148-460	
Average PaO ₂ /Fio ₂			
Mean ± SD	294 ± 86	260 ± 78	.031
Median	278	240	
Range	168-530	131-460	
Minimum PaO ₂ /Fio ₂			
Mean ± SD	266 ± 102	241 ± 91	.191
Median	255	233	
Range	70-530	105-460	

En réanimation

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

Crit Care Med 2004; 32:1817-1824

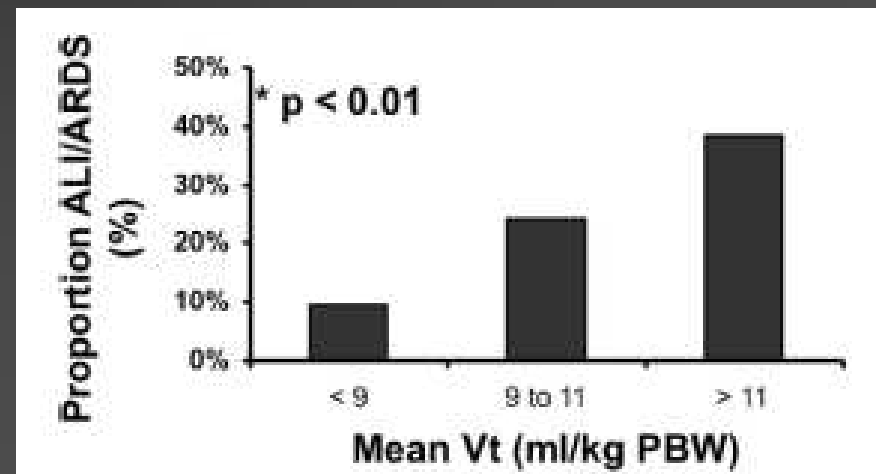


En réanimation

High tidal volume is associated with the development of acute lung injury after severe brain injury: An international observational study*

Luciana Mascia, MD, PhD; Elisabeth Zavala, MD; Karen Bosma, MD; Daniela Pasero, MD; Daniela Decaroli, MD; Peter Andrews, MD; Donatella Isnardi, MD; Alessandra Davi, MD; Maria Jose Arguis, MD; Maurizio Berardino, MD; Alessandro Ducati, MD; on behalf of the Brain IT group

Crit Care Med 2007; 35:1815-1820





En conclusion

- Il existe des lésions induites par la ventilation mécanique sur poumon sains
- La prévention par une stratégie de préservation du recrutement alvéolaire et d'adaptation du V_t semble intéressante et « safe »

Variation de Volume

