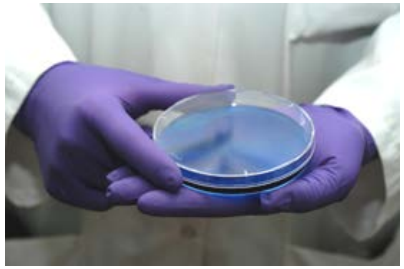


Ventilation au bloc : Les incontounables

Bourgain JL
Service d'anesthésie
Département du bloc opératoire

Institut de cancérologie
GUSTAVE ROUSSY
VILLEJUIF - www.igr.fr

Introduction

- **L'actualité :**
  - **La baisse des volumes pulmonaires et l'augmentation des pressions d'insufflation doivent être combattues.**
  - **La ventilation mécanique doit entrer dans une démarche de sécurité**
    - Assurer un niveau de connaissances au niveau de toute l'équipe
    - Maintenir l'ensemble des fonctions du respirateur et du moniteur à l'identique de la mise en circulation

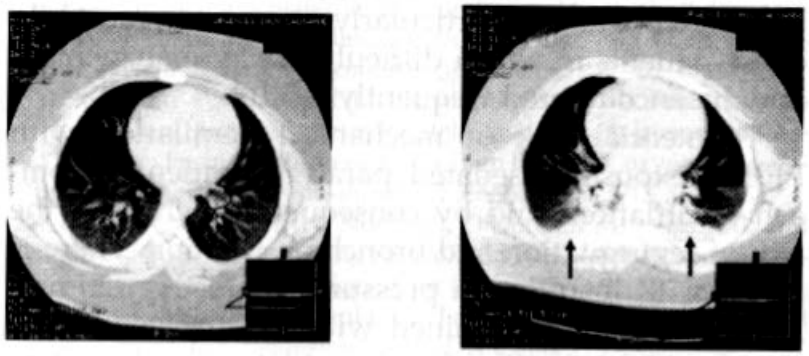
Anesthésie générale
➔ Baisse du tonus musculaire

↓

Le poids de la masse abdominale fait remonter le diaphragme dans la cage thoracique

↓

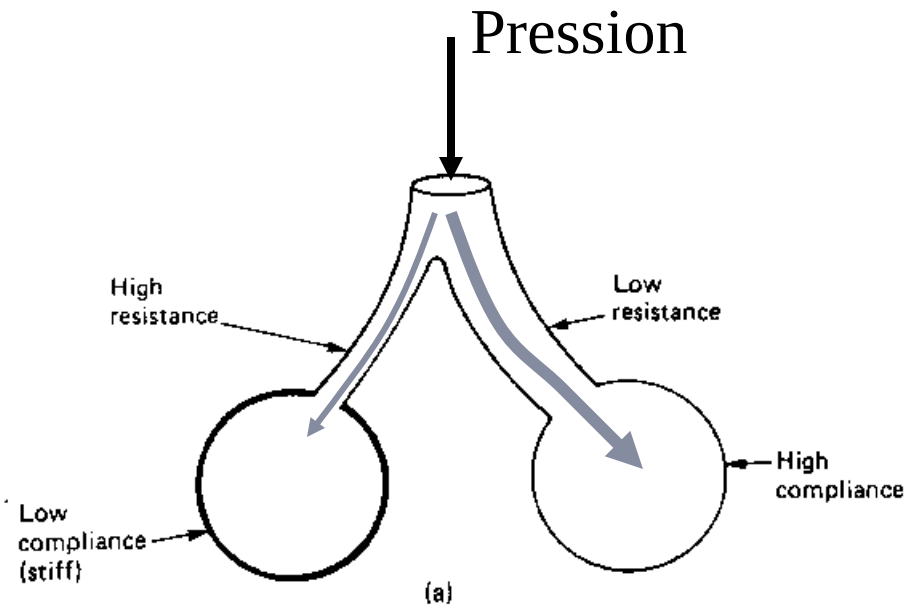
Baisse de la CRF Atélectasies



Before induction After intubation

- Limiter les FiO_2 élevées
- Recrutement alvéolaire + PEP
- Maintien ventilation spontanée
- Position assise

Les dangers de la ventilation en pression positive d'un poumon inhomogène



↗ FiO_2 ➔ atélectasies ⟷ ↗ Paw ➔ surdistension

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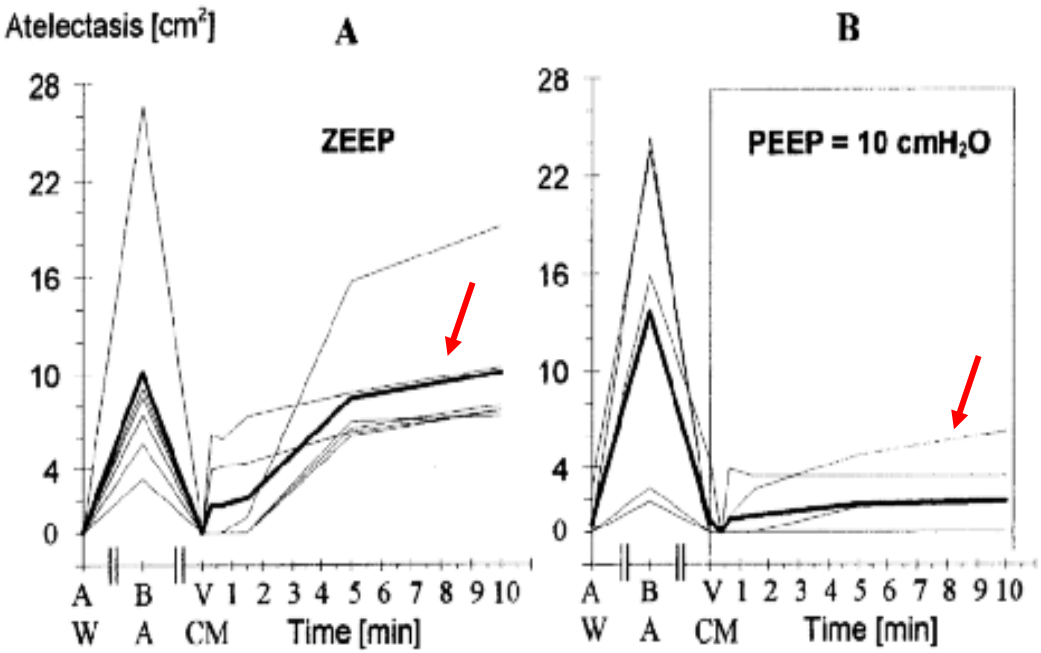
Positive end-expiratory pressure prevents atelectasis during general anaesthesia even in the presence of a high inspired oxygen concentration

Neumann, Rothen, Berglund, Valtysson, Magnusson, Hedenstierna
Acta Anaesthesiol Scand 1999; 43: 295–301



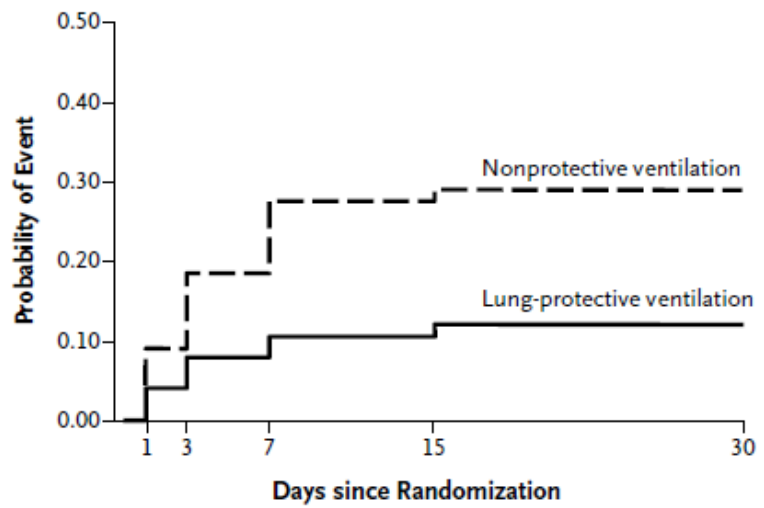
L'application d'une PEEP prévient la survenue d'atélectasie durant l'anesthésie générale

La ventilation protectrice

- Tidal volume of 6 to 8 ml per kilogram of predicted body weight*,
- PEEP of 6 to 8 cm of water,
- Recruitment maneuvers repeated every 30 minutes after tracheal intubation.
  - Applying a continuous positive airway pressure of 30 cm of water for 30 seconds.
- Plateau pressure of no more than 30 cm of water.

* IBW :
50 + 0.91 (height [cm] −152.4) for men
45.5 + 0.91 (height [cm] −152.4) for women

A Trial of Intraoperative Low-Tidal-Volume Ventilation in Abdominal Surgery
Futier E
N Engl J Med 2013 369;5:428-37



No. at Risk						
Nonprotective ventilation	200	182	163	145	142	142
Lung-protective ventilation	200	192	184	179	176	175

Figure 2. Kaplan–Meier Estimates of the Probability of the Composite Primary Outcome.

Data for the Kaplan–Meier estimates of the probability of the composite primary outcome of major pulmonary or extrapulmonary complications were censored at 30 days after surgery. Major pulmonary complications included pneumonia or the need for invasive or noninvasive ventilation for acute respiratory failure. Major extrapulmonary complications were sepsis, severe sepsis, septic shock, and death. P<0.001 by the log-rank test for the between-group difference in the probability of the primary outcome.

Curr Opin Anesthesiol 2013, 26:126–133

CURRENT OPINION

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

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

SNT Hemmes Curr Opin Anesthesiol 2013, 26:126–133

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

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

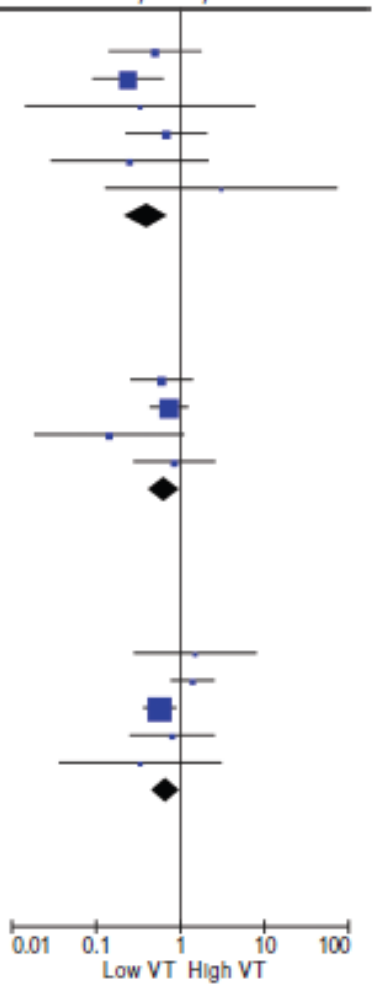
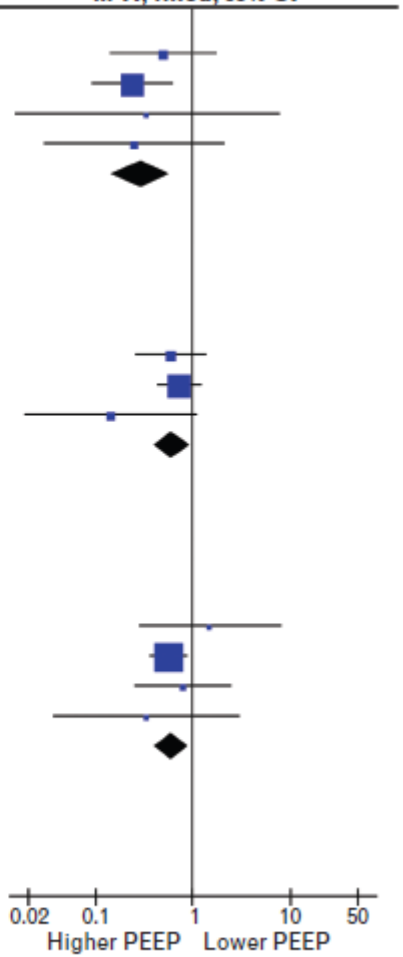


FIGURE 2. Effect of intraoperative ventilation with lower tidal volumes.

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



Test for subgroup differences: $Chi^2 = 3.55$, df = 2 ($P = 0.17$), $I^2 = 43.7\%$

FIGURE 3. Effect of intraoperative ventilation with higher levels of positive end expiratory pressure (PEEP).

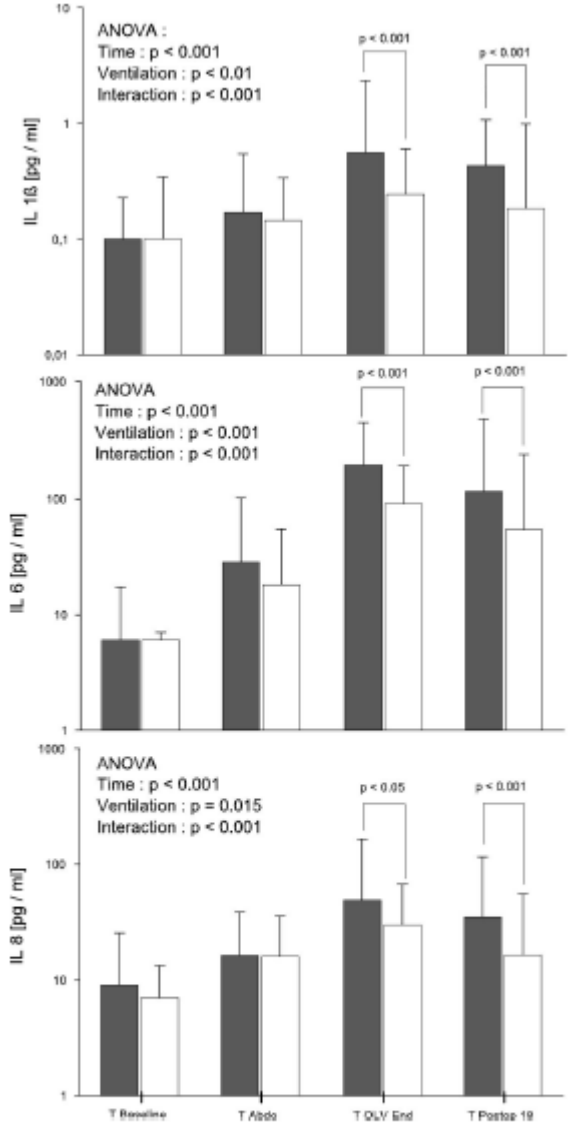


Fig. 2. Time course of blood cytokine levels in conventional ventilation group (*gray bars*) and protective ventilation group (*white bars*) at baseline ($T_{Baseline}$), at the end of abdominal time (T_{Abdo}), at the end of one-lung ventilation time ($T_{OLV\ End}$), and 18 h postoperatively ($T_{Postop\ 18}$). Data are expressed as median and 90th percentile. ANOVA = analysis of variance; IL = interleukin.

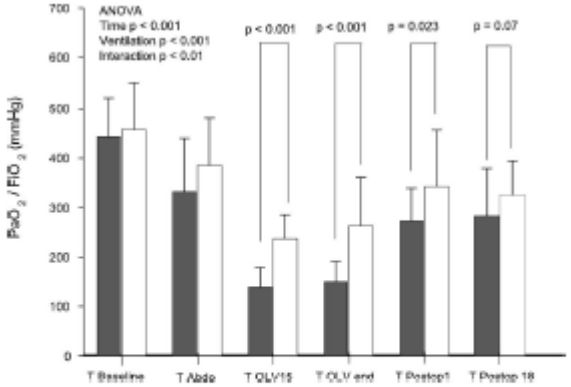


Fig. 3. Time course of arterial oxygen partial pressure/inspired oxygen fraction ratio (Pa_{O_2}/Fi_{O_2}) in conventional ventilation group (*gray bars*) and protective ventilation group (*white bars*) at baseline ($T_{Baseline}$), at the end of abdominal time (T_{Abdo}), after 15 min of one-lung ventilation ($T_{OLV\ 15}$), at the end of one-lung ventilation time ($T_{OLV\ End}$), and 1 h postoperatively ($T_{Postop\ 1}$). Data are expressed as mean and SD. ANOVA = analysis of variance. $T_{Postop\ 18}$ = 18 h postoperatively.

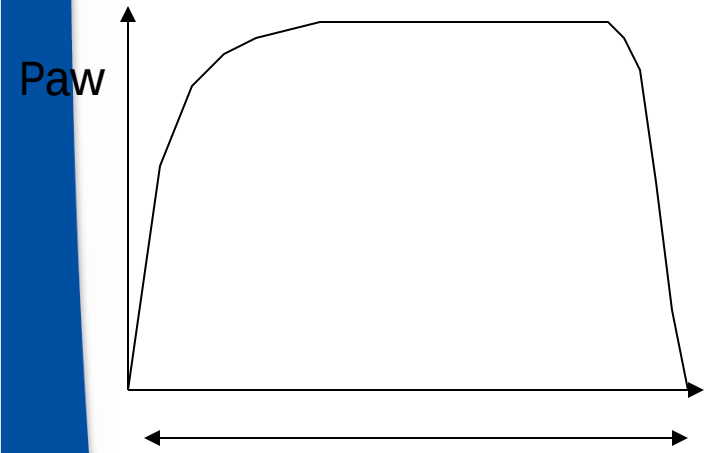
Protective Ventilation Influences Systemic Inflammation after Esophagectomy

Michelet P

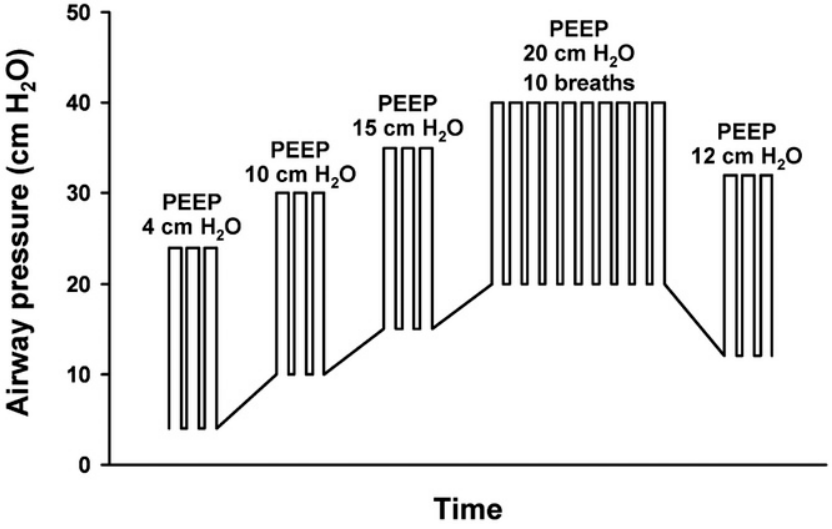
Anesthesiology 2006; 105:911–9

⇢ Manœuvres de recrutement (Attention à l'impact hémodynamique)

- Circuit en mode manuel
- Valve APL 30 à 40 cm H_2O
- Pression sur le ballon
- Surveillance sur le moniteur

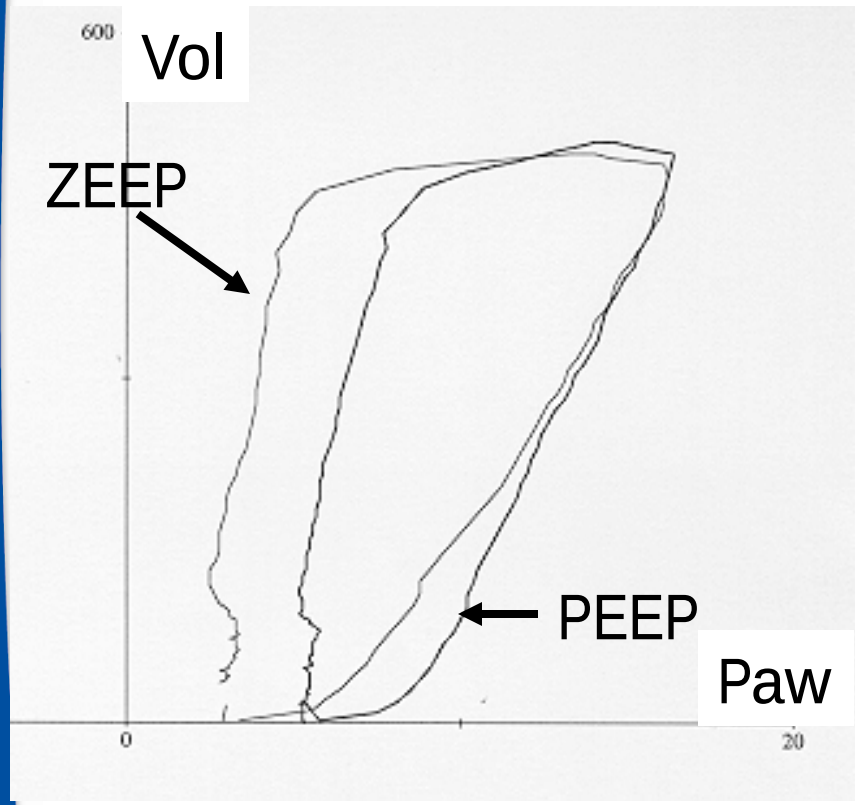


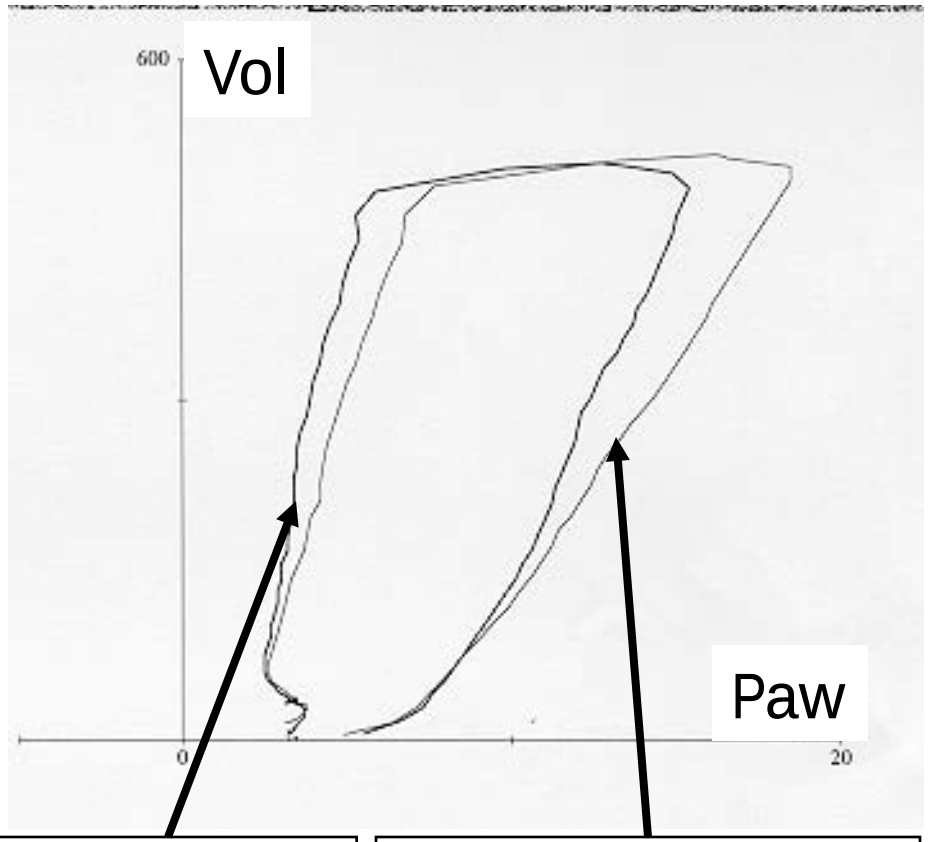
15 à 20 secondes



Whalen: Anesth Analg, Volume 102(1). 2006.298-305

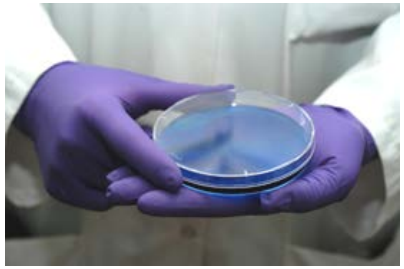
- **L'effet de la PEP ou des manœuvres de recrutement se juge sur la compliance pulmonaire (ou sur la pression d'insufflation si pas de boucle)**





Après ré-expansion

Avant ré-expansion



⇢ **Cas particuliers :**

Le décubitus ventral : PEEP inefficace

Le BPCO : enjeu de l'hyperinflation dynamique

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⇢ Quelle FiO_2 : encore la polémique?

- **L'utilisation d'une FiO_2 élevée favorise l'apparition des atélectasies qui sont réversibles par une manœuvre de recrutement**
- **L'intérêt d'une FiO_2 élevée à l'induction et au réveil est assez évident**
- **La réduction de l'incidence des infections postopératoires par la ventilation en FiO_2 0,8 reste très discutée.**

Does High Oxygen Concentration Reduce Postoperative Infection? G Hedenstierna Anesthesiology, 2014 120 (4) 1050

⇢ Mode volume contrôlé ou pression contrôlée ?

- **Résultats divergents dans la littérature mais la majorité des articles ne montrent pas ou peu de bénéfices cliniquement significatifs.**
- **Exception faite pour la ventilation au masque : facial ou laryngé :**
  - Gestion de la ventilation à fuites
  - Réduction du risque d'insufflation œsophagienne

Facemask Pressure-Controlled Ventilation in Children: What Is the Pressure Limit?

Sylvaine Lagarde, MD,* François Semjen, MD,* Karine Nouette-Gaulain, MD, PhD,*†
Françoise Masson, MD,‡ Maryline Bordes, MD,* Yves Meymat, MD,* and Anne-Marie Cros, MD*

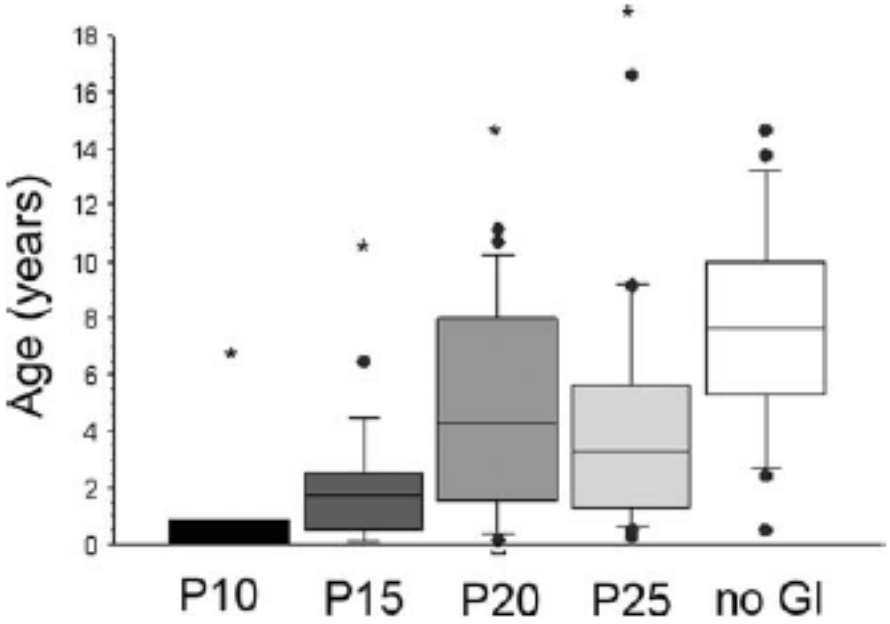


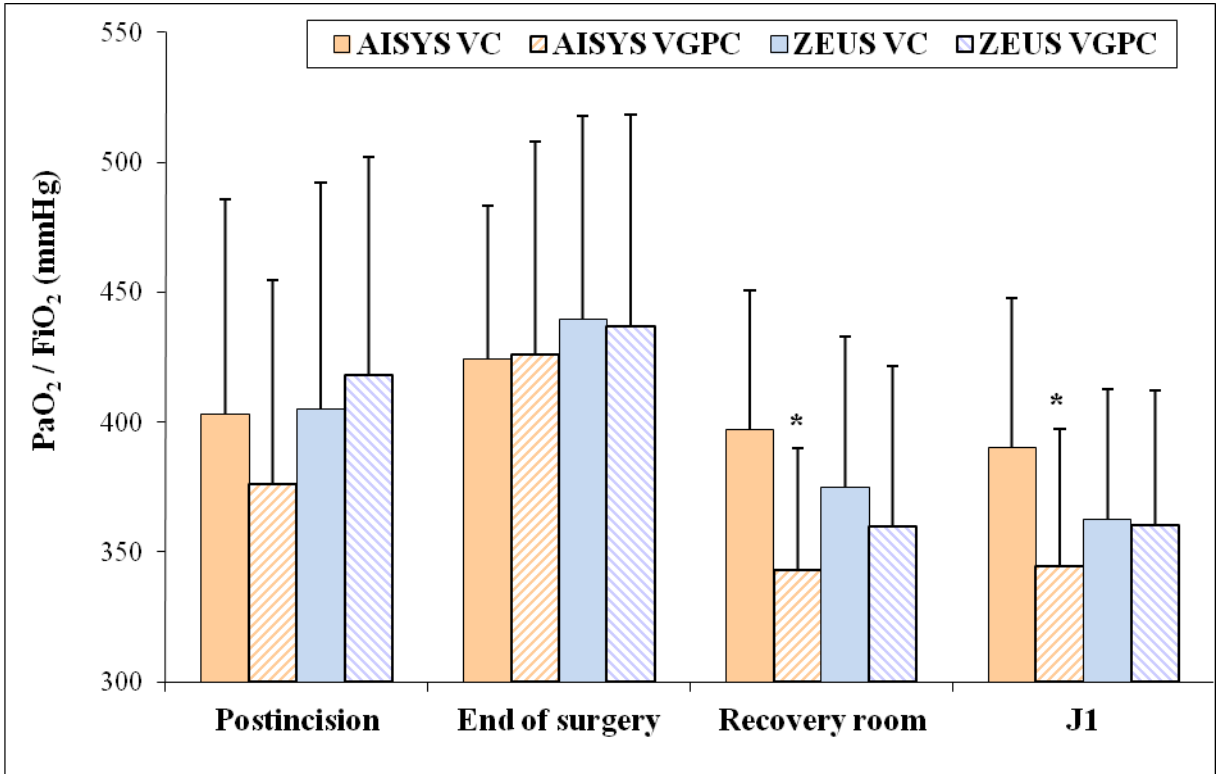
Figure 2. Age of children with or without gastric insufflation (GI) associated with different inspiratory pressure levels. Data are expressed as median (IQR [interquartile range]). White box represents group without GI (no GI). Dark box represents group in which GI occurred at 10 cm H_2O inspiratory pressure (P10). Gray boxes represent group with GI occurring at 15, 20, or 25 cm H_2O inspiratory pressure, respectively, designated as P15, P20, and P25. *$P < 0.05$ versus no GI group was considered significant.

Anesth Analg. 2010 Jun 1;110(6):1676-9.

Mode pression à volume garanti ou auto-flow

- **Réglage sur le même mode que la ventilation en volume contrôlé mais les cycles sont à débit décélérant**

Does intraoperative ventilation mode influence respiratory function in long lasting surgery? B Lortat Jacob



⇢ L'aide inspiratoire

- **Améliore la qualité de la pré-oxygénation**
- **Améliore la qualité de l'induction en pédiatrie**
- **Peut avoir une place pendant la chirurgie en permettant un plan d'anesthésie plutôt léger : s'intègre dans cette stratégie**
  - **Contrôle de l'analgésie**
  - **Contrôle de la profondeur d'anesthésie**
- **Aide dans certains cas à sevrer le patient avant extubation au bloc (non démontré) ?**
  - **S'intègre dans une stratégie d'extubation**
  - **Requiert une expertise et une surveillance étroite.**

Les pratiques suivent-elles les recommandations des experts ?

A multicentre observational study of intra-operative ventilatory management during general anaesthesia: tidal volumes and relation to body weight

Jaber S

Anaesthesia 2012, 67, 999–1008

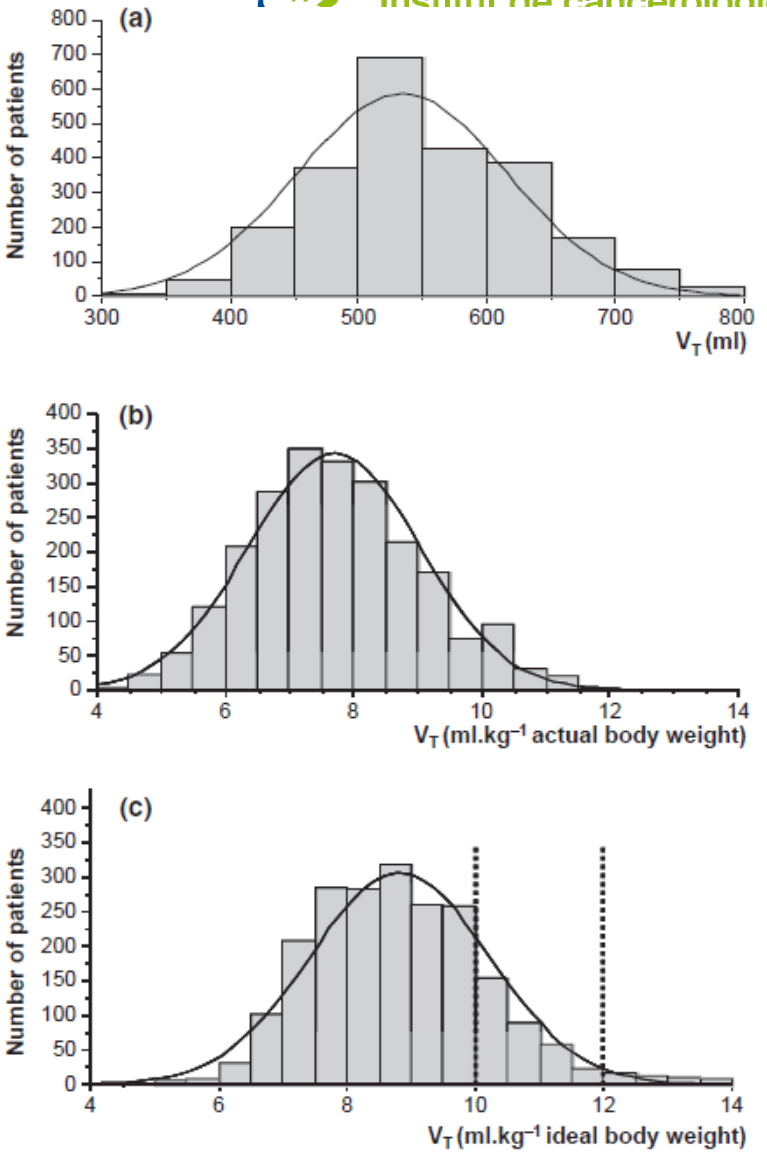


Figure 3 Distribution of tidal volume (V_T) in (a) ml, (b) ml.kg^{-1} of actual weight and (c) ml.kg^{-1} of ideal body weight. Dotted lines represent thresholds of 10 and 12 ml.kg^{-1} of ideal body weight (n = 2161).

Pire ! La morbidité par défaut de la machine d'anesthésie existe encore …

Patient Injuries from Anesthesia Gas Delivery Equipment

A Closed Claims Update

Anesthesiology, V 119 • No 4 October 2013 788 - 95

Sonya P. Mehta, M.D., M.H.S.,* James B. Eisenkraft, M.D.,† Karen L. Posner, Ph.D.,‡
Karen B. Domino, M.D., M.P.H.§

Closed Claims Project database of 9,806 total claims. Inclusion criteria were general anesthesia for surgical or obstetric anesthesia care (n = 6,022).

What This Article Tells Us That Is New
- The number of claims related to gas delivery, their severity, and their fraction of the total decreased markedly
- Provider error continues to contribute, as does failure to complete a full machine check

Les mésusages
- Enquête matériovigilance
- Enquête de pratiques

Constat

La difficulté rencontrée par les industriels lors des formations qu'ils effectuent

Une alliance pour améliorer la sécurité d'utilisation des dispositifs médicaux

Synergie de moyens

Convergence sécurité

Formation des utilisateurs suivie par une évaluation

Référents matériels dans les services cliniques

Rôle pédagogique

Gestion du parc (Biomed + fabricants)

Les actions

- **Formation ventilation mécanique au bloc et en réanimation**
  - Socle de connaissance + e-learning sur le site de la SFAR
- **Formation des référents matériel**
  - Trois formations par an

Conclusions

- **Le bénéfice de la ventilation protectrice en anesthésie a été démontré:**
  - **Il vise à limiter la pression alvéolaire et à prévenir les atélectasies**
  - **Les réglages dépendent des situations et des patients**
- **La formation des utilisateurs est indispensable**
  - **Maitrise des concepts**
  - **Maintien des performances des machines**

snitem
créer les instruments et les services du progrès médical
Le Syndicat National de l'Industrie des technologies Médicales

SFAR
Société Française d'Anesthésie et de Réanimation
La Société Française d'Anesthésie et de Réanimation

sfmu

L'Association Française des Ingénieurs Biomédicaux

Une démarche commune et constructive entre sociétés savantes et syndicat de fabricants

Sociétés Savantes

Parce que la sécurité patient passe par une formation organisée

Tronc commun de connaissance

Pré-requis médicaux techniques

Rôle du Référent

Utilisation des appareils

Support de formation dédié

Fabricants

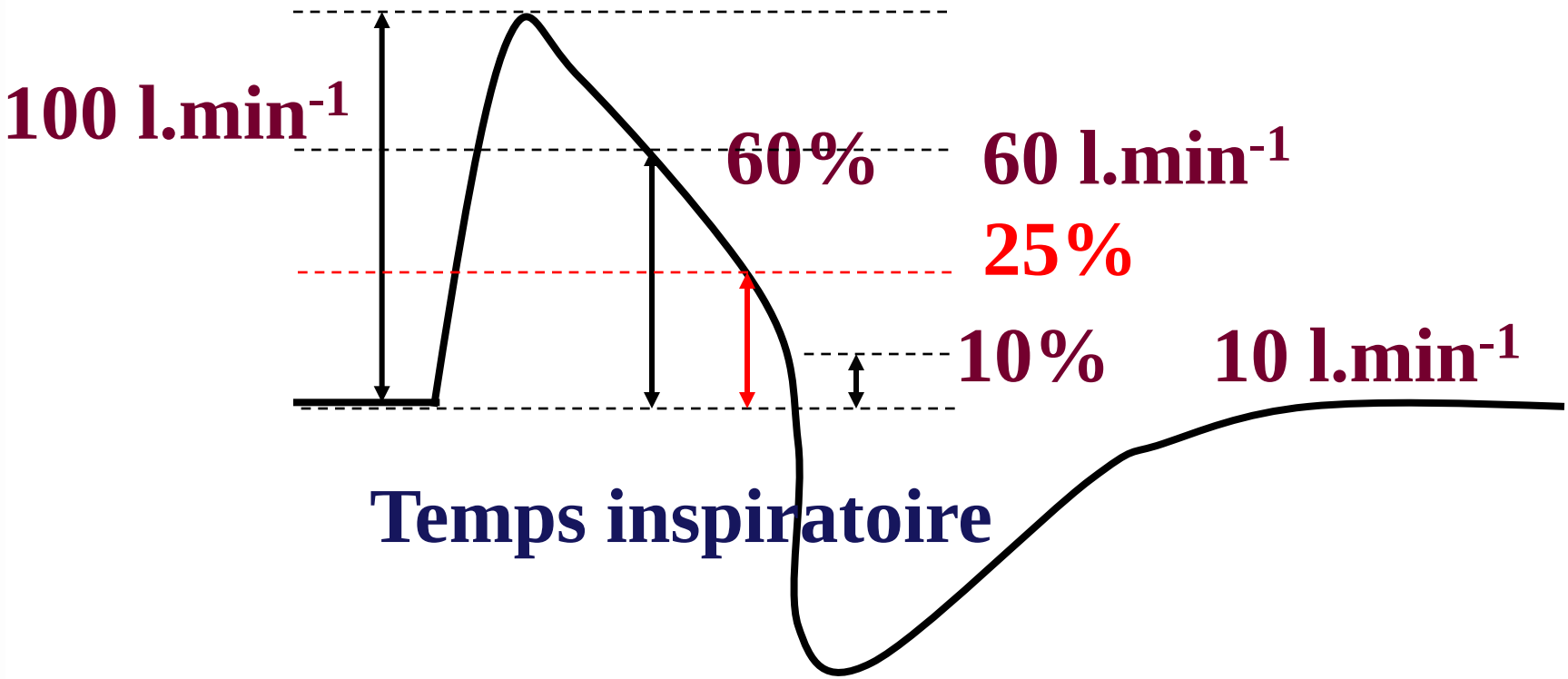
Choix de débuter par les respirateurs en 2011

Quelques conseils pour une bonne utilisation de l'aide inspiratoire

- **Ne pas régler le trigger trop bas car le risque d'autotrigger est réel**
  - **Si le patient ne déclenche pas, revoyez votre niveau d'anesthésie.**
- **La ventilation n'est pas toujours constante**
  - **Tachypnée ➔ augmentation de la ventilation minute**
  - **Effort inspiratoire important ➔ augmentation du Vt**
  - **Attention à la ventilation d'apnée**
    - Idéal : cycle non déclenché si temps expiratoire > valeur réglable
    - Pis allé : cycle imposé à fréquence réglable
- **Le rapport I/E n'est pas réglable. Il est déterminé par le patient.**
  - **Plus il est bas, plus la probabilité d'échec de la ventilation est élevée**

Justifie une surveillance attentive

Arrêt de l'aide en fin d'inspiration



Le rapport I/E est une valeur mesurée et non réglable

Anesthesiology 2010; 113:1310–9
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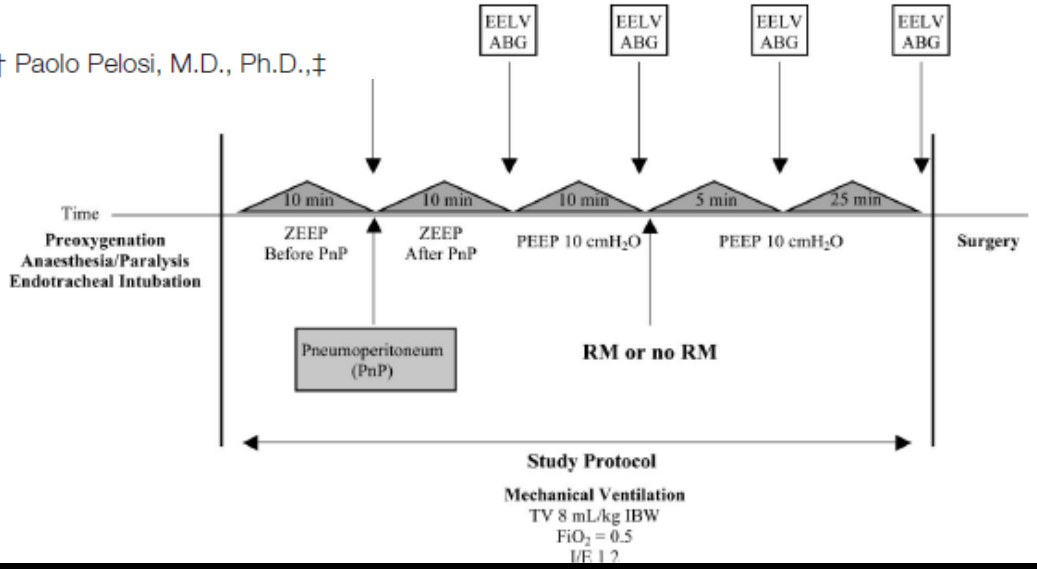
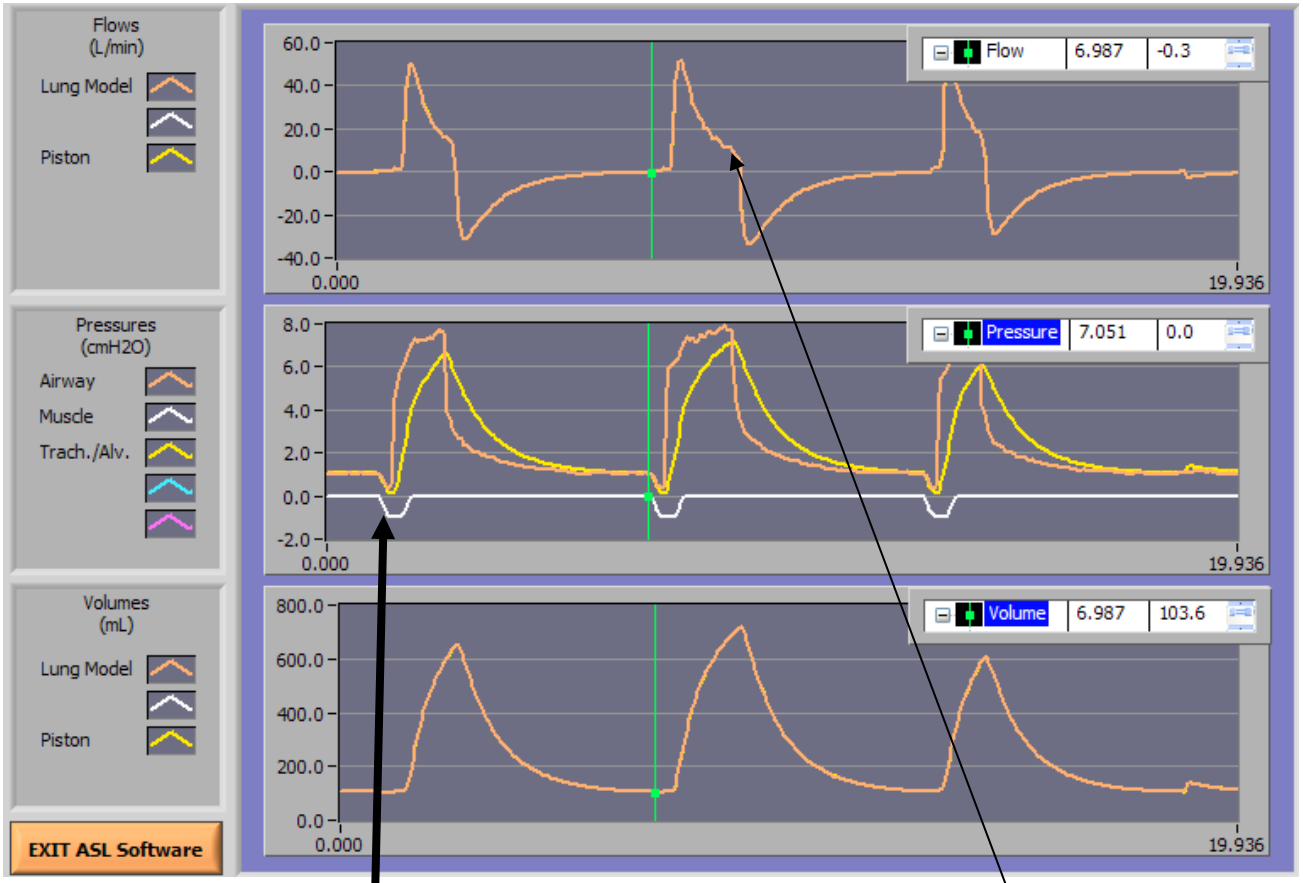
Intraoperative Recruitment Maneuver Reverses Detrimental Pneumoperitoneum-induced Respiratory Effects in Healthy Weight and Obese Patients Undergoing Laparoscopy

Emmanuel Futier, M.D.,* Jean-Michel Constantin, M.D., Ph.D.,† Paolo Pelosi, M.D., Ph.D.,‡



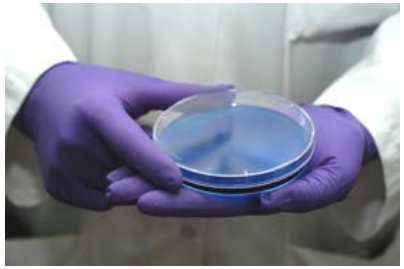
		Non obèse BMI ≈ 22		Obèse BMI ≈ 45		Commentaires
		Avant	Après	Avant	Après	
Pneumo CO2	EEV ml	1724	1194	886	751	↘ volume
	PaO2 mmHg	165	152	107	105	= PaO2
PEEP 10	EEV ml	1225	1680	771	1017	↗ volume
	PaO2 mmHg	152	158	94	108	= PaO2
PEEP 10 + recrutement	EEV ml	1750	1958	1115	1348	↗ volume
	PaO2 mmHg	176	207	111	146	↗ PaO2

L'aide inspiratoire



Trigger inspiratoire :
Déclenche l'inspiration

Trigger expiratoire :
Arrête l'insufflation



⇢ **Mais**

En mode pression, le niveau de ventilation dépend des conditions mécaniques d'aval

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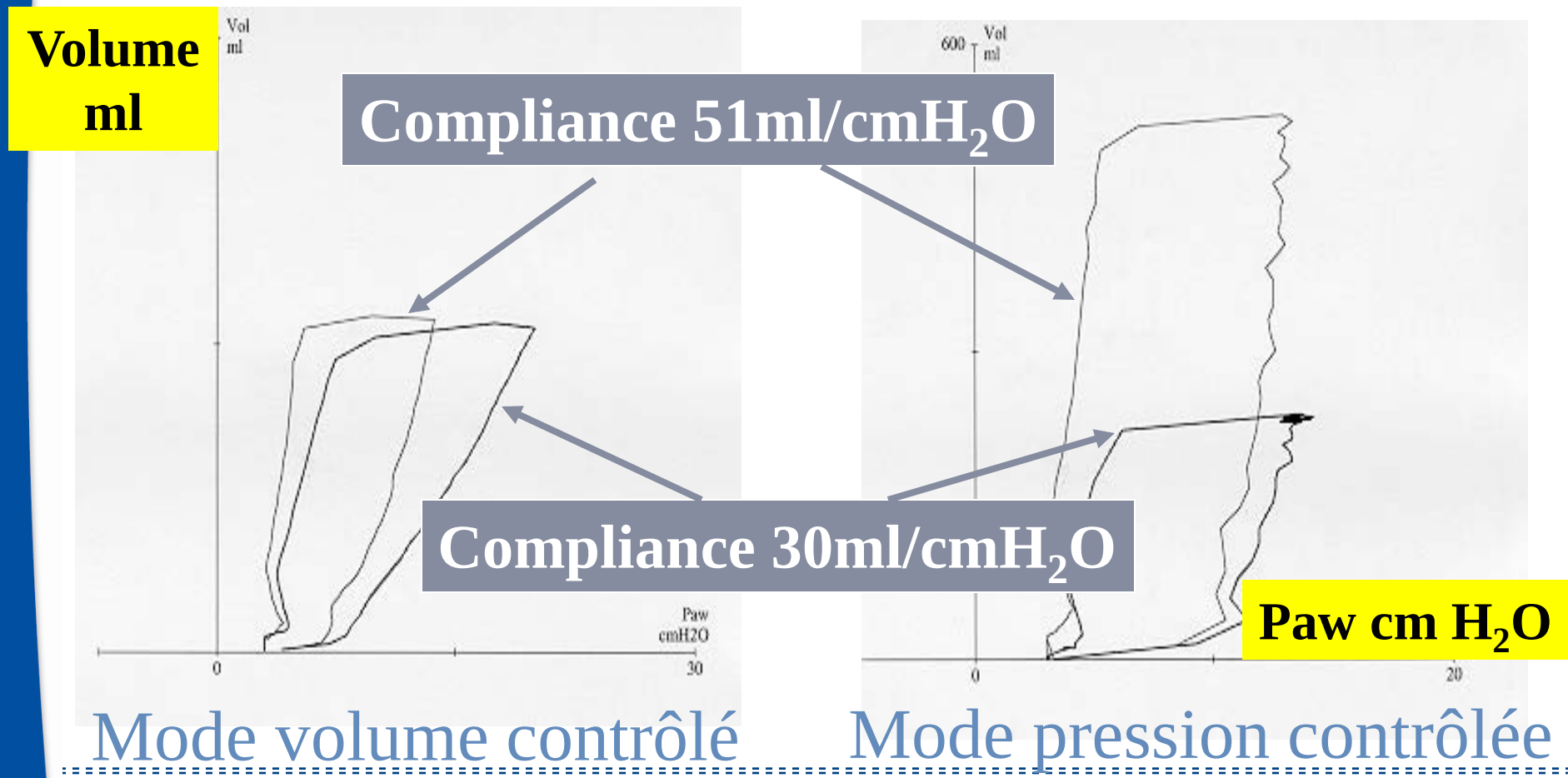
Indications de l'aide inspiratoire

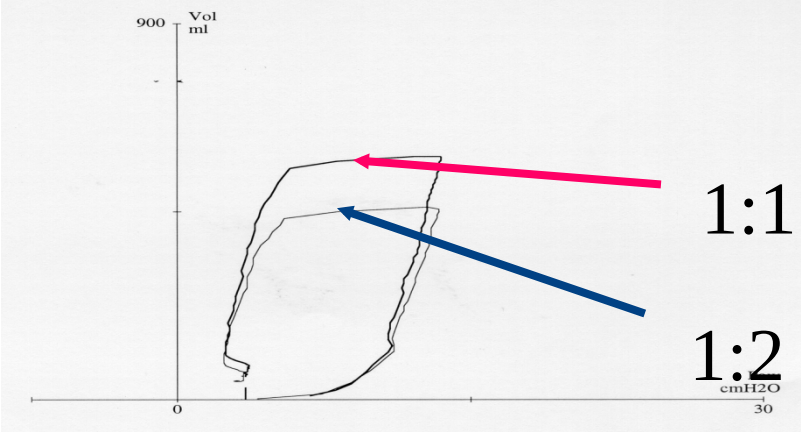
- **Pré-oxygénation**
  - **Diminue le temps pour obtenir une FeO2 à 90%**
  - **Diminue le taux d'échec de la préoxygénation**
    - Sujets sains Tanoubi I Ann Fr Anesth Réanim 2010
    - Obèses Delay JM Anesth Analg 2008
  - **Améliore la préoxygénation des patients de réanimation Baillard C AJRCCR 2006**
- **En cours d'anesthésie**
  - **Induction en ventilation spontanée**
    - Pédiatrie (Banchereau F 2005)
    - Airway difficile (Bourgain JL 2007, Bonnet L sous presse)
    - Intubation chez les patients hypoxémiques (Da Conceicao 2003)
  - **Assistance ventilatoire peropératoire**
    - Au cours des sédations
    - Sous masque laryngé Garcia-Fernandez, J 2007
- **Au réveil, dépend de la stratégie d'extubation, sur table ou en SSPI**

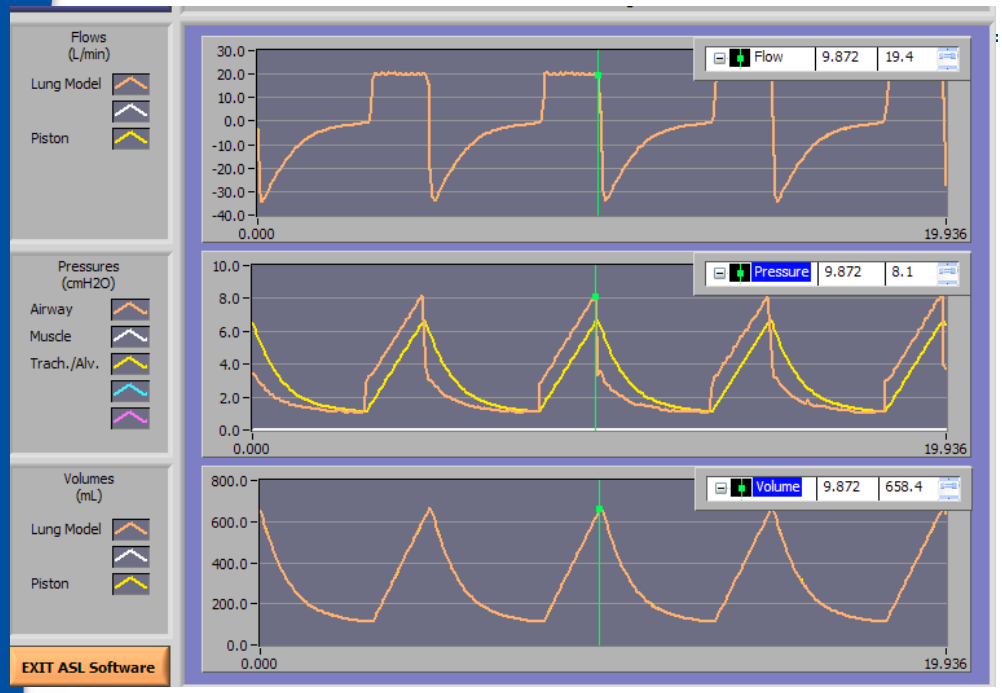
Variation de compliance (modèle de poumon)



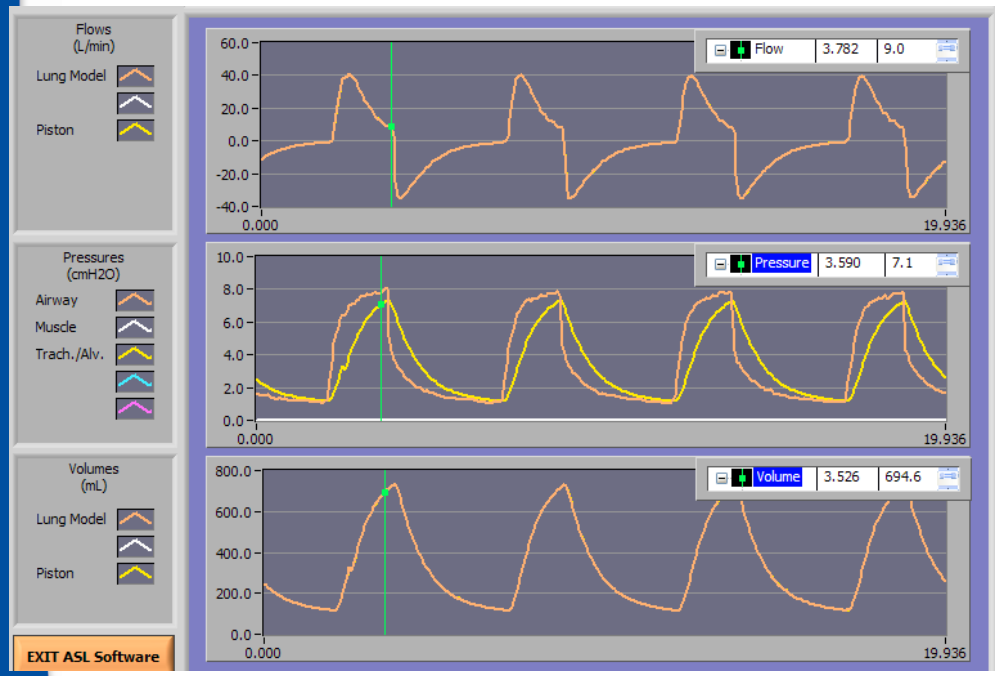
Tester l'efficacité des réglages par le monitorage respiratoire

Limitation des pressions



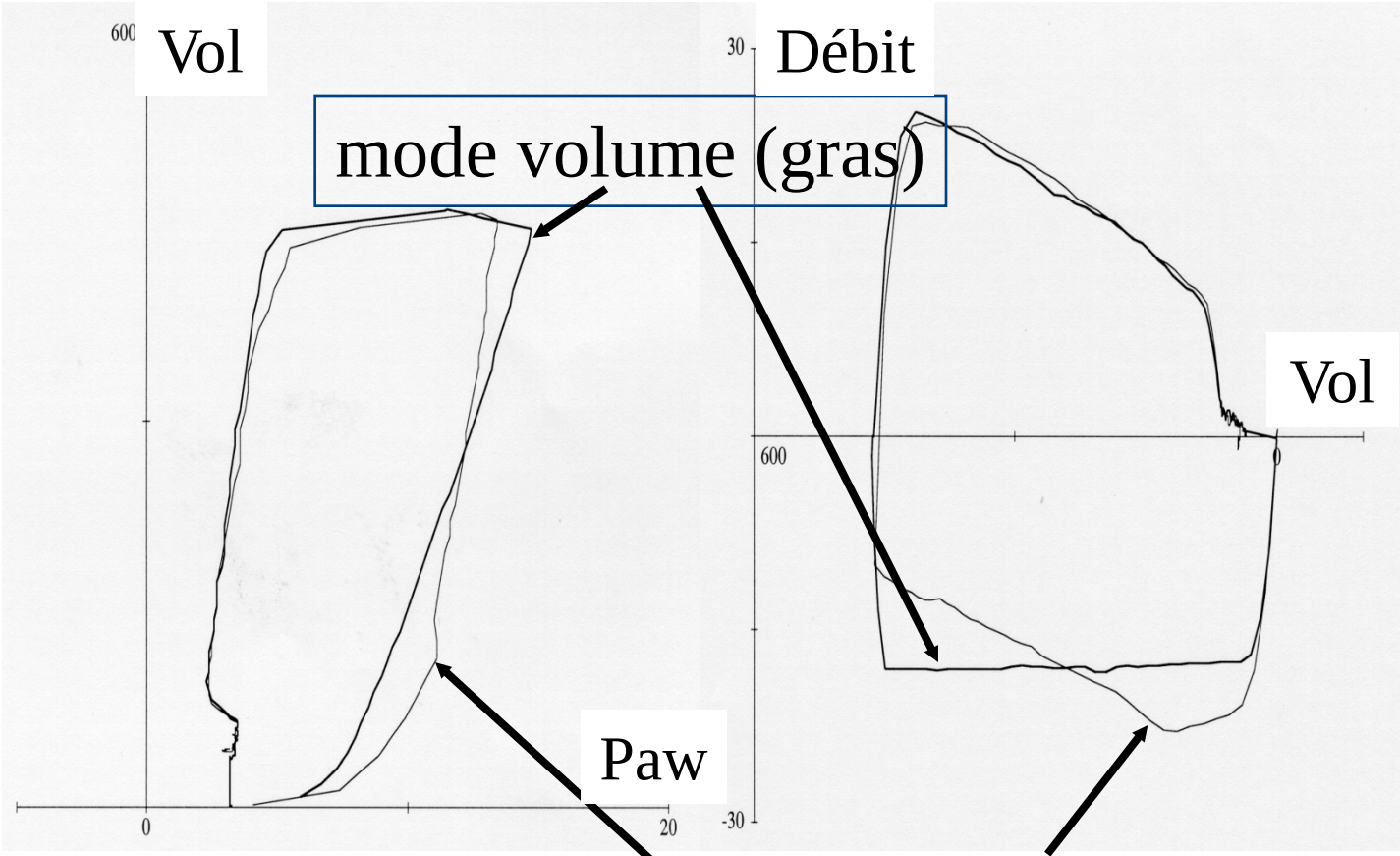


Volume contrôlé



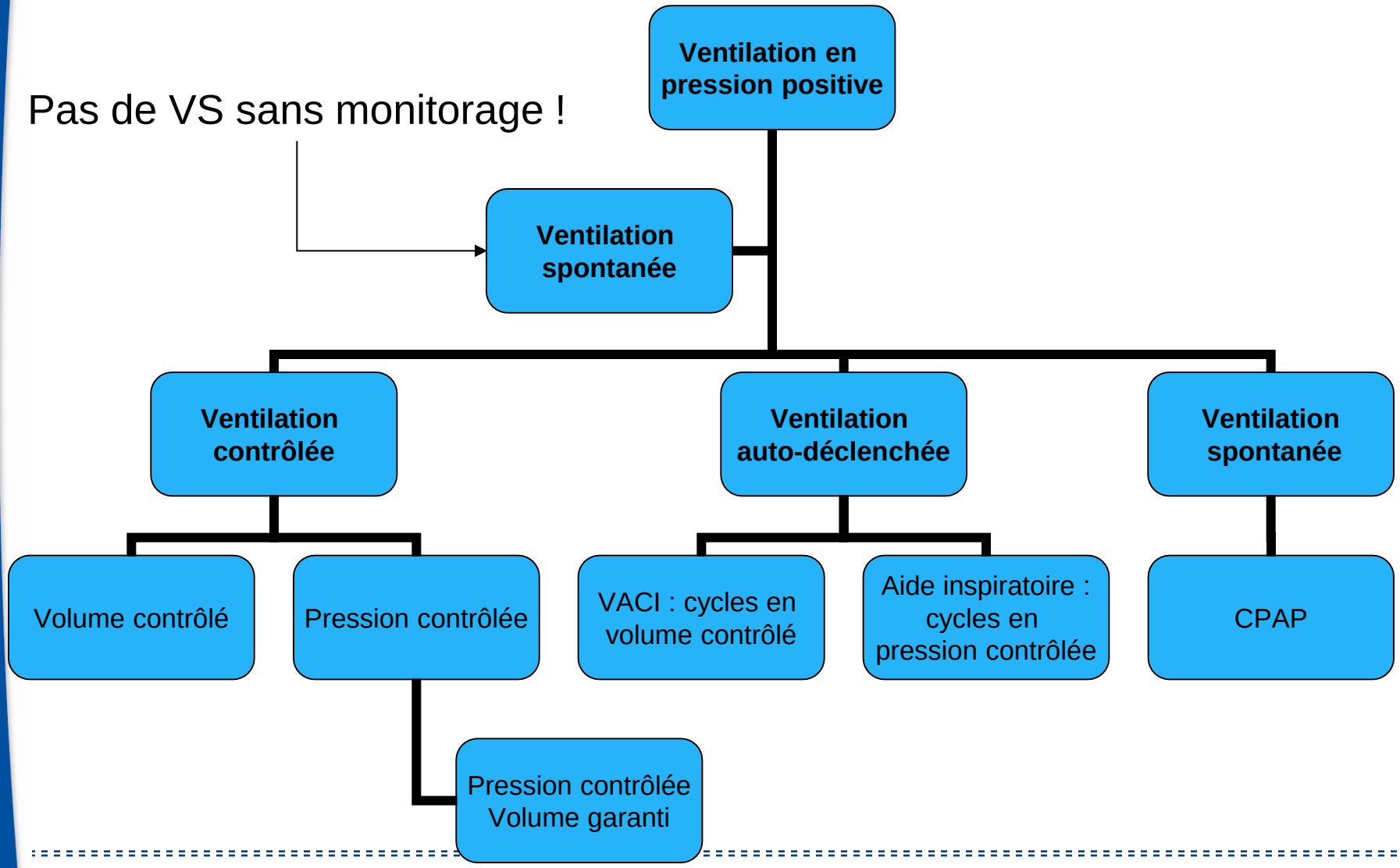
Pression contrôlée

Mode pression / mode volume



mode pression (fin)

Pas de VS sans monitorage !



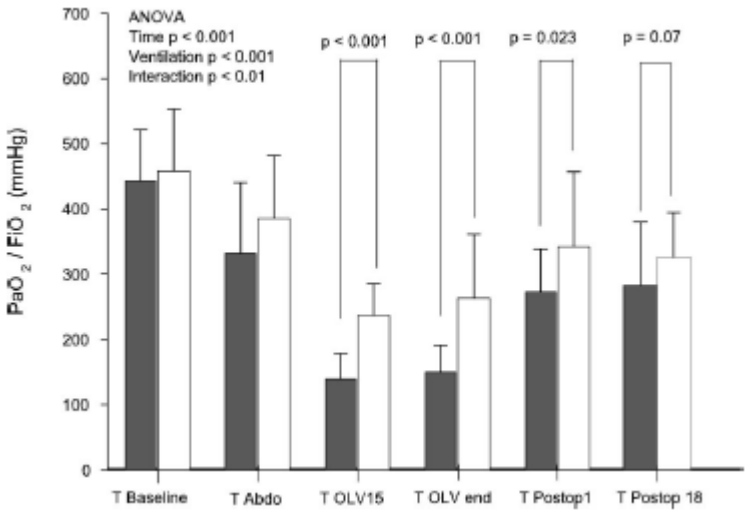
Anesthesiology 2006; 105:911–9 Copyright © 2006, the American Society of Anesthesiologists, Inc. Lippincott Williams & Wi

Protective Ventilation Influences Systemic Inflammation after Esophagectomy

A Randomized Controlled Study

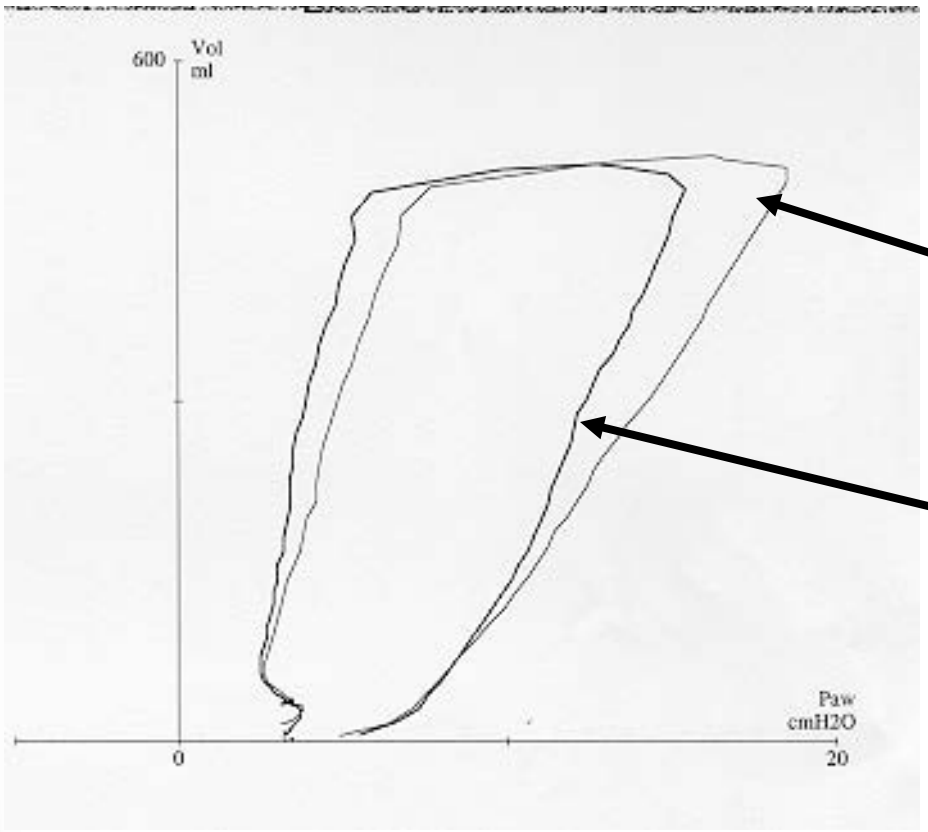
Pierre Michelet, M.D., Xavier-Benoît D'Journo, M.D.,† Antoine Roch, M.D., Ph.D.,‡ Christophe Doddoli, M.D.,§*

	Conventionnel	Protective	
IL-1β	0,56	0,24	pg.ml-1
IL-6	1,89	91	pg.ml-1
IL-8	49	30	pg.ml-1
Duration MV	171	115	Min



Barre blanche : protective ventilation 5 ml.kg^{-1} PEEP 5
Barre grise : ventilation conventionnelle 9 ml.kg^{-1} ZEEP

Effets d'une manœuvre de recrutement



Avant recrutement

Après recrutement

+ Amélioration de la SpO_2 et interprétation de la $FeCO_2$

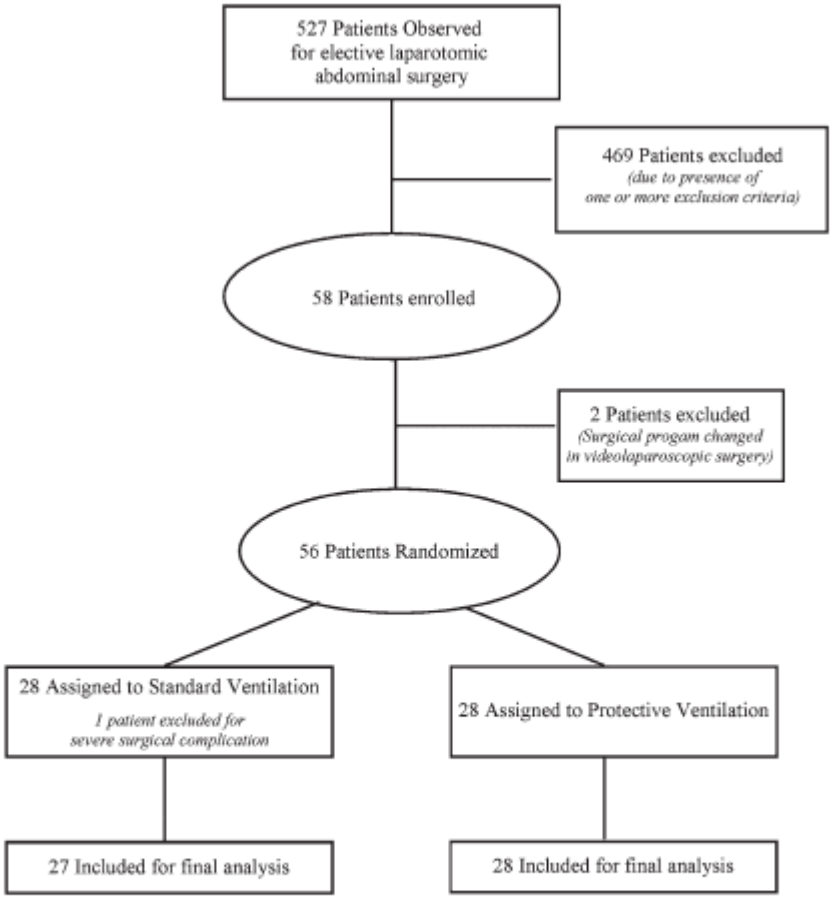


Fig. 1. Flow diagram summarizing inclusion, allocation, and analysis. Five hundred twenty-seven patients were observed during the study period; 469 patients were excluded due to the presence of one or more exclusion criteria. Fifty-eight patients were enrolled; two patients were excluded because of a change in surgical strategy, one patient was excluded for surgical complication, and finally 55 patients were included for analysis.

Anesthesiology 2013; 118:1307-21 1311 Severgnini *et al.*

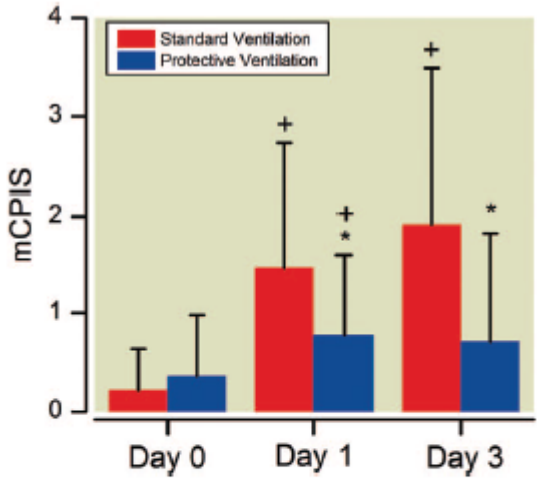


Fig. 2. Modified Clinical Pulmonary Infection Score (mCPIS) in standard (*red bar*) and protective (*blue bar*) ventilation group evaluated on days 0, 1, and 3. * $P < 0.05$ *versus* standard ventilation group on days 1 and 3; within the same group $^{+}P < 0.05$ *versus* preoperative period (day 0). Group effect over time $P = 0.001$. The individual pair-wise comparisons (Bonferroni corrected) show statistical significance as follows: mCPIS day 1 $P < 0.0002$ *versus* day 0 (95% CI, 0.3367–1.3232) and mCPIS day 3 $P < 0.0001$ *versus* day 0 (95% CI, 0.5305–1.5169).

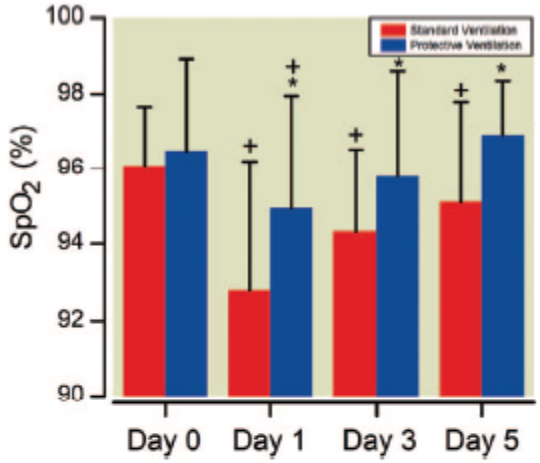


Fig. 3. Peripheral oxygen saturation (Spo_2) evaluated on postoperative days 1, 3, and 5 compared with the preoperative period (day 0) in standard (*red bar*) and protective (*blue bar*) ventilation strategy groups. * $P < 0.05$ *versus* standard ventilation group on days 1, 3, and 5, respectively; within the same group $^{+}P < 0.05$ *versus* preoperative period (day 0). Group effect over time $P < 0.001$. The individual pair-wise comparisons (Bonferroni corrected) show statistical significance as follows: Spo_2 day 1, $P < 0.0001$ *versus* day 0 (95% CI, −3.7065 to −1.1086); Spo_2 day 3, $P < 0.0715$ *versus* day 0 (95% CI, −2.5362 to 0.06174); Spo_2 day 5, $P = 1.0$ *versus* day 0 (95% CI, −1.5850 to 1.0254).

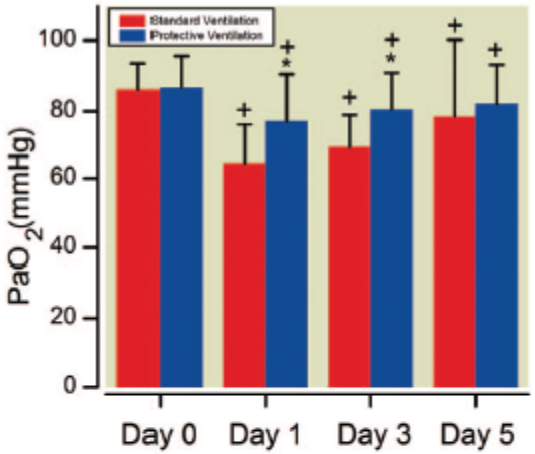
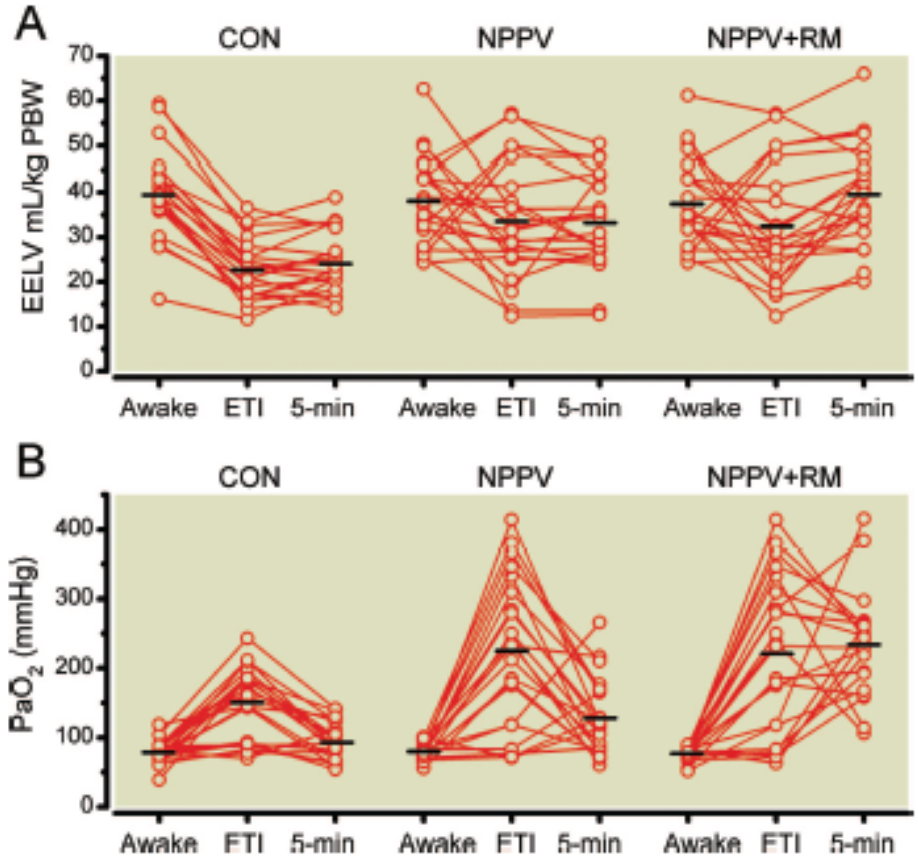


Fig. 4. Arterial oxygen pressure (Pao_2) evaluated on postoperative days 1, 3, and 5 compared with the preoperative period (day 0) in standard (*red bar*) and protective (*blue bar*) ventilation strategy groups. * $P < 0.05$ *versus* standard ventilation group on days 1, 3, and 5, respectively; within the same group $^{+}P < 0.05$ *versus* preoperative period (day 0). Group effect over time $P < 0.001$. The individual pair-wise comparisons (Bonferroni corrected) show statistical significance as follows: Pao_2 on day 1 $P < 0.0001$ *versus* on day 0 (95% CI, 21.8521 to −9.3786); Pao_2 on day 3 $P < 0.0001$ *versus* on day 0 (95% CI, 17.7832 to −5.3096); Pao_2 on day 5 $P < 0.046$ *versus* on day 0 (95% CI, 12.6022 to −0.06890).

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

A Randomized Controlled Study *Anesthesiology 2011;114:1354-63*

Emmanuel Futier, M.D.,* Jean-Michel Constantin, M.D., Ph.D.,† Paolo Pelosi, M.D., Ph.D.,‡



1. La VNI améliore l'efficacité de la pré-oxygénation
2. Le recrutement alvéolaire aussi
3. Grosse variabilité individuelle

Comparison of two ventilatory strategies in elderly patients undergoing major abdominal surgery

1. recruitment manoeuvres, tidal volume 6 ml kg^{-1} predicted body weight, and 12 cm H_2O PEEP
2. no recruitment manoeuvres, tidal volume 10 ml kg^{-1} predicted body weight, and ZEEP

Table 3 Number of postoperative complications. *Some patients had more than one pulmonary complication

Complication	Control	Recruitment
Any pulmonary complication (*n*)	8	5
Type of pulmonary complication*		
Atelectasis	5	4
Pulmonary oedema	0	1
Pneumonia	1	1
Pleural effusions	4	1
Hypercapnia in the recovery room	1	0
Acute lung injury	1	0
Pulmonary embolism	1	0
Prolonged respiratory failure	1	0
Death (*n*)	1	1

Table 5 Mean (SD) intra- and postoperative oxygenations and ventilation. *Two sample *t*-test $P<0.05$ for recruitment *vs* control. †Paired *t*-test $P<0.05$ for within-group comparison *vs* baseline. ‡Elevated Pa_{CO_2} in the recruitment group at baseline can be attributed to lower tidal volume used in this group

	Control (*n*=20)	Recruitment (*n*=20)
Pa_{O_2}/FI_{O_2} (kPa)		
Baseline	47.2 (13.1)	41.5 (12.8)
60 min	40.0 (12.7)†	54.5 (10.7)†,*
Recovery room	44.8 (15.7)	40.0 (7.6)
Pa_{CO_2} (kPa)		
Baseline‡	5.3 (0.6)	6.2 (0.6)*
60 min	5.4 (0.6)	6.8 (0.7)†,*
Recovery room	6.0 (0.9)†	6.4 (0.6)

T. N. Weingarten British Journal of Anaesthesia 104 (1): 16–22 (2010)

Ventilation mécanique chez l'obèse

- **Tidal volume of 6-10 ml kg^{-1} ideal body weight, increasing respiratory rate to maintain physiological $PaCO_2$, while avoiding intrinsic positive end-expiratory pressure (PEEPi)**
- **Recruitment manoeuvre (35-55 cmH_2O for 6 s) followed by the application of an end-expiratory pressure (PEEP) of 10 cmH_2O.**

Best Pract Res Clin Anaesthesiol. 2010 Jun;24(2):211-25.
Perioperative management of obese patients. Pelosi P,

CRITICAL CARE MEDICINE
Anesthesiology 2010; 113:1361–9

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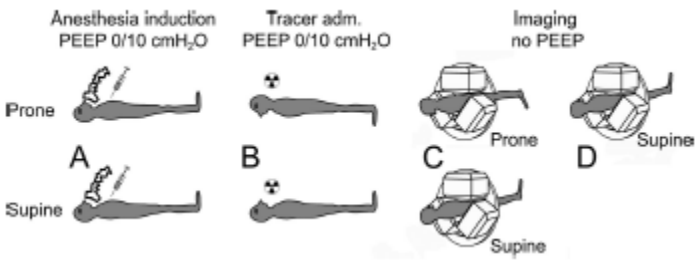
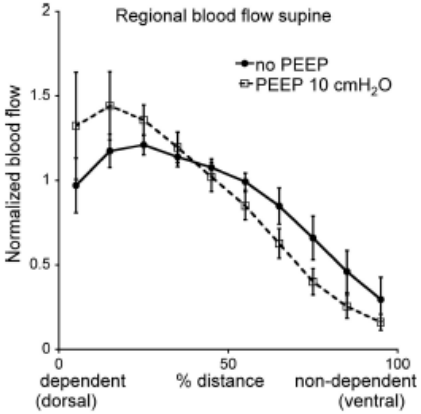
Positive End-expiratory Pressure Redistributes Regional Blood Flow and Ventilation Differently in Supine and Prone Humans

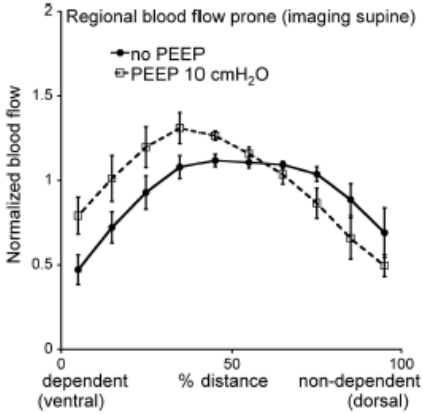
Johan Petersson, M.D., Ph.D.,* Malin Ax, M.D.,* Joana Frey, M.D.,*



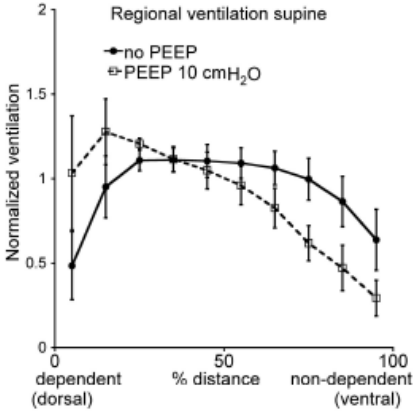
Volontaires sains

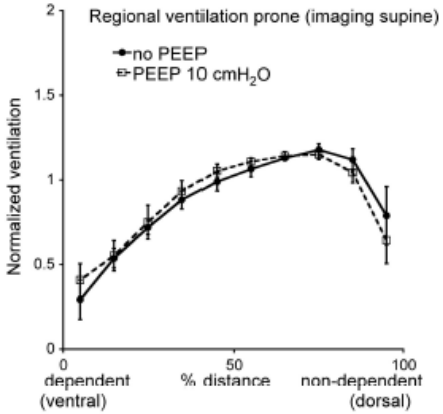
Décubitus dorsal Décubitus ventral



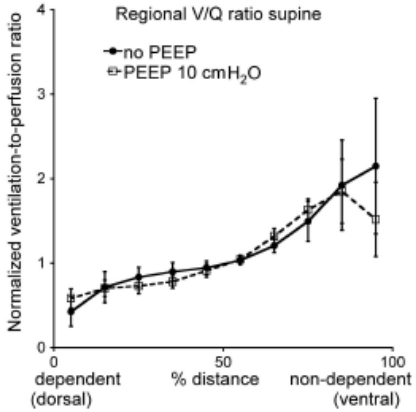


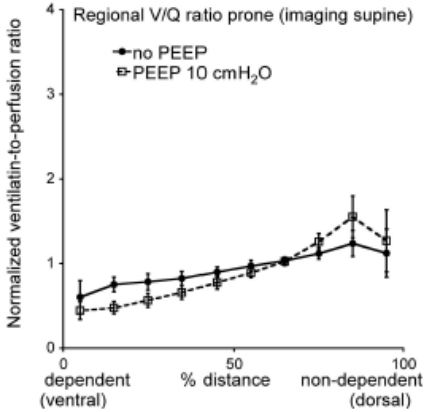
Ventilation





Perfusion





VA/Q : la PEEP altère la distribution des VA/Q

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Intraoperative Recruitment Maneuver Reverses Detrimental Pneumoperitoneum-induced Respiratory Effects in Healthy Weight and Obese Patients Undergoing Laparoscopy

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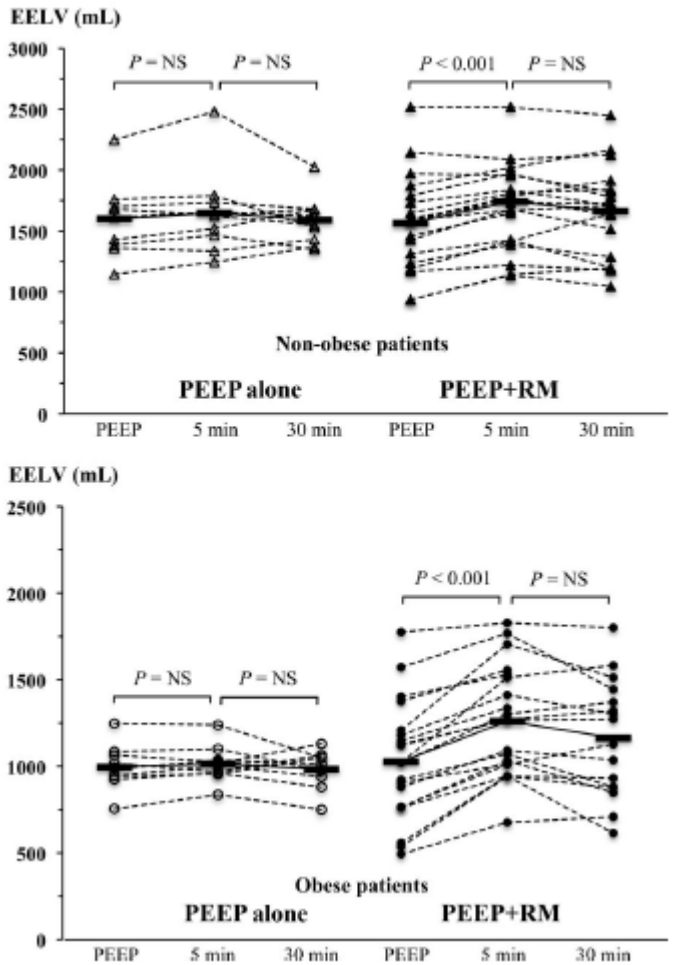
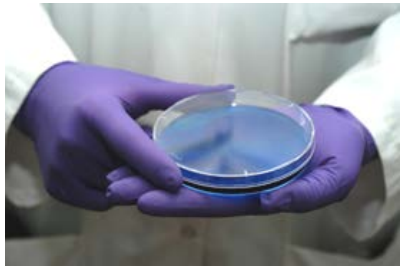


⇢ Variabilité individuelle

Nécessité d'une surveillance
Le monitorage de la CRF se fait par la boucle P/V



Probablement plus compliqué pour le BPCO

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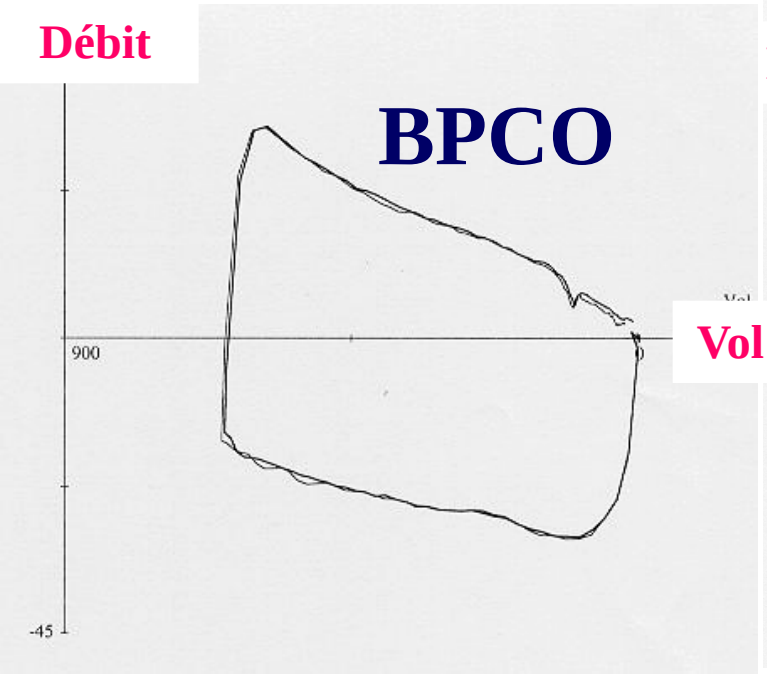
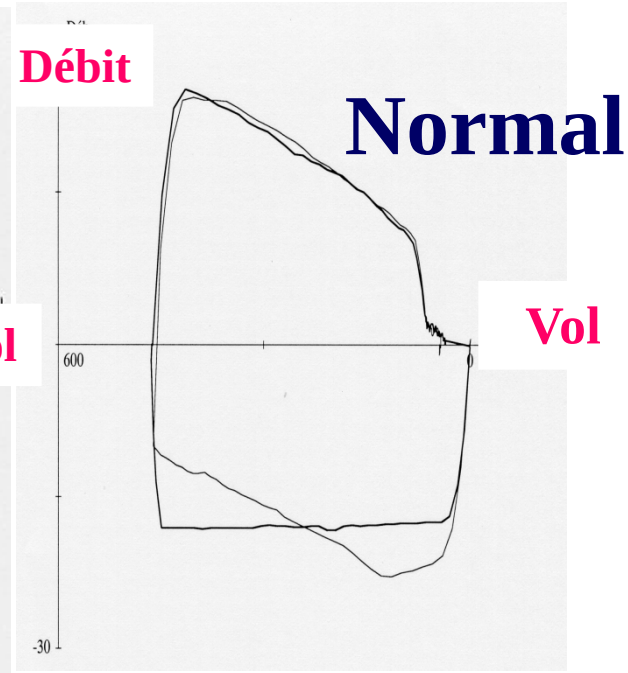
Hyperinflation dynamique : le temps expiratoire

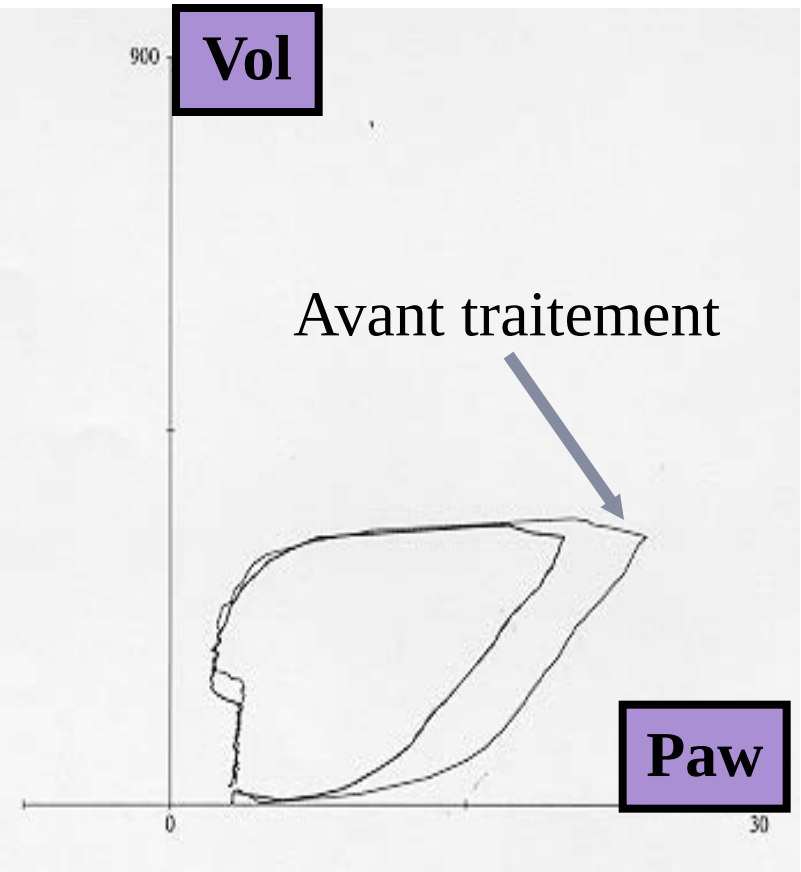
n'est pas suffisamment long pour que le poumon se vide jusqu'à la CRF

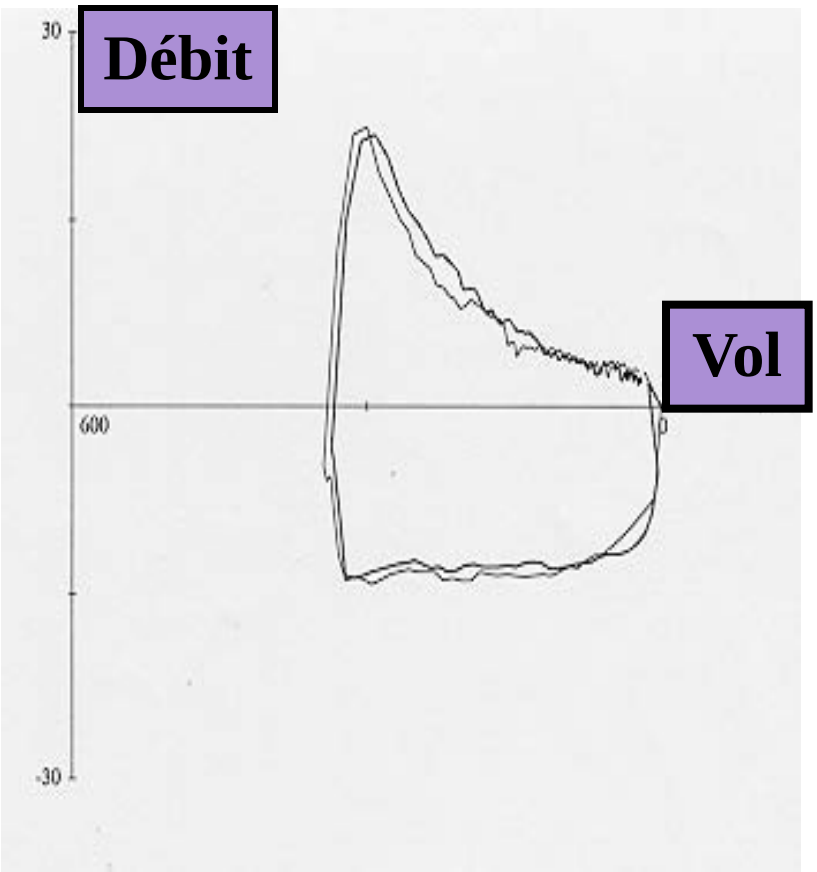




Contrôler l'efficacité des réglages sur les courbes
L'hypercapnie permissive peut être une solution dans les cas difficiles

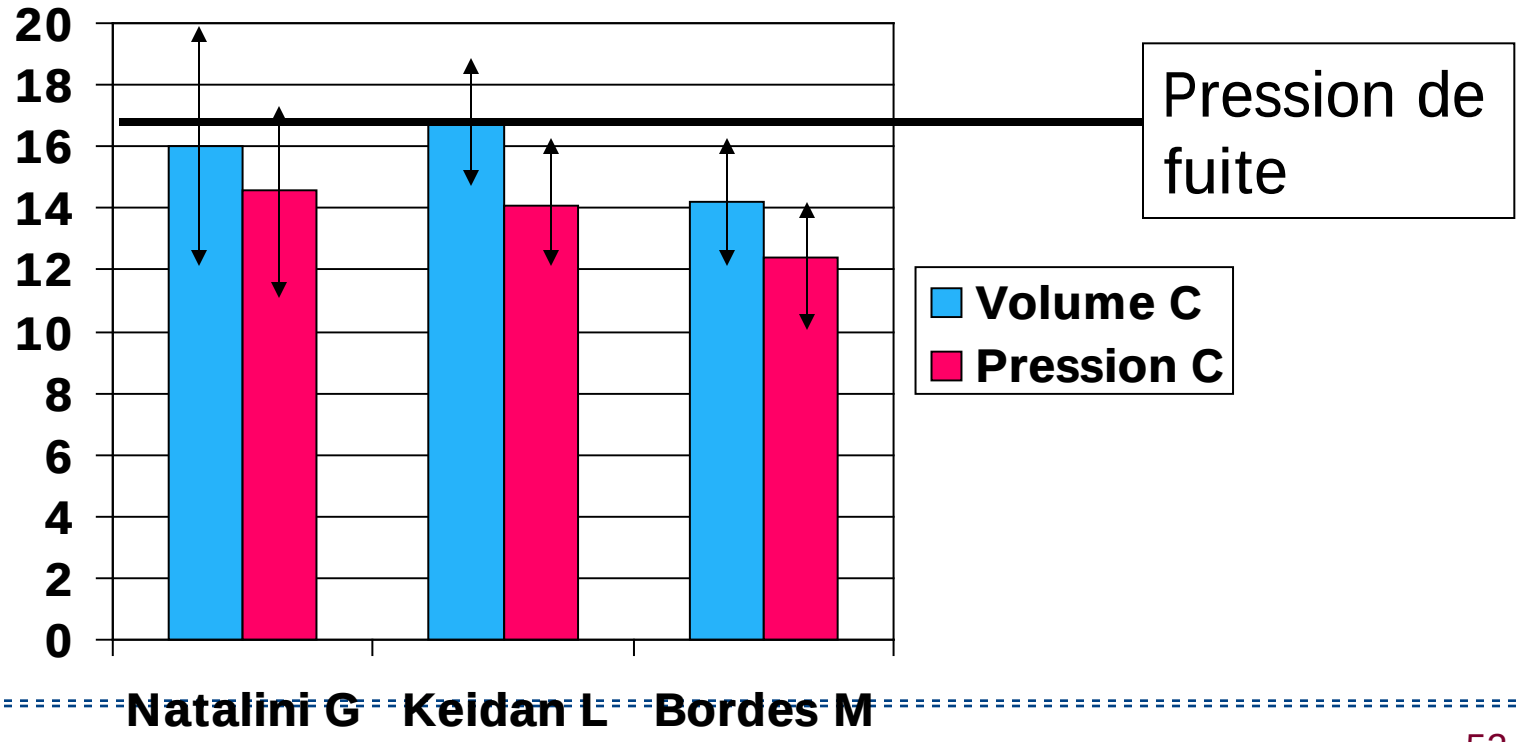
Levée du bronchospasme





Ventilation en pression contrôlée et masque laryngé

- Ventilation préservée en cas de fuites
- Baisse de la pression d'insufflation



Mode auto-flow ou pression contrôlée à volume garanti

- **Ventilation en mode pression**
  - Réglage d'un Vt et d'une fréquence
  - ΔPai → 5 cm H_2O puis adaptation par pallier pour obtenir le Vt réglé
  - Assure un Vt avec une pression minimale en cas de modification des conditions mécaniques (pédiatrie, cœliochirurgie)

⇢ Ventilation à l'induction

Comparaison ventilation manuelle vs pression contrôlée

Table 2. Hemodynamic and Respiratory Characteristics in 41 Patients During Pressure-Controlled Ventilation (PCV) and Circle System Ventilation (CSV)

Variable	PCV	CSV	*P* value
Heart rate (bpm)	69 ± 13	70 ± 11	NS
Mean arterial blood pressure (mm Hg)	78 ± 8	78 ± 11	NS
Oxygen saturation (%)	98 ± 1	98 ± 1	NS
End-tidal carbon dioxide (mm Hg)	34 ± 3	33 ± 4	NS
Respiratory rate (breaths/min)	15 ± 0	15.4 ± 1	0.015
Expiratory tidal volume (mL)	650 ± 100	680 ± 100	0.001
Minute ventilation (L/min)	10.4 ± 1.8	11.6 ± 1.8	<0.001
Peak airway pressure (cm H_2O)	10.6 ± 1.5	14.4 ± 2.4	<0.001
Delta airway pressure (cm H_2O)	8.5 ± 1.5	11.9 ± 2.3	<0.001
Peak inspiratory flow rate (L/s)	0.81 ± 0.06	1.06 ± 0.26	<0.001
Inspiratory time fraction (%)	48 ± 0.8	33 ± 7.7	<0.001
Stomach inflation (*n*)	0/41	0/41	NS

Data are mean ± SD or *n*.
NS = not significant.

von Goedecke: Anesth Analg, Volume 98(1).January 2004.260-263

Encore plus vrai chez l'enfant !

S. Français, C. *Ann. Fr. Anesth. Réanim.* **24** (2005), p. R317