ANESTHESIE MODERNE DE PROTECTION:
LA VENTILATION

T. IAICHE ACHOUR

Université Alger1- faculté de Médecine d’Alger-CHU Hussein Dey

22 ÈME Congres National de la SAARSUI

15, 16 & 17 Décembre 2022

Hotel Mercure Alger

Concept d'Anesthésie Moderne

Toutes les Stratégies Anesthésiques, en plus d'assurer narcose-analgésie-myorelaxation, --> **diminution complications respiratoires postopératoires (ppcs)**

- Oxygénation apnéique **HFNO**
- Ventilation protectrice
- Manœuvres de recrutement

Oxygénation apnéique HFNO

HFNC : High Flow Nasal Cannula

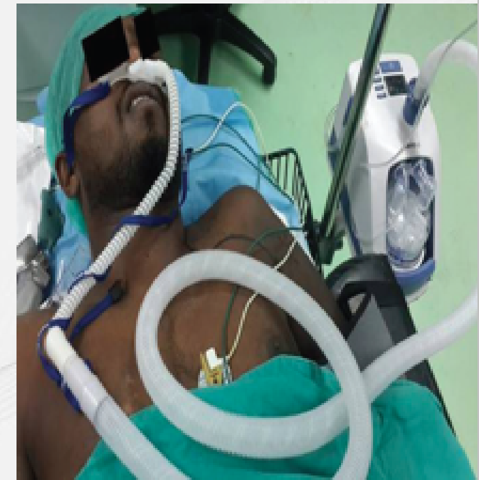
HFNO: High Flow Nasal Oxygen

THRIVE: Transnasal Échange ventilatoire à insufflation rapide humidifié

Définition: Un système innovant à haut débit qui permet de fournir jusqu' à 60L / min de gaz chauffé et entièrement humidifié avec un FIO2 compris entre 21% et 100%.

Pourquoi deux termes THRIVE et HFNO?

Lorsque l' HFNO a été initialement utilisé pour l' oxygénation apnéique pendant l' anesthésie, le terme échange ventilatoire rapide par insufflation rapide humidifié transnasal (THRIVE) a été utilisé.



Oxygénation apnéique HFNO

Standalone HFNC devices

Max blend2
Max flow 100L/min

F&P AIRVO 2
Max flow 70 L/min

F&P Optiflow
Nasal Cannula

Oxygénation apnéique HFNO

- Au patient :
- Maintenir la saturation et prolonger le temps d' apnée
- Atteignez rapidement la saturation optimale
- Réduire le travail de respiration
- Augmenter le confort du patient

- Aux anesthésistes :
- Aide à intuber plus facilement :
- Temps d' apnée sans danger prolongé
- Intubation moins stressante
- Pas besoin d' utiliser la technique de maintien du masque à une main,
- Pas besoin de technique de maintien du masque à deux mains
- un défi en raison de la pénurie de personnel médical

Oxygénation apnéique HFNO

- Oxygénation apnéique
- Effet PEP
- Rinçage de l' espace mort
- Réduction du travail de respiration
- Amélioration de la clairance mucociliaire et du confort du patient
- Une FiO2 constante
-

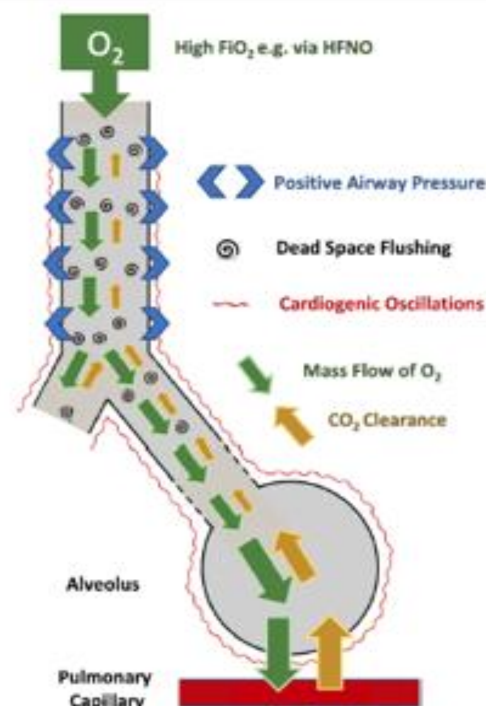


Figure 1 Apnoeic oxygenation involves the mass flow of a high fraction of inspired oxygen, aided by flushing of dead space, generation of positive airway pressure and cardiogenic oscillations. Higher flow rates can enable clearance of carbon dioxide.

©2019 Association of Anaesthetists

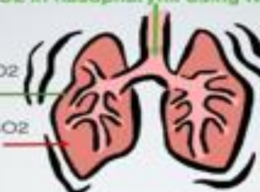
APNEIC OXYGENATION

100% O2 in nasopharynx using NC @15l/min

During apnea:

250ml/min O2

8-20ml/min CO2



generates flow of 100% O2 from pharynx to alveoli

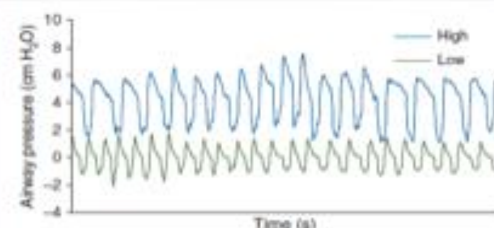
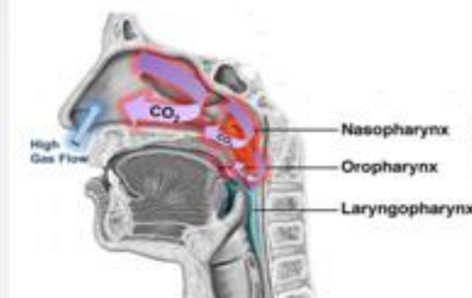


Fig 2 Oropharyngeal airway pressure tracing on HFNC and low-flow oxygen over 1 min. For this participant, mean airway pressure on HFNC was 4.4 cm H_2O and on low-flow oxygen was 0 cm H_2O.



Renda T. et al. High-flow nasal oxygen therapy in intensive care and anaesthesia. Br J Anaesth. 2018 Jan;120(1):18-27. doi: 10.1016/j.bja.2017.11.010.

Uses and mechanisms of apnoeic oxygenation: a narrative review, Anaesthesia 2019

Oxygénation apnéique HFNO

❖ **Oxygénation apnéique : stratégie efficace pour améliorer les réserves d' oxygène**

AIRWAY/SYSTEMATIC REVIEW/META-ANALYSIS

Effectiveness of Apneic Oxygenation During Intubation: A Systematic Review and Meta-Analysis

Lucas Oliveira J. e Silva; Daniel Cabrera, MD; Patricia Barrionuevo, MD; Rebecca L. Johnson, MD; Patricia J. Erwin, MLS; M. Hassan Murad, MD, MPH; M. Fernanda Bellolio, MD, MS*

*Corresponding Author. E-mail: Bellolio.Fernanda@mayo.edu, Twitter: @mfbellolio, @lucasojesilva12.

Study objective: We conduct a systematic review and meta-analysis to evaluate the effectiveness of apneic oxygenation during emergency intubation.

Methods: We searched Ovid MEDLINE, Ovid EMBASE, Ovid CENTRAL, and Scopus databases for randomized controlled trials and observational studies from 2006 until July 2016, without language restrictions. Gray literature, clinicaltrials.gov, and reference lists of articles were hand searched. We conducted a meta-analysis with random-effects models to evaluate first-pass success rates, incidence of hypoxemia, and lowest peri-intubation SpO_2 between apneic oxygenation and standard oxygenation cases.

Results: A total of 1,386 studies were screened and 77 selected for full-text review. A total of 14 studies were included for qualitative analysis, and 8 studies (1,837 patients) underwent quantitative analysis. In the meta-analysis of 8 studies (1,837 patients), apneic oxygenation was associated with decreased hypoxemia (odds ratio [OR] 0.66; 95% confidence interval [CI] 0.52 to 0.84), but was not associated with decreased severe hypoxemia (6 studies; 1,043 patients; OR 0.86; 95% CI 0.47 to 1.57) or life-threatening hypoxemia (5 studies; 1,003 patients; OR 0.90; 95% CI 0.52 to 1.55). Apneic oxygenation was associated with increased first-pass success rate (6 studies; 1,658 patients; OR 1.59; 95% CI 1.04 to 2.44) and increased lowest peri-intubation SpO_2 (6 studies; 1,043 patients; weighted mean difference 2.2%; 95% CI 0.8% to 3.6%).

Conclusion: In this meta-analysis, apneic oxygenation was associated with increased peri-intubation oxygen saturation, decreased rates of hypoxemia, and increased first-pass intubation success. [Ann Emerg Med. 2017;70:483-494.]

Please see page 484 for the Editor's Capsule Summary of this article.

A podcast for this article is available at www.annemergmed.com.

0196-0644/$-see front matter
Copyright © 2017 by the American College of Emergency Physicians. Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license

Oxygénation apnéique HFNO

Induction (intubation)

- For high-risk patients
- obèse
- Pediatrie
- Difficulté de ventilation
- Grossesse
- Induction à sequences rapide

Anesthésie

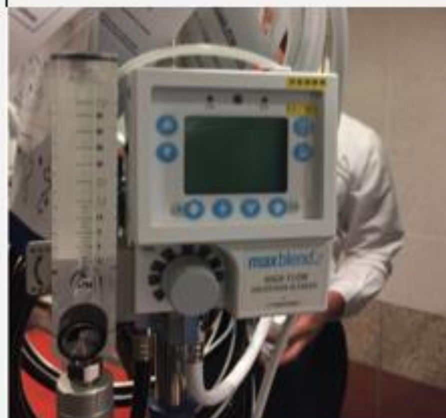
- sedation
- partagées (chirurgie ORL)
- Chirurgie de court durée

post-anesthésie

- Pour les patients à haut risque
- Éviter la réintubation

Oxygénation apnéique HFNO

La HFNO est une solution, mais la HFNO intégrée constitue la solution la plus appropriée pour les anesthésistes en salle d' opération



Ventilation protectrice

Concept d'Anesthésie Moderne

Monitorages

- Bis
- TOF
- Nirs
- PAS- Débit cardiaque
- Pression oesophagienne (transpulmonaire)
- FiO_2 peropératoire
- Gestion des liquides peropératoire

Techniques anesthésiques

- ALR
- AIVOC
- AINOC

Problématique

Complications pulmonaires postopératoires (PPCs)

A9
Anesthesia Workstation
All-round Safety

PHILOSOPHICAL TRANSACTIONS

XI. *Obſervations on a Caſe publiſhed in the laſt Volume of the* Medical Eſſays, *&c. of* Recovering *a* Man Dead *in Appearance, by diſtending the* Lungs *with Air. Printed at* Edinburgh, 1744; *by* John Fothergill, *Licent. Coll. Med. Lond.*

Read Feb. 21. 1744-5. *Now printed with Additions.*

THERE are ſome Facts, which, in themſelves, are of ſo great Importance to Mankind, or which may lead to ſuch uſeful Diſcoveries, that it would ſeem to be the Duty of every one, under whoſe Notice they fall, to render them as extenſively public as it is poſſible.

Postoperative Pulmonary Complications (PPCs)

BJA

British Journal of Anaesthesia, 118 (3): 317–34 (2017)

doi: 10.1093/bja/aex002
Review Article

Postoperative pulmonary complications

A. Miskovic and A. B. Lumb*

Department of Anaesthesia, St James's University Hospital, Leeds LS9 7TF, UK

*Corresponding author. E-mail: a.lumb@leeds.ac.uk

- PPCs includes:
  - ✓ Hypoxemia
  - ✓ Atelectasis
  - ✓ Pneumonia
  - ✓ Bronchitis
  - ✓ Acute respiratory failure
  - ✓ ARDS
  - ✓ Bronchospasm
  - ✓ Pulmonary infection
  - ✓ Pneumothorax

Outcome measure	EPCO definitions (identical set used by Canet and colleagues[4] and subsequent studies)[5 6]	Other published definitions
Respiratory infection	Antibiotics for suspected infection with one or more of the following: new or changed sputum, new or changed lung opacities, fever, white blood cell count $>12 \times 10^9$ litre^{-1}	Two or more of the following for >48 h: new cough/sputum production, physical findings compatible with pneumonia, fever >38 °C, and new infiltrate on CXR[7]
Respiratory failure	Postoperative Pa_{O_2} <8 kPa (60 mm Hg) on room air, a Pa_{O_2}:FI_{O_2} ratio <40 kPa (300 mm Hg), or arterial oxyhaemoglobin saturation measured with pulse oximetry <90% and requiring oxygen therapy	Ventilator dependence for >1 postoperative day or re-intubation[8 9] Need for postoperative mechanical ventilation >48 h[10–13] Unplanned re-intubation because of respiratory distress, hypoxia, hypercarbia, or respiratory acidosis within 30 days of surgery[10 11 13–15] Re-intubation within 3 days requiring mechanical ventilation[16] Postoperative acute lung injury[17] ARDS[17–19] Requiring mechanical ventilation within 7 days of surgery[20 21] Requiring NIV[22]
Pleural effusion	CXR with blunting of costophrenic angle, loss of sharp silhouette of the ipsilateral hemidiaphragm in upright position, displacement of adjacent anatomical structures, or (in supine position) hazy opacity in one hemithorax with preserved vascular shadows	Pleural effusion requiring thoracocentesis[8 9 20]
Atelectasis	Lung opacification with mediastinal shift, hilum or hemidiaphragm shift towards the affected area, with compensatory hyperinflation in adjacent non-atelectatic lung	Requiring bronchoscopic intervention[20] Major atelectasis (one or more pulmonary segments)[23]
Pneumothorax	Air in the pleural space with no vascular bed surrounding the visceral pleura	Pneumothorax requiring thoracocentesis[20 22]
Bronchospasm	Newly detected expiratory wheeze treated with bronchodilators	Clinical diagnosis resulting in change in therapy[89] Refractory wheeze requiring parenteral drugs in addition to preoperative regimen[24]
Aspiration pneumonitis	Acute lung injury after inhalation of regurgitated gastric contents	
Pneumonia	CXR with at least one of the following: infiltrate, consolidation, cavitation;plus at least one of the following: fever >38 °C with no other cause, white cell count <4 or > 12×10^9 litre^{-1}, >70 yr of age with altered mental status with no other cause;-plus at least two of the following: new purulent/changed sputum, increased secretions/suctioning, new/worse cough/dyspnoea/tachypnoea, rales/bronchial breath sounds, worsening gas exchange	Radiographic change and antibiotics[89] Antibiotics with new/changed sputum or radiographic change or fever or increased white cell count >12 000 μl^{-1} [4] Two or more of the following for ≥2 consecutive days: new cough/sputum production, examination compatible with pneumonia, temperature >38 °C, and radiographic change[7 23] New or progressive infiltrate on CXR or crackles or dullness on percussion and any of the following: new purulent/changed sputum, positive blood cultures, isolation of pathogen from sputum[20 25] Positive sputum culture or infiltrate on CXR, and diagnosis of pneumonia or pneumonitis[18] New infiltrate on CXR plus fever, leucocytosis, and positive sputum Gram stain/culture[24]
ARDS		Ventilated, bilateral infiltrates on CXR, Pa_{O_2}:FI_{O_2} ≤300, minimal evidence of left atrial fluid overload within 7 days of surgery[19]
Tracheobronchitis		Purulent sputum with normal chest radiograph, no i.v. antibiotics[8 9]

Continued

A9 Anesthesia Workstation | All-round Safety

JACS Journal of the American College of Surgeons

Multivariable Predictors of Postoperative Respiratory Failure after General and Vascular Surgery: Results from the Patient Safety in Surgery Study

Johnson, Robert G. MD, FACS[a,*]; Arozullah, Ahsan M. MD, MPH[b]; Neumayer, Leigh MD, MS, FACS[c]; Henderson, William G. MPH, PhD[d]; Hosokawa, Patrick MS[e]; Khuri, Shukri F. MD, FACS[f,g,h]

JACS Journal of the American College of Surgeons

- Sur 180 359 patients, 5 389 (3,0 %) de PPCs
- --> classe ASA,
- urgence,
- chirurgie majeure,
- BPCO, tabac,
- âge, homme,
- insuffisance rénale, i. Cardiaque,
- Durée d’anesthésie et de ventilation

Incidence & Impact of PPCs

- Approximately 5% of patients undergoing general surgery will develop a PPC
- In Cardiac, Thoracic surgery or obese patient, the incidence may be higher than 30%

- Postoperative pulmonary complications (PPCs) can have an important impact on the morbidity and mortality of patients who need major surgery.
- One of the five patients who developed a PPC will die within 30 days of surgery.
- The number of PPCs is strongly associated with postoperative length of stay and prolonged mechanical ventilation and care cost.

PERIOPERATIVE MEDICINE

Prospective External Validation of a Predictive Score for Postoperative Pulmonary Complications

Valentín Mazo, M.D., Sergi Sabaté, M.D., Ph.D., Jaume Canet, M.D., Ph.D., Lluís Gallart, M.D., Ph.D., Marcelo Gama de Abreu, M.D., Ph.D., Javier Belda, M.D., Ph.D., Olivier Langeron, M.D., Ph.D., Andreas Hoeft, M.D., Ph.D., Paolo Pelosi, M.D.

ABSTRACT

Results: The full Prospective Evaluation of a RIsk Score for postoperative pulmonary COmPlications in Europe data set included 5,099 patients; 725 PPCs were recorded for 404 patients (7.9%). The score's discrimination was good: *c*-statistic (95% CI), 0.80 (0.78 to 0.82). Predicted *versus* observed PPC rates for low, intermediate, and high risk were 0.87 and 3.39% (score <26), 7.82 and 12.98% (≥26 and <45), and 38.13 and 38.01% (≥45), respectively; the positive likelihood ratio for a score of 45 or greater was 7.12 (5.93 to 8.56). The score performed best in the Western Europe subsample—*c*-statistic, 0.87 (0.83 to 0.90) and positive likelihood ratio, 11.56 (8.63 to 15.47)—and worst in the Eastern Europe subsample. The predicted (5.5%) and observed (5.7%) PPC rates were most similar in the Spain subsample.

Conclusions: The Assess Respiratory Risk in Surgical Patients in Catalonia score predicts three levels of PPC risk in hospitals outside the development setting. Performance differs between geographic areas. (ANESTHESIOLOGY 2014; 121:219-31)

Table 5. The ARISCAT Model's Performance in the Overall PERISCOPE Cohort and the Subsamples: Discrimination, Calibration, and Clinical Usefulness

	Overall	Spain	WE	EE
Sample size	5,099	2,000	1,538	1,561
PPC incidence	7.92% (7.20–8.70%)	5.70% (4.72–6.81%)	8.19% (6.87–9.68%)	10.51% (9.03–12.13%)

Anesthesiology 2010; 113:1338–50

Copyright © 2010, the American Society of Anesthesiologists, Inc. Lippincott Williams & Wilkins

Prediction of Postoperative Pulmonary Complications in a Population-based Surgical Cohort

Jaume Canet, M.D., Ph.D.,* Lluís Gallart, M.D., Ph.D.,† Carmen Gomar, M.D., Ph.D.,‡ Guillem Paluzie, M.D.,§ Jordi Vallès, M.D.,† Jordi Castillo, M.D., Ph.D.,† Sergi Sabaté, M.D., Ph.D.,‖ Valentín Mazo, M.D.,# Zahara Briones, M.Math.,** Joaquín Sanchis, M.D., Ph.D.††; on behalf of the ARISCAT Group‡‡

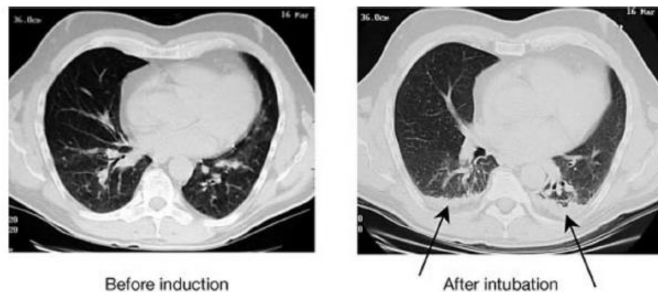
Table 3. Characteristics of PPCs and Postoperative Mechanical Ventilation According to Surgical Specialties

	General and Digestive	Cardiac	Orthopedic	Thoracic	Other	Total
Patients, n	726	53	799	35	851	2,464
Patients with at least 1 PPC, n (%)	52 (42.3)	21 (17.1)	19 (15.4)	11 (8.9)	20 (16.3)	123 (100)
Incidence of patients with at least 1 PPC within specialty, %	7.2	39.6	2.4	31.4	2.4	5.0
Patients with at least 1 PPC dead at 30 days, n (% of patients with PPC)	18 (34.6)	0 (0)	1 (5.3)	2 (18.2)	3 (15.0)	24 (19.5)
Patients with at least 1 PPC dead at 90 days, n (% of patients with PPC)	20 (38.5)	1 (4.8)	2 (10.5)	2 (18.2)	5 (25.0)	30 (24.4)
Patients with prolonged mechanical ventilation after surgery, n	27	50	7	2	31	117
Patients with prolonged mechanical ventilation >24 h, n (%)	11 (40.7)	9 (18.0)	0 (0)	0 (0)	7 (22.6)	27 (23.1)

Anesthesiology. 2014 Aug;121(2):219-31
Anesthesiology. 2010 Dec;113(6):1338-50.

Incidence & Impact of Atelectasis

- An estimated 234 million major surgical procedures are undertaken each year worldwide. Atelectasis may develop in nearly 90% of patients put under general anaesthesia and can persist during the immediate postoperative period and up to several days after surgery. Persistence of atelectasis after surgery is potentially associated with postoperative pulmonary complications such pneumonia, acute lung injury and extubation failure requiring reintubation. Hypoxaemia, a direct consequence of atelectasis, may also promote systemic complications such as acute myocardial is chaemia or impaired wound he



Before induction After intubation

Open Access Research

BMJ Open

The accuracy of postoperative, non-invasive Air-Test to diagnose atelectasis in healthy patients after surgery: a prospective, diagnostic pilot study

Carlos Ferrando,[1] Carolina Romero,[2] Gerardo Tusman,[3] Fernando Suarez-Sipmann,[4,5] Jaume Canet,[6] Rosa Dosdá,[7] Paola Valls,[1] Abigail Villena,[1] Ferran Serralta,[1] Ana Jurado,[1] Juan Carrizo,[1] Jose Navarro,[1] Cristina Parrilla,[7] Jose E Romero,[8] Natividad Pozo,[9] Marina Soro,[1] Jesús Villar,[5,10] Francisco Javier Belda[1]

< Previous Article October 2018 Volume 121, Issue 4, Pages 899–908 Next Article >

To read this article in full, please review your options for gaining access at the bottom of the page.

Intraoperative ventilation settings and their associations with postoperative pulmonary complications in obese patients

L. Ball, S.N.T. Hemmes, A. Serpa Neto, T. Bluth, J. Canet, M. Hiesmayr, M.W. Hollmann, G.H. Mills, M.F. Vidal Melo, C. Putensen, W. Schmid, P. Severgnini, H. Wrigge, M. Gama de Abreu, M.J. Schultz, P. Pelosi for

British Journal of Anaesthesia 91 (1): 61–72 (2003)
DOI: 10.1093/bja/aeg085

BJA

New concepts of atelectasis during general anaesthesia

L. Magnusson* and D. R. Spahn

Department of Anaesthesiology, University Hospital, CHUV, CH-1011 Lausanne, Switzerland

**Corresponding author. E-mail: lennart.magnusson@chuv.hospvd.ch*

Br J Anaesth 2003; 91: 61–72

A9 Anesthesia Workstation | All-round Safety

Risk Factors for PPCs

- Patient
  - ✓ ASA >=3
  - ✓ Obese patient
  - ✓ COPD/Smoking
- Surgery
  - ✓ Open Thoracic surgery
  - ✓ Cardiac surgery
  - ✓ Duration of surgery >2h
  - ✓ Emergent surgery
- Anesthetic Management
  - ✓ General anesthesia
  - ✓ High respiratory driving pressure
  - ✓ High insp oxygen fraction

David S. Warner, M.D., Editor

Anesthesiology 2015; 123:692–713

Intraoperative Protective Mechanical Ventilation for Prevention of Postoperative Pulmonary Complications

A Comprehensive Review of the Role of Tidal Volume, Positive End-expiratory Pressure, and Lung Recruitment Maneuvers

Andreas Güldner, M.D., Thomas Kiss, M.D., Ary Serpa Neto, M.D., M.Sc., Ph.D., Sabrine N. T. Hemmes, M.D., Jaume Canet, M.D., Ph.D., Peter M. Spieth, M.D., Patricia R. M. Rocco, M.D., Ph.D., Marcus J. Schultz, M.D., Ph.D., Paolo Pelosi, M.D., F.E.R.S., Marcelo Gama de Abreu, M.D., M.Sc., Ph.D., D.E.S.A.

This article has been selected for the Anesthesiology CME Program. Learning objectives and disclosure and ordering information can be found in the CME section at the front of this issue.

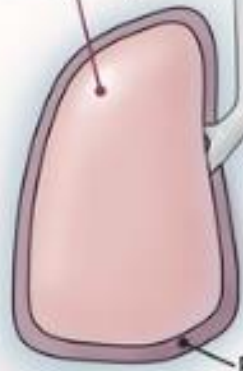
Table 1. Risk Factors for Postoperative Pulmonary Complications

Patient Characteristics	Preoperative Testing	Surgery	Anesthetic Management
Age	Low albumin	Open thoracic surgery	General anesthesia
Male sex	Low Spo_2 (≤95%)	Cardiac surgery	High respiratory driving pressure (≥13 cm H_2O)
ASA class ≥3	Anemia (Hb <10 g/dl)	Open upper abdominal surgery	High inspiratory oxygen fraction
Previous respiratory infection		Major vascular surgery	High volume of crystalloid administration
Functional dependency		Neurosurgery	Erythrocyte transfusion
Congestive heart failure		Urology	Residual neuromuscular blockade
COPD		Duration of surgery >2 h	Nasogastric tube use
Smoking		Emergent surgery	
Renal failure			
Gastroesophageal reflux disease			
Weight loss			

Respiratory driving pressure is defined as inspiratory plateau airway pressure *minus* positive end-expiratory pressure.

ASA = American Society of Anesthesiologists; COPD = chronic obstructive pulmonary disease; Hb = hemoglobin concentration; Spo_2 = oxygen saturation as measured by pulse oximetry.

A Normal spontaneously breathing person, at end inspiration

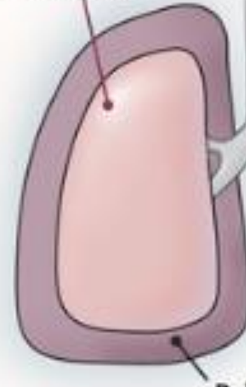


Ptp = 0 − (−8) = +8 cm H_2O

B Normal anesthetized, paralyzed patient on mechanical ventilation, at end inspiration

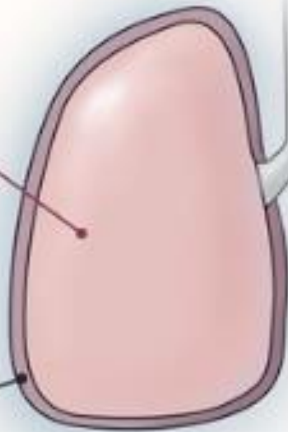
Ptp = 9 − 1 = +8 cm H_2O

C Patient with stiff chest wall, on mechanical ventilation, at end inspiration



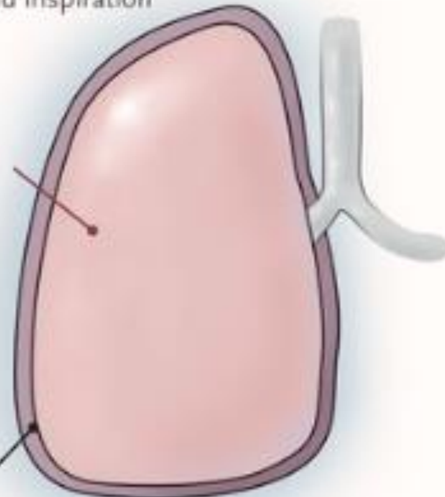
Ptp = 30 − 25 = +5 cm H_2O

D Trumpet player while playing a note



Ptp = 150 − 140 = +10 cm H_2O

E Patient with marked respiratory distress, on noninvasive ventilation, at end inspiration



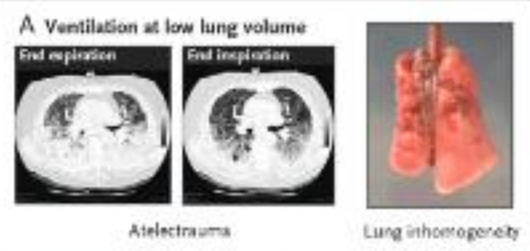
Ptp = 10 − (−15) = +25 cm H_2O

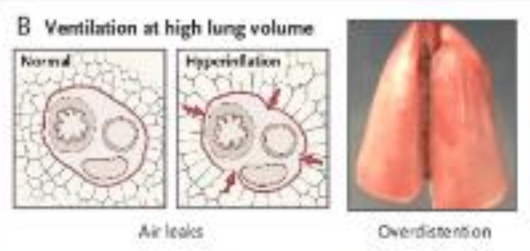
- la pression des voies respiratoires mesurée pendant une période où le flux d'air est arrêté à la fin de l'inspiration est appelée pression de plateau.
- la pression pleurale -= par la mesure de la pression œsophagienne. [9]
- la pression de plateau est la variable la plus couramment utilisée dans un contexte clinique pour indiquer une surdistension pulmonaire
- la pression plateau représente la pression qui distend les poumons plus la paroi thoracique. Chez un patient avec une paroi thoracique raide (par exemple, un patient avec un épanchement pleural ou une ascite massive), une grande partie de la pression délivrée par le ventilateur est dissipée en gonflant la paroi thoracique plutôt que le poumon

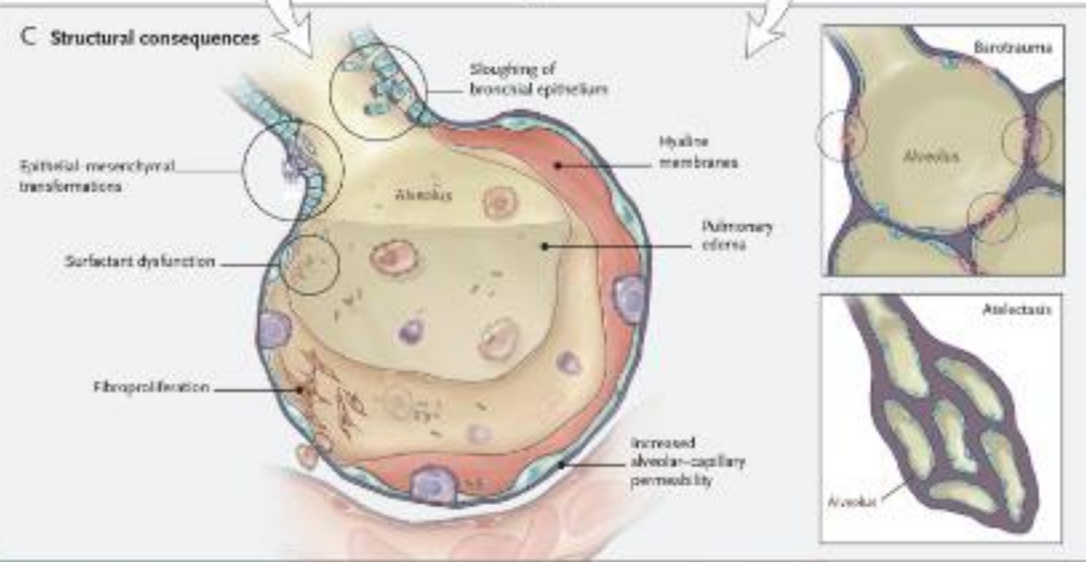
Fig 1 D expli ue pno covid

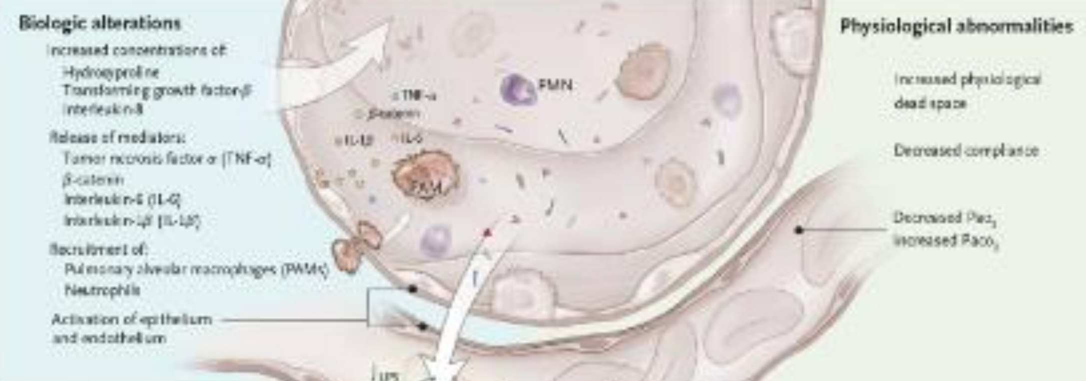
- Par analogie, lorsqu'un musicien joue de la trompette, la pression des voies respiratoires peut atteindre 150 cm d'eau, [10] mais le pneumothorax est rare, car la pression pleurale est également élevée et il n'y a pas de surdistension (**Figure 1D**). En revanche, lors d'une ventilation non invasive, si le patient est très angoissé et génère de très fortes pressions pleurales négatives, la pression transpulmonaire (et donc l'étirement pulmonaire) peut être extrêmement élevée, malgré de faibles pressions des voies respiratoires (**Figure 1E**).

A- Lesions dus aux forces physiques sur le poumon


A Ventilation at low lung volume
End expiration
End inspiration
Atelectrauma
Lung inhomogeneity


B Ventilation at high lung volume
Normal
Hyperinflation
Air leaks
Overdistention


C Structural consequences
Sloughing of
bronchial epithelium
Epithelial–mesenchymal
transformations
Hyaline
membranes
Alveolus
Pulmonary
edema
Surfactant dysfunction
Fibroproliferation
Increased
alveolar–capillary
permeability
Barotrauma
Alveolus
Atelectasis
Alveolus


Biologic alterations
Increased concentrations of:
Hydroxyproline
Transforming growth factor-β
Interleukin-8
Release of mediators:
Tumor necrosis factor α (TNF-α)
β-catenin
Interleukin-6 (IL-6)
Interleukin-1β (IL-1β)
Recruitment of:
Pulmonary alveolar macrophages (PAMs)
Neutrophils
Activation of epithelium
and endothelium
TNF-α
β-catenin
IL-1β
IL-6
PMN
PAM
Physiological abnormalities
Increased physiological
dead space
Decreased compliance
Decreased Pa_{O_2}
Increased Pa_{CO_2}

Systemic effects
LPS
Bacteria
Mediators
Capillary
Translocation of:
Lipopolysaccharides (LPS)
Bacteria
Various mediators
Multiple mechanisms
(e.g., increased apoptosis)
Multiorgan
dysfunction
Death

B- FORCES BIOLOGIQUES

- Les forces physiques décrites ci-dessus peuvent provoquer la libération de divers médiateurs intracellulaires [21] soit directement (en blessant diverses cellules) soit indirectement (en transduisant ces forces en activation des voies de signalisation cellulaire dans les cellules épithéliales, endothéliales ou inflammatoires). Certains médiateurs peuvent directement blesser le poumon ; d'autres peuvent préparer le terrain pour le développement ultérieur de la fibrose pulmonaire. [22] Des médiateurs supplémentaires peuvent agir comme des molécules de homing recrutant des cellules (par exemple, des neutrophiles) dans les poumons, et ces cellules peuvent alors libérer des molécules plus nocives (**Figure 2**).
- Ce processus a été appelé biotraumatisme. [23] La translocation de médiateurs, [24] bactéries, [25] ou lipopolysaccharide [26] des espaces aériens dans la circulation systémique peut se produire dans les poumons qui ont une perméabilité alvéolo-capillaire accrue, inhérente au SDRA ou induite par un volutraumatisme ou des microdéchirures épithéliales. Cette translocation peut entraîner un dysfonctionnement ultérieur de plusieurs organes et la mort [27] (**Figure 2**).

Protective ventilation strategy

Concept d’Anesthésie Moderne

Modalites ventilatoires protectrices

- Vt bas/peep élevée
- Vt/ poids ideal
- PCO_2 permicive
- Pression oesophagienne pour optimiser la Peep
- Manoevres de recrutement : 30 -30 -30 cm H_2O
- Augmentation progressive du Vt / 30 mn

Un changement de dogme

- Objectif de la ventilation : échange gazeux
- Objectif actuel: échange gazeux qui maintien la vie en minimisant les lésions pulmonaires
- La reconnaissance de l'importance des lésions pulmonaires induites par la ventilation a conduit à un changement marqué dans la philosophie sous-jacente à la fourniture de la ventilation mécanique. Alors qu'auparavant, les objectifs de la ventilation mécanique étaient de maintenir les échanges gazeux tout en minimisant le travail respiratoire, un objectif supplémentaire a été établi : fournir des échanges gazeux maintiennent la vie tout en minimisant les lésions pulmonaires induites par le ventilateur.

Comment réduire l'incidence des PPCs

- Il est de plus en plus évident que la ventilation mécanique de protection pulmonaire peropératoire utilisant :
- ✓ faibles volumes courant,
- ✓ avec ou sans niveaux élevés de pression expiratoire positive (PEEP), et
- ✓ Manœuvres de recrutement

3. Fernández-Pérez ER,: Intraoperative ventilator settings and acute lung injury after elective surgery: A nested case control study. Thorax 2009; 64:121–7
4. H emmes SN, Intraoperative ventilatory strategies to prevent postoperative pulmonary complications: A meta-analysis. Curr Opin Anaesthesiol 2013; 26:126–33
5. Futier E, Protective lung ventilation in operating room: A systematic review. Minerva Anestesiol 2014; 80:726–35
6. Gajic O, U.S. Critical Illness and Injury Trials Group: Lung Injury Prevention Study Investigators (USCIITG-LIPS): Early identification of patients at risk of acute lung injury: Evaluation of lung injury prediction score in a multicenter cohort study. Am J Respir Crit Care Med 2011; 183:462–70

EJA

Eur J Anaesthesiol 2018; **35**:1–9

ORIGINAL ARTICLE

Protective ventilation during anaesthesia reduces major postoperative complications after lung cancer surgery

A double-blind randomised controlled trial

Emmanuel Marret, Raphael Cinotti, Laurence Berard, Vincent Piriou, Jacques Jobard, Benoit Barrucand, Dragos Radu, Samir Jaber and Francis Bonnet, and the PPV Study Group

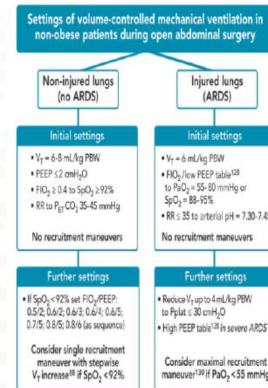
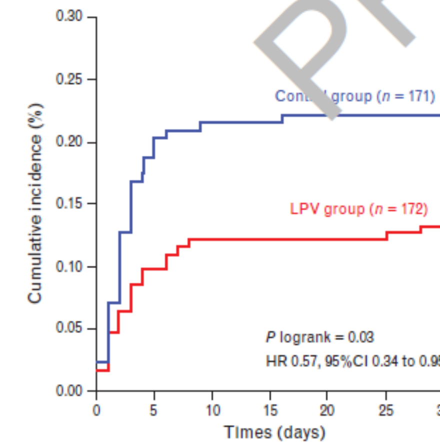


Fig. 7. Proposed settings of protective mechanical ventilation in nonobese patients during open abdominal surgery according to the concept of intraoperative permissive atelectasis. ARDS = acute respiratory distress syndrome; FiO_2 = inspiratory oxygen fraction of oxygen; PaO_2 = partial pressure of arterial oxygen; PBW = predicted body weight; PEEP = positive end-expiratory pressure; $PETCO_2$ = end-tidal pressure of carbon dioxide; Pplat = inspiratory airway plateau pressure; RR = respiratory rate; SpO_2 = peripheral oxygen saturation; V_T = tidal volume.

Fig. 2

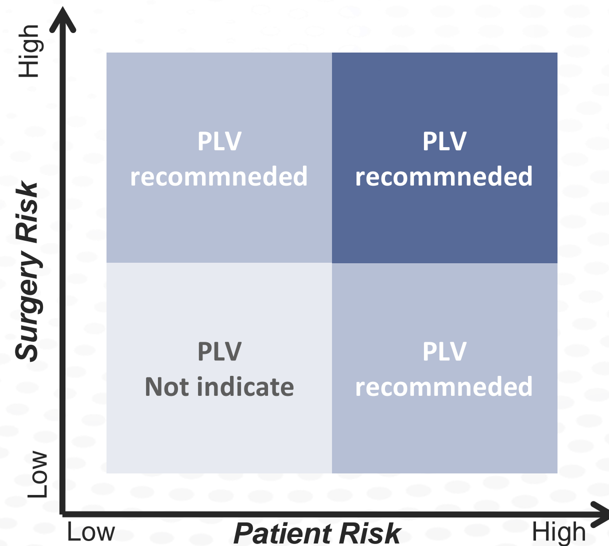


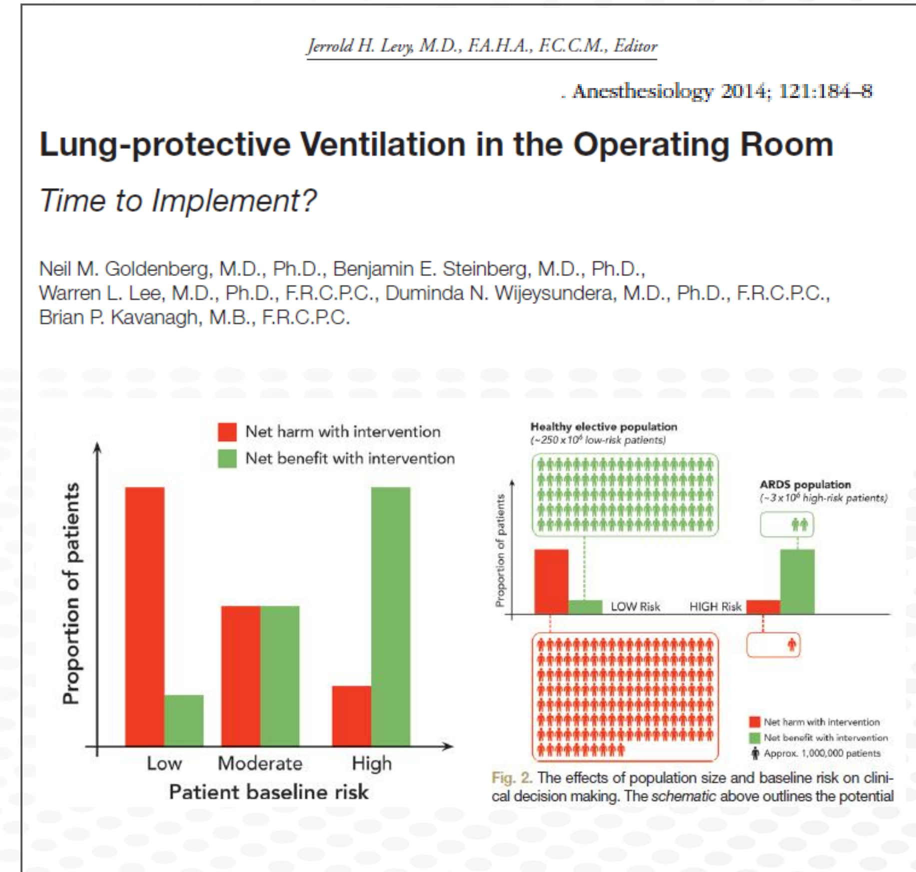
No. at risk	D0	D5	D10	D15	D20	D25	D30
Control group	171	139	135	135	134	134	134
LPV group	172	157	152	152	152	151	150

A9 Anesthesia Workstation | All-round Safety

Comment réduire l'incidence des PPCs

- Réglage optimal de la ventilation pour chaque patient
- Différences entre l'USI et l'anesthésie
- Les poumons sont habituellement normaux dans les salles d'opération
- Équilibre entre les avantages et les risques
- Patient à faible risque : risque> bénéfice
- Patient à risque élevé : bénifice > risque
-





Jerrold H. Levy, M.D., F.A.H.A., F.C.C.M., Editor

Anesthesiology 2014; 121:184–8

Lung-protective Ventilation in the Operating Room

Time to Implement?

Neil M. Goldenberg, M.D., Ph.D., Benjamin E. Steinberg, M.D., Ph.D., Warren L. Lee, M.D., Ph.D., F.R.C.P.C., Duminda N. Wijeysundera, M.D., Ph.D., F.R.C.P.C., Brian P. Kavanagh, M.B., F.R.C.P.C.

Fig. 2. The effects of population size and baseline risk on clinical decision making. The *schematic* above outlines the potential

A9 Anesthesia Workstation | All-round Safety

Protective ventilation

Stratégie de ventilation protectrice

1 Optimal PEEP ⇨ Pression transpulmonaire

2 Recrutement pulmonaire ⇨ Outil de recrutement

3 Volume courant bas ⇨ Vt/poids idéal

A9 Anesthesia Workstation | All-round Safety

Comment décider de la PEP optimale?

- Experts option

✓ Basé sur le rapport Pep / Fio_2 révisé-tableau PEEP (tutoriels CCM ou NIH ARDSnet)

OXYGENATION GOAL: PaO_2 55-80 mmHg or SpO_2 88-95%
Use a minimum PEEP of 5 cm H_2O. Consider use of incremental FiO_2/PEEP combinations such as shown below (not required) to achieve goal.

Lower PEEP/higher FiO2

FiO_2	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.7
PEEP	5	5	8	8	10	10	10	12

FiO_2	0.7	0.8	0.9	0.9	0.9	1.0
PEEP	14	14	14	16	18	18-24

Higher PEEP/lower FiO2

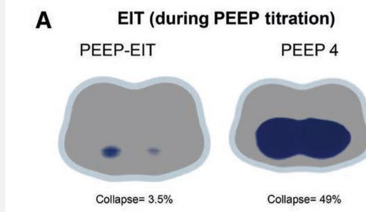
FiO_2	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5
PEEP	5	8	10	12	14	14	16	16

FiO_2	0.5	0.5-0.8	0.8	0.9	1.0	1.0
PEEP	18	20	22	22	22	24

- Par imagerie
- CT scan

✓ Ultrasound

✓ Imagerie pulmonaire fonctionnelle

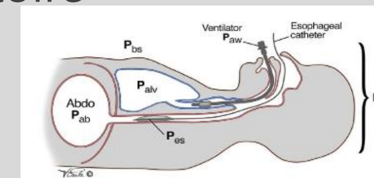


- Par échange de gaz/mécanique du système respiratoire

✓ Boucle pression /volume de (point d'inflection)

✓ Test PEP à l'expiration (meilleure conformité)

✓ Par pression transpulmonaire



Ann Transl Med 2017;5(14):288
Anesthesiology, V 129 • No 6,2018

A9 Anesthesia Workstation | All-round Safety

Surveillance de la pression transpulmonaire pour guider la PEP

Review Article
Ann Transl Med 2018;6(19):379
Page 1 of 6

Respiratory mechanics during general anaesthesia

Lorenzo Ball[1,2], Federico Costantino[1,2], Martina Fiorito[1,2], Sara Amodio[1,2], Paolo Pelosi[1,2]

[1]Anaesthesia and Intensive Care, San Martino Policlinico Hospital, IRCCS for Oncology, Genoa, Italy; [2]Department of Surgical Sciences and Integrated Diagnostics, University of Genoa, Genoa, Italy
Contributions: (I) Conception and design: L Ball, P Pelosi; (II) Administrative support: None; (III) Provision of study materials or patients: None; (IV) Collection and assembly of data: None; (V) Data analysis and interpretation: None; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.
Correspondence to: Lorenzo Ball. Anaesthesia and Intensive Care, San Martino Policlinico Hospital, IRCCS for Oncology, Genoa, Italy; Department of Surgical Sciences and Integrated Diagnostics, University of Genoa, Genoa, Italy. Email: lorenzo.ball@edu.unige.it.

Surveillance de la pression transpulmonaire

- **Titrer la PEP optimale en Conserver la pression transpulmonaire en fin d'exp au-dessus de zéro, en évitant le collapsus alvéolaire. 1,2**
- **Limiter le volume courant ou la pression de pointe pour maintenir la pression transpulmonaire terminale inférieure à 20 cmH2O ,** éviter les barotraumatismes. 1,2

[1] Mechanical ventilation guide by esophageal pressure in ALI, NEJM, 2008
[2] Lung recruitment in obese patient with ARDS. Anesthesiology 2019

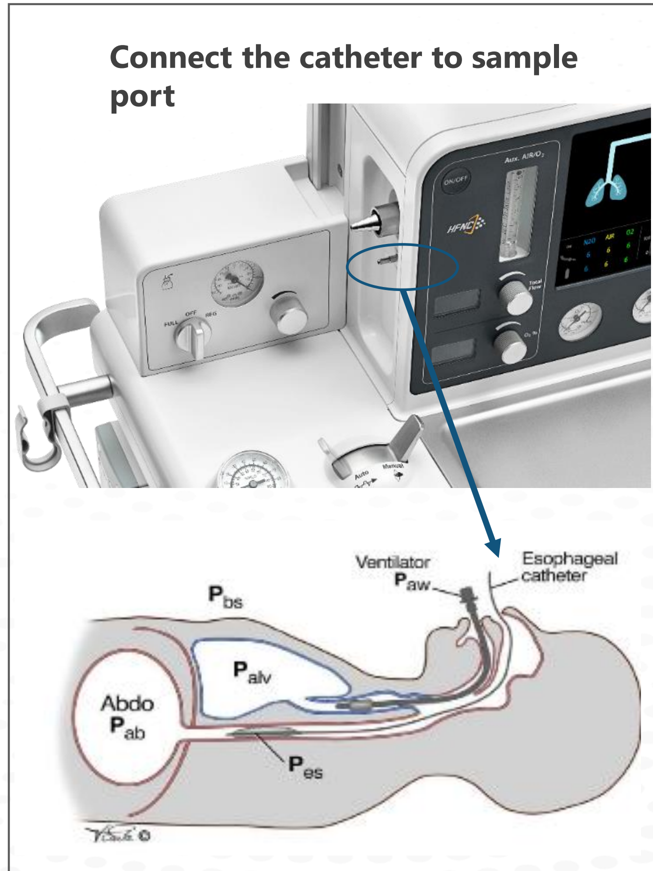
Transpulmonary pressure

Another fundamental concept debated in clinical settings is the transpulmonary pressure (P_L), defined as the actual pressure distending the lung, defined as the difference between the airway pressure and the pleural pressure (19). This measurement is used to estimate P_L both at end-inspiration and end-expiration. In order to eliminate the resistance component, the inspiratory pressure is usually acquired in absence of flow. In addition, instead of the pleural pressure that is challenging to be acquired in clinical settings, oesophageal pressure (P_{es}) is measured through an oesophageal balloon catheter that gives an acceptable, even if questioned (20), approximation of pleural pressure. In summary, at end inspiration $P_{L,\ end\text{-}inspiration} = P_{plat} - P_{es,\ end\text{-}inspiration}$ while $_{at\ end\text{-}expiration}$ $P_{L,\ end\text{-}expiration} = P_{EEP} - P_{es\ ,\ end\ expiration}$ (19). The $P_{L,\ end\text{-}inspiration}$, may be used to estimate the maximal stress of the lung at inspiration (avoiding values higher than 20 cmH_2O). On the other hand, $P_{L,\ end\text{-}expiration.}$ may help to optimize the level of PEEP to avoid opening and closing of the alveolar units and hopefully lung injury. For this aim, PEEP is set at a value in order to zeroed or reaching positive (+2 cmH_2O) values od $P_{L,\ end\text{-}expiration}$ However, the need for an oesophageal balloon limits the application of this technique mainly for research purposes. Further, the correct, accurate and precise interpretation of oesophageal pressure is under discussion.

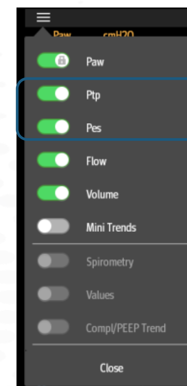
A9 Anesthesia Workstation | All-round Safety

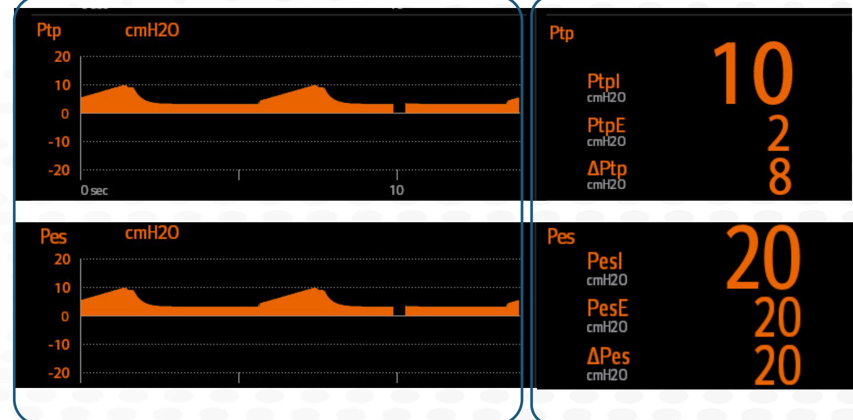
Ventilation protectrice
- Surveillance de la pression transpulmonaire

Connect the catheter to sample port



Waveform and monitoring parameters





Waveform of transpulmonary pressure and esophageal pressure

Monitoring parameters of transpulmonary pressure and esophageal pressure

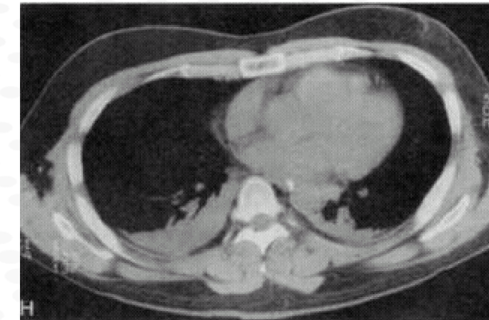
Recrutement

Le recrutement est une stratégie visant à réexpanssion du tissu pulmonaire effondré, puis à maintenir une PEP élevée pour prévenir le « désrecrutement » ultérieur.

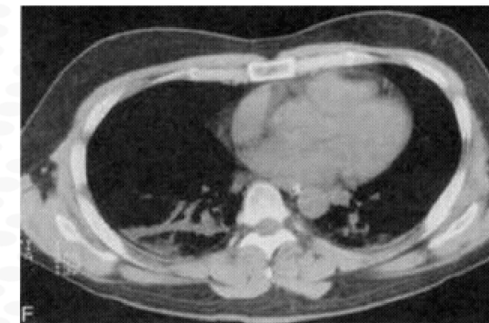
http://www.anaesthetist.com/icu/organs/lung/recruit/Findex.htm

Comment faire le recrutement pulmonaire

- ✓ **Ouvrez les alvéoles effondrées et gardez-les ouvertes**
- ✓ Pour augmenter la surface d'échange @ la membrane alvéole-capillaire (plus d'O2 dedans, plus de CO2 dehors)
- ✓ Pour éviter les complications pulmonaires intra et postopératoires



Before RM



After RM

Magnusson L, Spahn D – New concepts of atelectasis during general anesthesia. British Journal of Anesthesia, 2003;91:61-72.

A9 Anesthesia Workstation | All-round Safety

Recrutement

Trois types de manœuvres de recrutement

Manœuvre1 : Compression du bollon

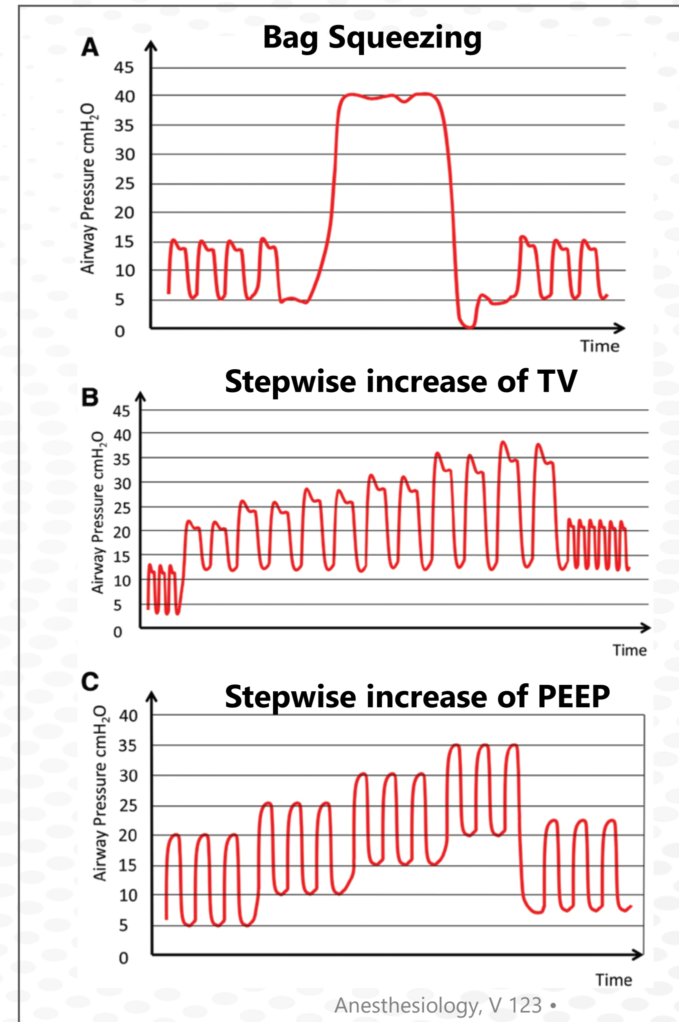
Usage courant, mais reprise du risque de barotraumatisme et désamorssage cardiac

Manœuvre2 : Augmentation progressive du volume courant

Pas de 4 ml / kg jusqu'à la pression d'ouverture cible (30-40cmH2O), Débit 6-8 bpm

Manœuvre3 : Augmentation progressive de la PEP

Pallier de 5cmH2O (jusqu'à 20cmH2O), pression d'entraînement 15-20cmH2O

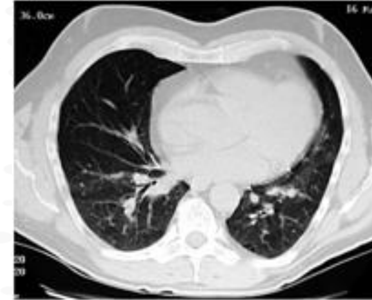


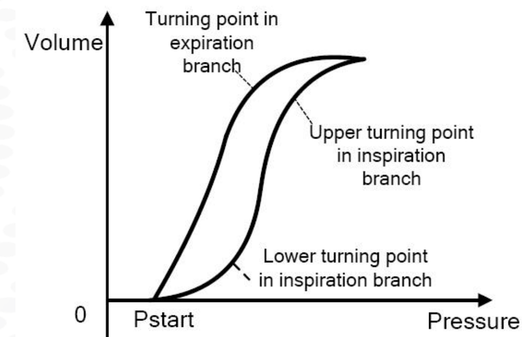
Anesthesiology, V 123 • No 3

A9 Anesthesia Workstation | All-round Safety

Comment évaluer la capacité de recrutement pulmonaire

- **Méthode 1**: CT Scan
- Golden standard
  - Difficile à exécuter pendant la chirurgie
  - **Méthode 2:** Mécanique respiratoires
  - ✓ Tidal Volume
  - ✓ Compliance
  - ✓ Boucle pression-volume
  - ✓ Obtenu de l'appareil d'anesthésie directement et facilement
- **Méthode 3:** Oxygénation
- SpO2 or PaCO2

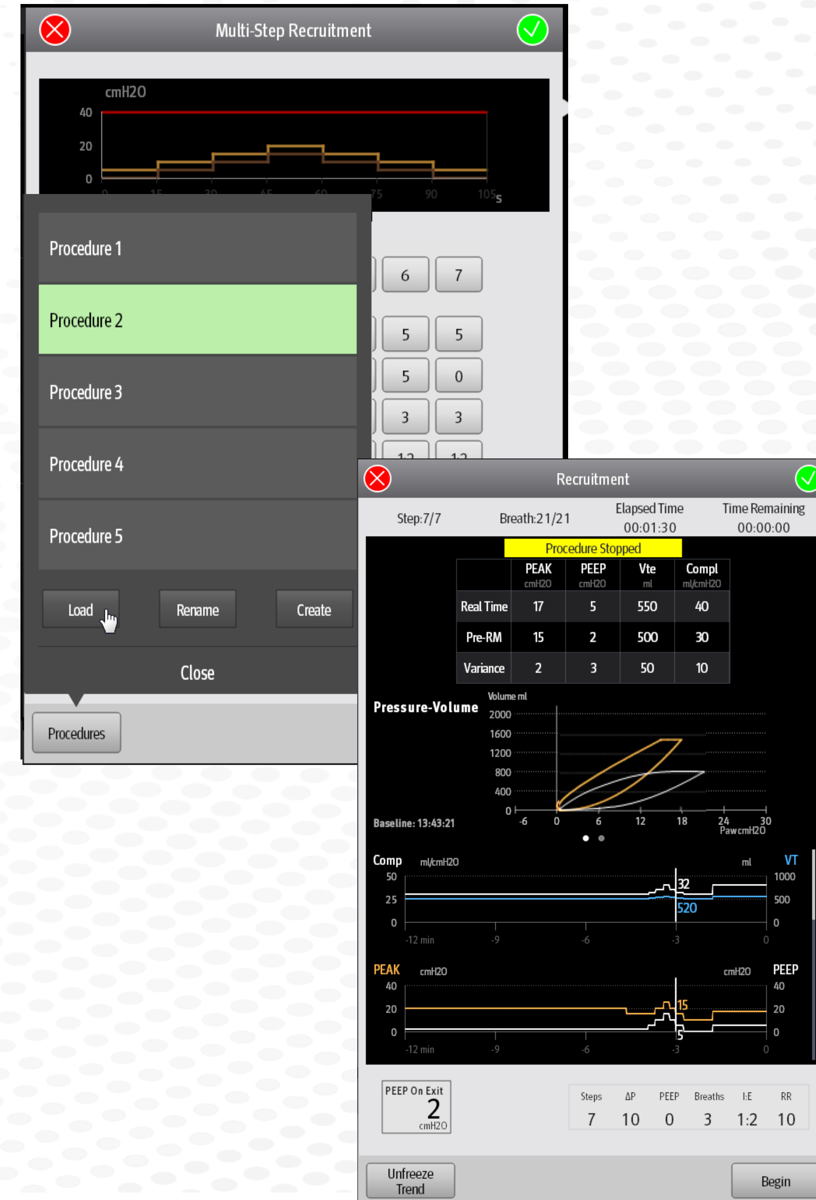




A9 Anesthesia Workstation | All-round Safety

Protective ventilation tools in A9/A8 - Recruitment Pro tool

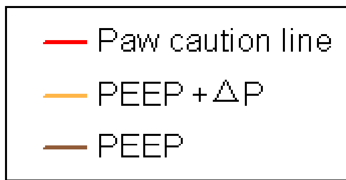
- Common maneuvers
  - ✓ One-step recruitment (Sustain Inflation)
  - ✓ Multi-step recruitment (PEEP incremental)
- Quick start and stop
  - ✓ Customized preset procedures with configurable names
  - ✓ Schedule recruitment automatically
- Multi criteria to evaluate outcomes
  - ✓ Real time value and trend of Pressure, VTe, Comp
  - ✓ Loops (P-V, F-V) before and after RM



All-round Safety

Recruitment Pro tool – Multi-step recruitment

Multi-step procedure (Setup)



Preview of current procedure

The protocol of current procedure
All the grids are configurable

PEEP setting after RM
“optimal PEEP” decided during RM

Load a preset procedure
Up to 5, Name can be customized

Start RM

Multi-Step Recruitment

cmH2O

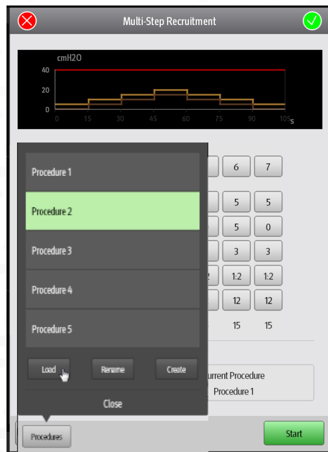
Steps	1	2	3	4	5	6	7
ΔP	5	5	5	5	5	5	5
PEEP	0	5	10	15	10	5	0
Breaths	3	3	3	3	3	3	3
I:E	1:2	1:2	1:2	1:2	1:2	1:2	1:2
RR	12	12	12	12	12	12	12
Duration(s)	15	15	15	15	15	15	15

PEEP On Exit 0 cmH2O

Current Procedure
Procedure 1

Procedures

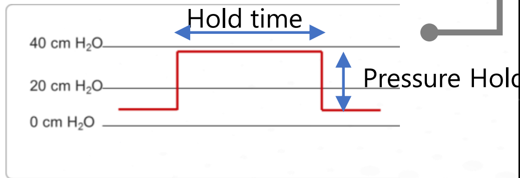
Start



A9 Anesthesia Workstation | All-round Safety

Recruitment Pro tool – One-step recruitment

one-step procedure



One-Step Recruitment

Pressure Hold	cmH2O	35
Hold Time	sec	15
PEEP On Exit	cmH2O	0
Cycle Interval	min	Off

Pressure-Volume

Volume ml

Paw cmH2O

Compl ml/cmH2O

Vte ml

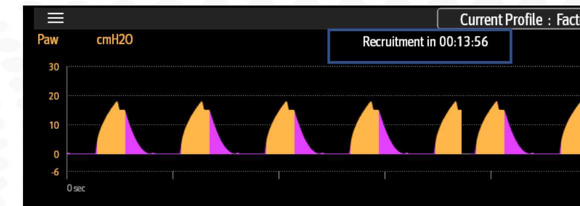
PtpE cmH2O

PEEP cmH2O

Freeze Trend

Start

Time to repeat the lung recruitment



Loops before and after RM

Trend of Compliance, VT, PEAK, PEEP and PtpE (if configured)

Freeze the trend to read single point value

Start RM by one button

A9 Anesthesia Workstation | All-round Safety

Faible volume courant et pression motrice

The NEW ENGLAND JOURNAL of MEDICINE

SPECIAL ARTICLE

N ENGL J MED 372;8 NEJM.ORG FEBRUARY 19, 2015

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.,

Higher drving pressures increase the risk of death in the hospital

Resampling A: Matched PEEP
Resampling B: Matched ΔP
Resampling C: Matched Plateau Pressure
Airway Pressure (cm of water)
ΔP
PEEP
No. of Patients in Subsample
Multivariate Relative Risk of Death in the Hospital
P<0.001
P=0.61
P<0.001
Contrast
Higher plateau pressure: Not always risky
Higher PEEP: Not always protective

Association between driving pressure and development of postoperative pulmonary complications in patients undergoing mechanical ventilation for general anaesthesia: a meta-analysis of individual patient data

Ary Serpa Neto, Sabrine N T Hemmes, Carmen S V Barbas, Martin Beiderlinden, Ana Fernandez-Bustamante, Emmanuel Futier, Ognjen Gajic, Mohamed R El-Tahan, Abdulmohsin A Al Ghamdi, Ersin Günay, Samir Jaber, Serdar Kokulu, Alf Kozian, Marc Licker, Wen-Qian Lin, Andrew D Maslow, Stavros G Memtsoudis, Dinis Reis Miranda, Pierre Moine, Thomas Ng, Domenico Paparella, V Marco Ranieri, Federica Scavonetto, Thomas Schilling, Gabriele Selmo, Paolo Severgnini, Juraj Sprung, Sugantha Sundar, Daniel Talmor, Tanja Treschan, Carmen Unzueta, Toby N Weingarten, Esther K Wolthuis, Hermann Wrigge, Marcelo B P Amato, Eduardo L V Costa, Marcelo Gama de Abreu, Paolo Pelosi, Marcus J Schultz, for the PROVE Network Investigators

Lancet Respir Med 2016
Published Online
March 3, 2016
http://dx.doi.org/10.1016/S2213-2600(16)00057-6

Department of Intensive Care
(Prof A Serpa Neto MD,

Higher drving pressures increase the risk of PPCs

2679 patients from 15 RCTs

Adjusted odds ratio (95% CI)
Low PEEP group
Decrease in driving pressure
No change in driving pressure
Increase in driving pressure
Response of driving pressure

Figure 2: Odds of postoperative pulmonary complications according to response of driving pressure after increase of PEEP
PEEP=positive end-expiratory pressure.

A9 Anesthesia Workstation | All-round Safety

Outils de ventilation de protection Indicateur Vt/IBW

- Paramètres de volume courant par défaut basés sur le poids corporel idéal (IBW).
- Calculez Vt/IBW
- Aide à régler le volume courant optimal pour éviter les barotraumatismes.
-

Vt
Range 5 - 1500 ml
496 Vt/IBW = 7.0ml/Kg
+100 +50 +25 -25 -50 -100
Total Flow 2.0 Vt 496 RR 10

Vt
Range 5 - 1500 ml
400 Vt/IBW = 5.6ml/Kg
+100 +50 +25 -25 -50 -100
Total Flow 2.0 Vt 496 RR 10

Adult Kg Age | Timer 00:00:00 | Current Mode Standby

Patient Information

Patient | Location

Size: Adult | Pediatric | Neonate

Gender: Male | Female | Unspecified

Height cm 175

IBW Kg 70.9

Weight Kg 70.0

Age yrs 40

Patient ID Please Input

Visit Number Please Input

Last Name Please Input

Find Patient

Journal of Cardiothoracic and Vascular Anesthesia 35 (2021) 2952–2960

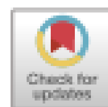
Contents lists available at ScienceDirect

Journal of Cardiothoracic and Vascular Anesthesia

journal homepage: www.jcvaonline.com

Original Article

Pulmonary Complications in Esophagectomy Based on Intraoperative Fluid Rate: A Single-Center Study



Ryan S. D'Souza, MD[*], Charles R. Sims III, MD[*,†,1], Nicole Andrijasevic, RRT, LRT[‡,§], Thomas M. Stewart, MD[*], Timothy B. Curry, MD, PhD[*], James A. Hannon, MD[*], Shanda Blackmon, MD, MPH[||], Stephen D. Cassivi, MD, MS[||], Robert K. Shen, MD[||], Janani Reisenauer, MD[||], Dennis Wigle, MD[||], Michael J. Brown, MD[*]

[*]Department of Anesthesiology and Perioperative Medicine, Mayo Clinic, Rochester, MN
[†]Division of Critical Care Medicine, Mayo Clinic, Rochester, MN
[‡]Department of Respiratory Therapy, Mayo Clinic, Rochester, MN
[§]Anesthesia Clinical Research Unit, Mayo Clinic, Rochester, MN
[||]Department of Thoracic Surgery, Mayo Clinic, Rochester, MN

Take home message

A9
Anesthesia Workstation
All-round Safety

Take home message

- La stratégie de ventilation protectrice réduit l'incidence des complications postopératoire (PPCs)
- Protection ventilatoire
  - ✓ Faible volume courant - Indicateur Vt/IBW
  - ✓ Optimal PEEP – Surveillance de la pression transpulmonaire
  - ✓ Recrutement – Outil de Recrutement
  - ✓ Recrutement Pro dans A9/A8
  - ✓ Manœuvres en une et plusieurs étapes
  - ✓ Planifier le recrutement à intervalles prédéfinis

A9 Anesthesia Workstation | All-round Safety

Merci