

CEC EN CHIRURGIE THORACIQUE

PR HADRIEN ROZÉ

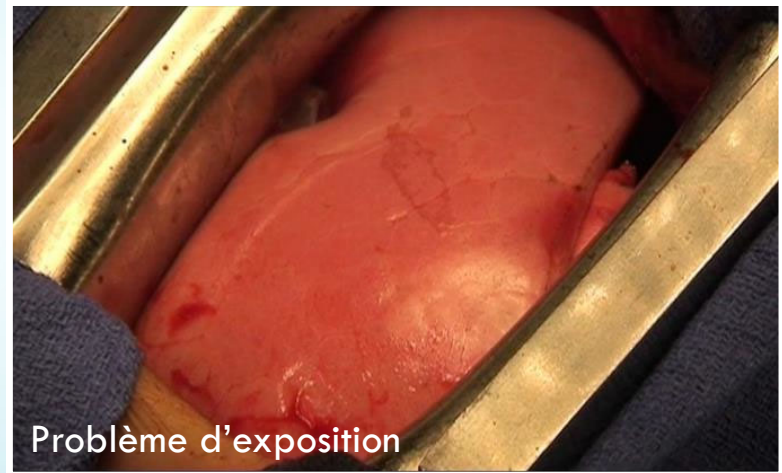
DU CEC MAI 2025

EXPOSITION CHIRURGICALE

MAINTIEN DE L'HÉMATOSE
MAINTIEN DU DÉBIT CARDIAQUE

PROTECTION VENTILATION

PROTECTION PERFUSION



CARDIAQUE ET/OU PULMONAIRE

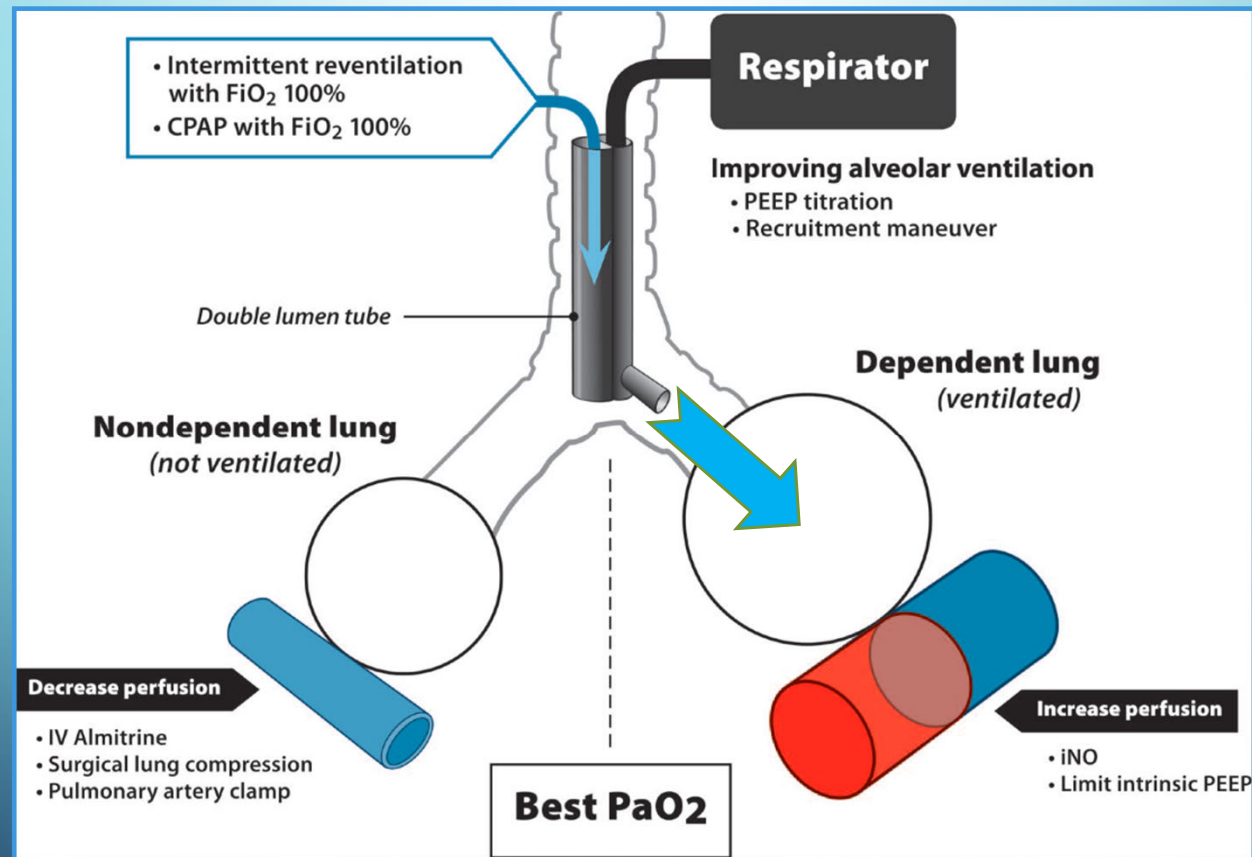
- **Assistance cardiaque**
- **Hématose 100% CEC**
 - Oxygénation
 - Décarboxylation
- **+/-Ventilation alvéolaire**
 - De 0 à 100%

- * **Assistance respiratoire**
- * Hématose mixte
- * CEC ou ECMO
- * Mécanique respiratoire
 - * Volume aéré, volume courant
 - * Pressions : Pplat, Pmo et PEEP
 - * Fréquence respiratoire

Poumons sains

Poumons lésés

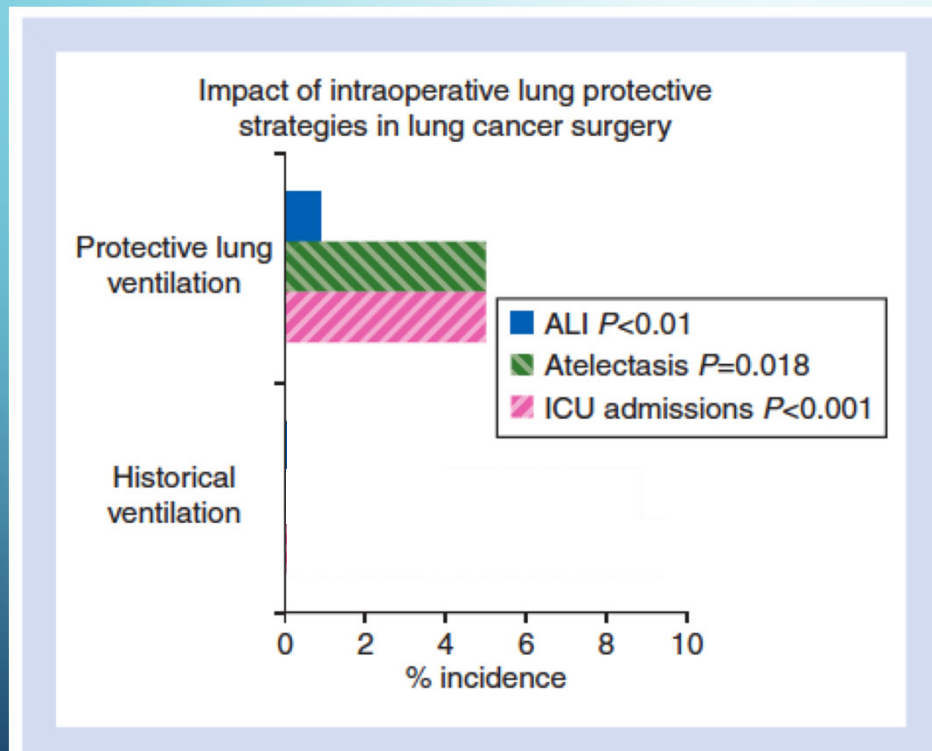
LA VENTILATION UNIPULMONAIRE



RESPIRATION AND THE AIRWAY

Lung protective strategies in anaesthesia

B. Kilpatrick* and P. Slinger



Protective

Moins de Volume = Moins de complications

VS

Historique

Gros Volume = Meilleure PaO₂

ASSISTANCE VEINO VEINEUSE

- Objectif garantir l'hémostase (sécurité): CaO_2 , pas d'assistance du débit TaO_2 et extraction du CO_2
- Possibilité de diminuer la ventilation minute: Volume et fréquence
- Possibilité d'être protecteur avec une pression motrice contrôlée

VENTILATION SOUS ECMO VV

Poumons lésés

- Hématose

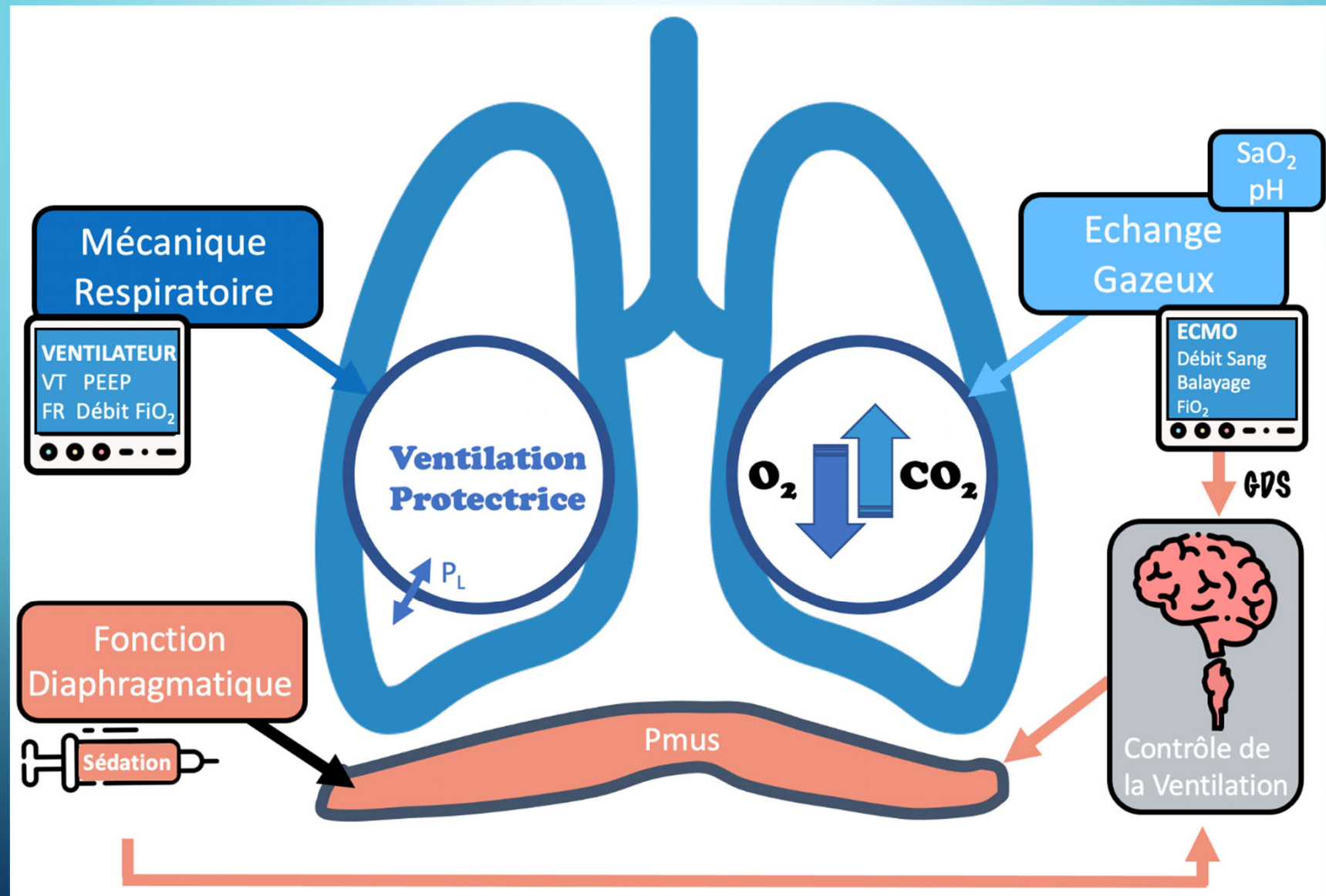
- Oxygénation
- Décarboxylation

- * Mécanique respiratoire

- * Volume aéré et volume courant
- * Pressions : Pplat Pmo et PEEP
- * Pression motrice
- * Fréquence respiratoire

Dissociation

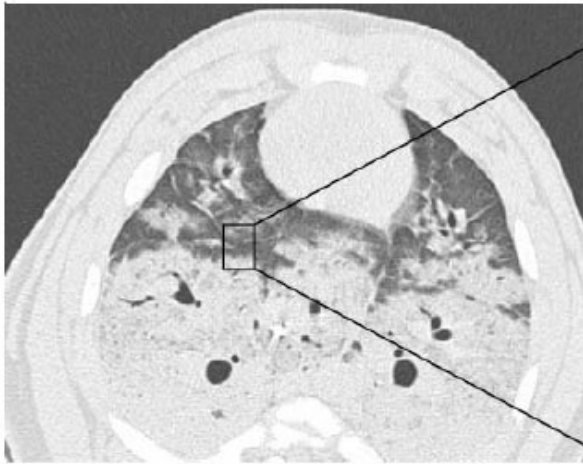




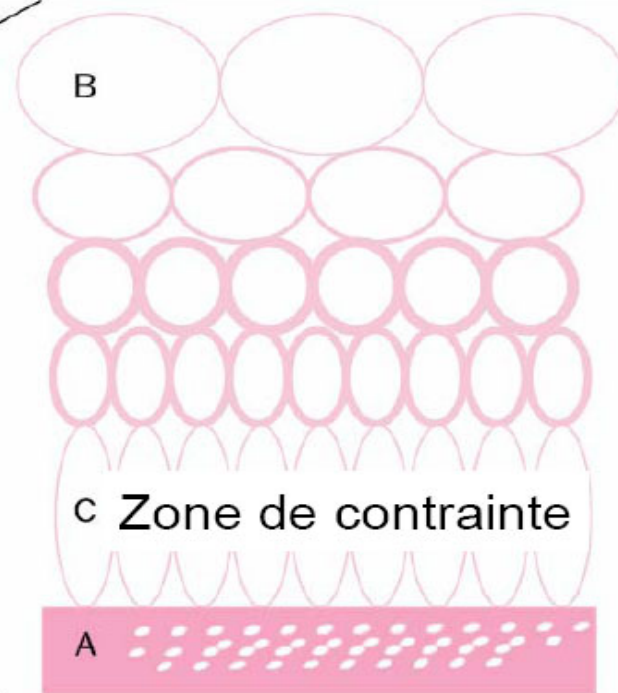
LÉSIONS ALVEOLAIRES DE LA VENTILATION



Zone de surdistension



Zone d'atelectasie



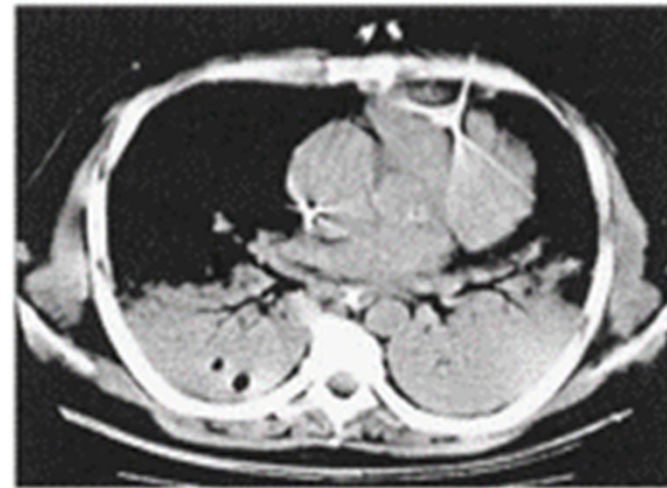
Etirement Alvéolaire



VOLUME PULMONAIRE AÉRÉ N'EST PAS LA CPT SI LÉSIONS



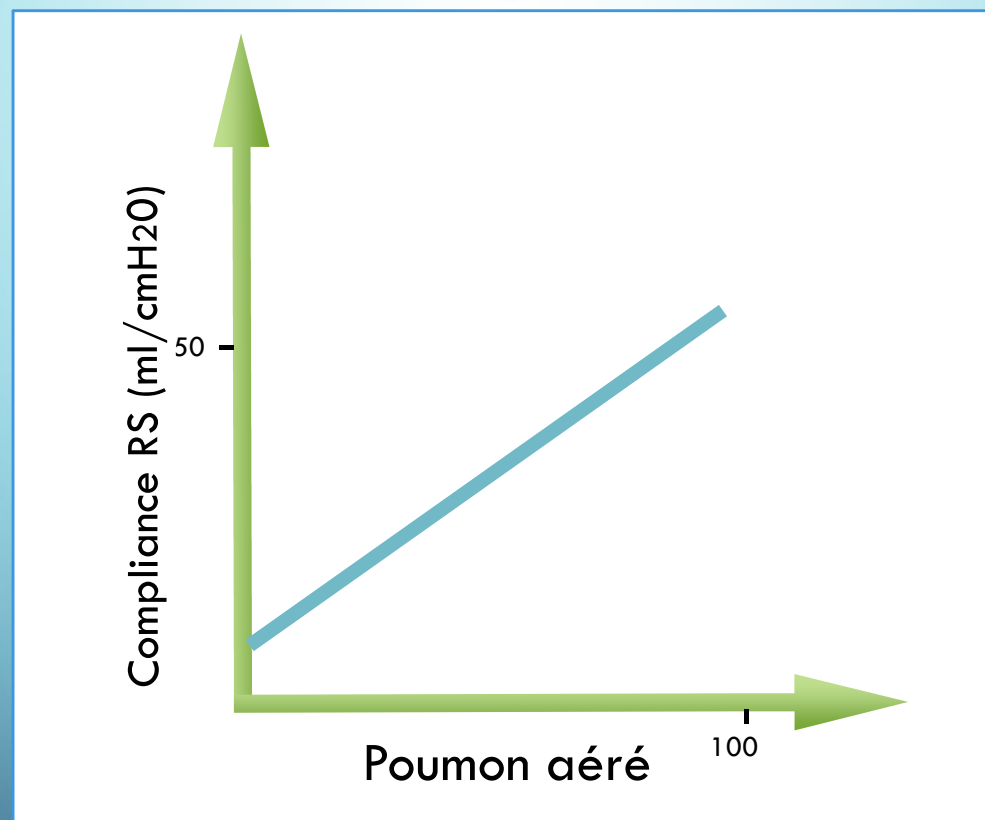
Tissu non aéré = 11,7%
 $PaO_2/FiO_2 = 350$



Tissu non aéré = 55,6%
 $PaO_2/FiO_2 = 100$

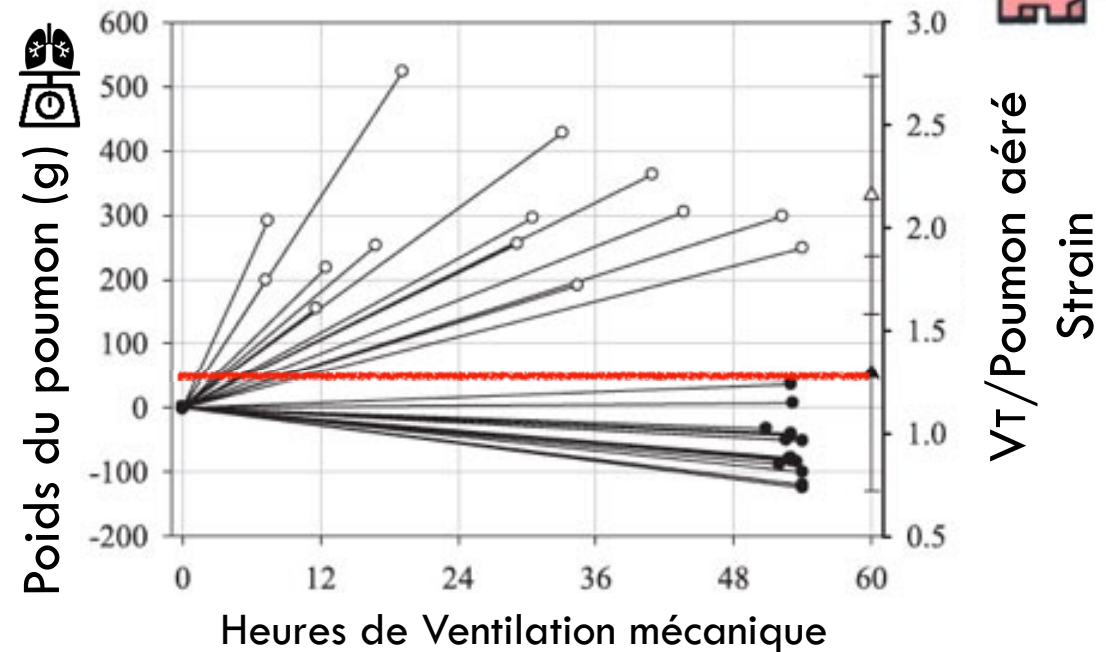
Faut il donner le même V_T ?

DANS LE SDRA LE POUMON AÉRÉ EST CORRÉLÉ À LA COMPLIANCE C_{RS}



EFFETS DU RATIO V_T /POUMON AÉRÉ SUR L'OEDEME

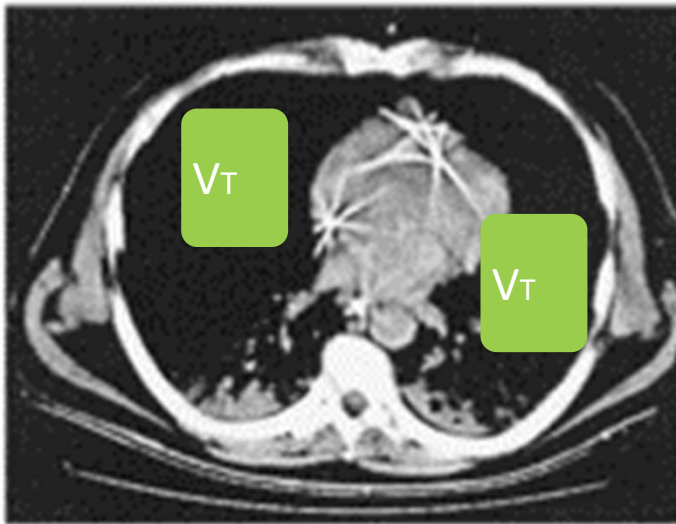
Lung Stress and Strain during Mechanical Ventilation Any Safe Threshold?



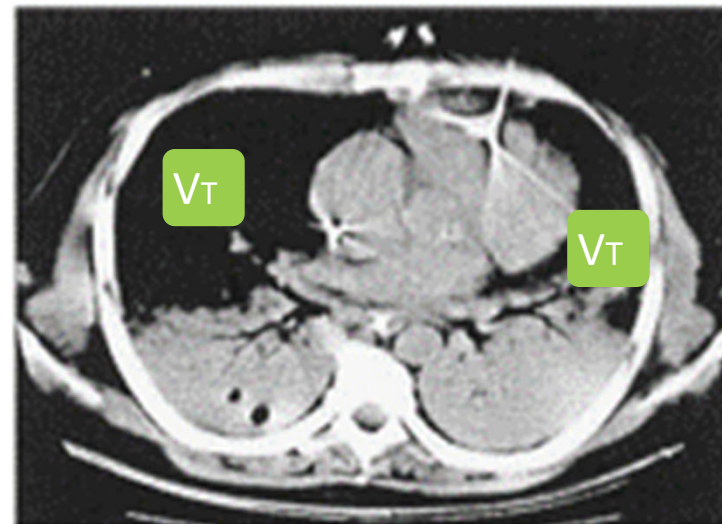
Am J respir Crit Care Med 2011;183:1354-1362

ON DOIT ADAPTÉ LE VT AU POUMON AÉRÉ (BABYLUNG)

Espace tid = VD/VT



Tissu non aéré = 11,7%
 $\text{PaO}_2/\text{FiO}_2 = 350$



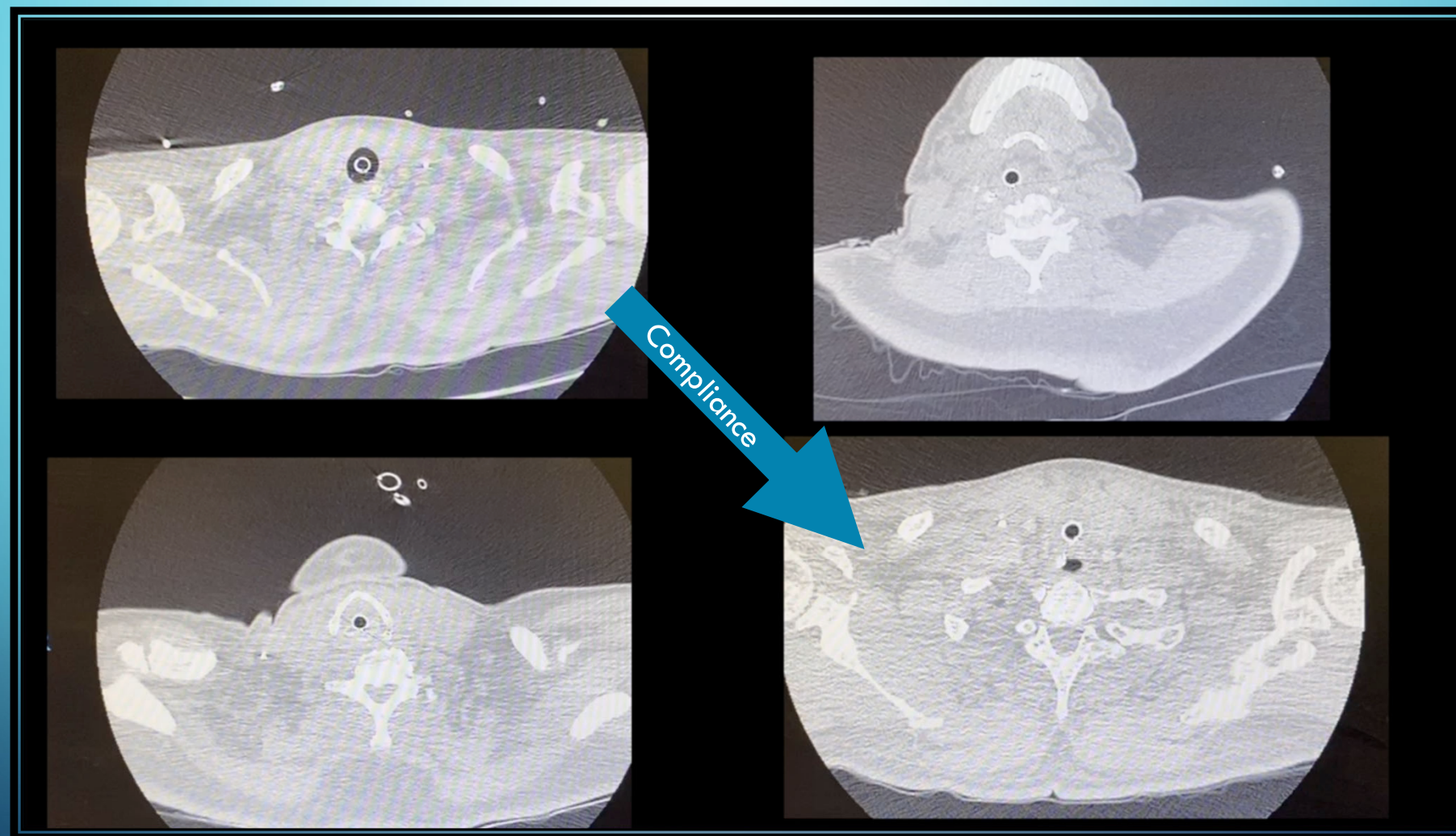
Tissu non aéré = 55,6%
 $\text{PaO}_2/\text{FiO}_2 = 100$

Hypercapnie permissive dans une certaine limite : $\text{pH} < 7,15$

- Il faut adapter le V_T au volume pulmonaire aéré
- Le volume pulmonaire aéré est corrélé à la Compliance du système respiratoire (C_{rs})
- VT normalisé à la $C_{rs} = V_T / C_{rs} = \cancel{V_T} / (\cancel{V_T} / P_{plat} - PEEP_{tot})$

Donc

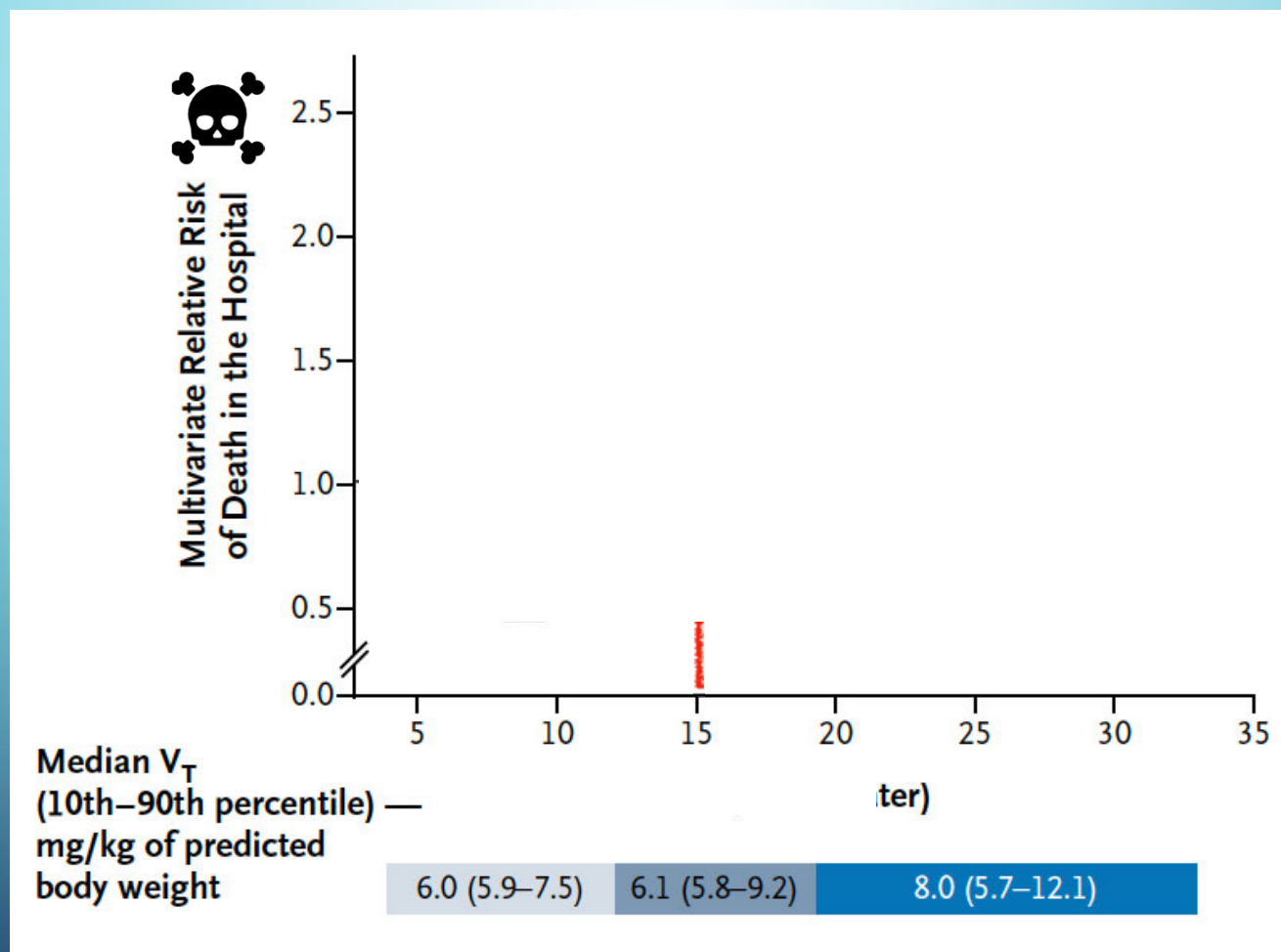
$$V_T / C_{rs} = P_{plat} - PEEP_{tot} = \text{Pression Motrice}$$



SDRA COVID-19



DIMINUER LA PRESSION MOTRICE DIMINUE LE RISQUE DE

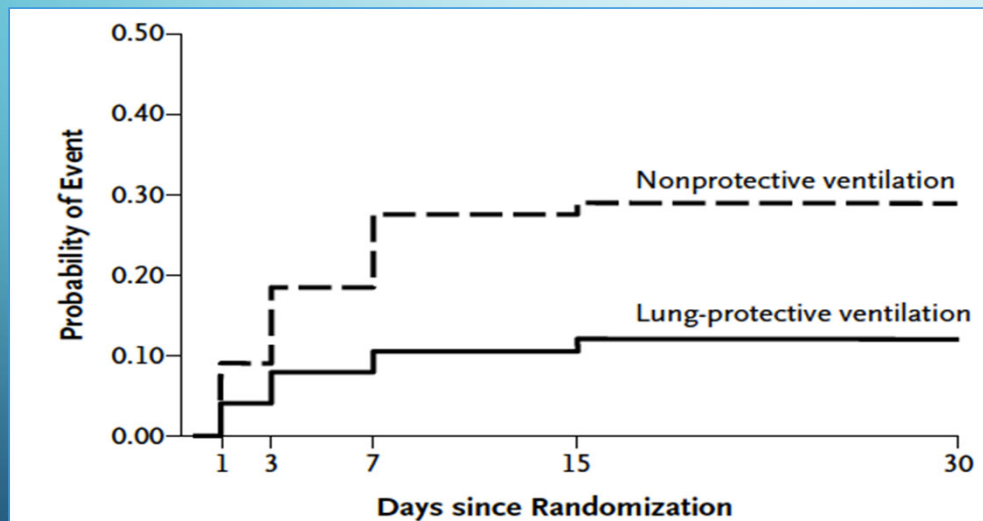


VT PER OPÉRATOIRE EN EN CHIRURGIE ABDOMINALE



Protocole de ventilation protectrice:

V_T 6 à 8 ml/kg de poids idéal, PEEP 6 à 8 cmH₂O
et MRA: PEEP 30 cmH₂O pendant 30 sec toutes les 30 minutes



MRA augmente poumon aéré
 V_t diminué à 6-8 ml/kg PP

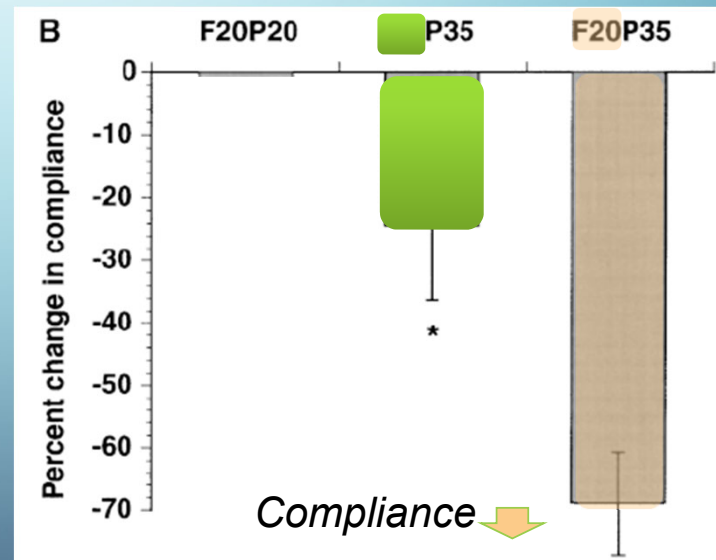
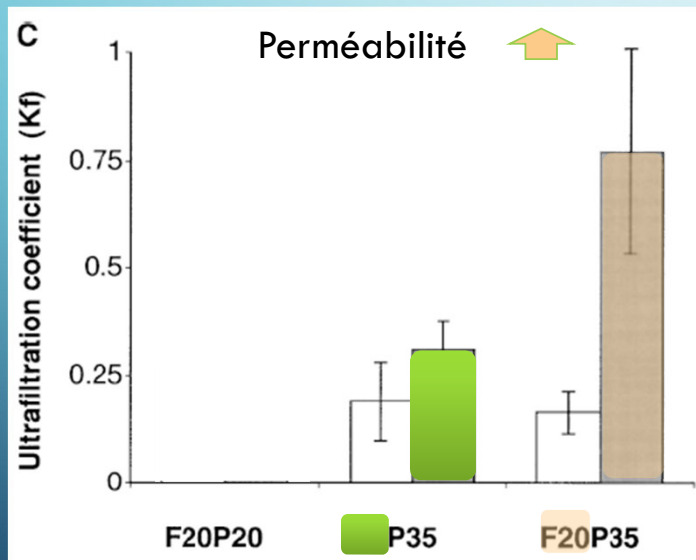
Ventilation protectrice améliore le pronostic post opératoire respiratoire

Futier et al. NEJM 2003;369:428-37

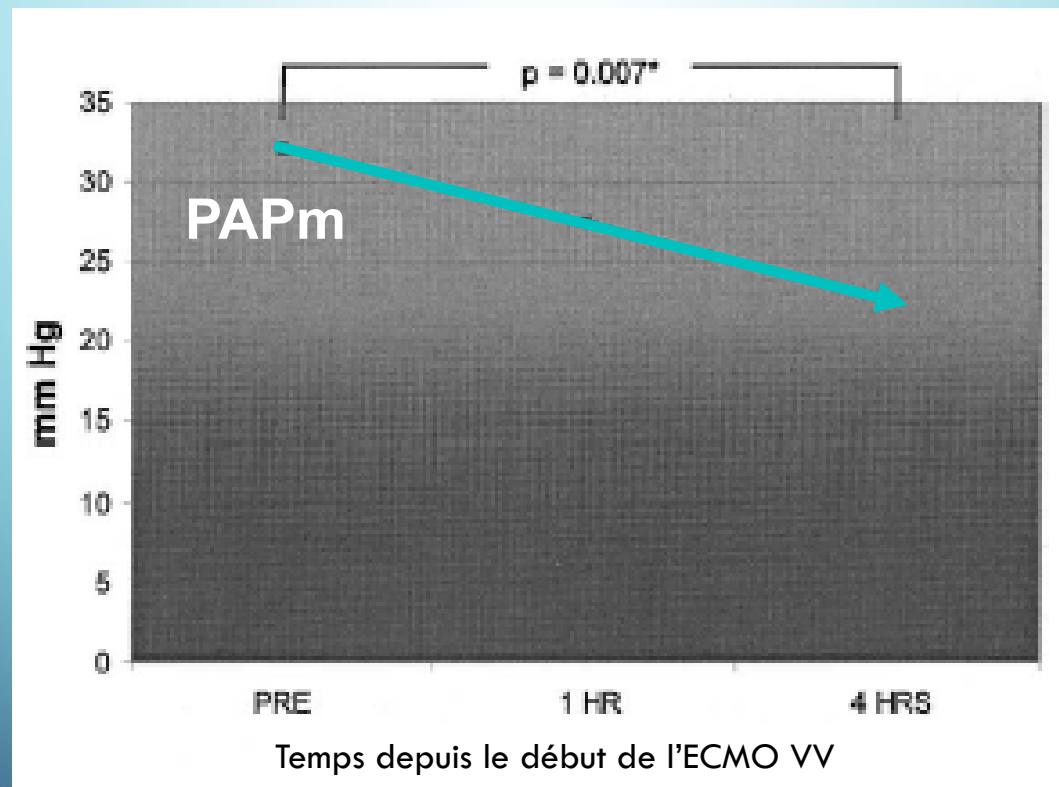
Effects of Decreased Respiratory Frequency on Ventilator-induced Lung Injury

JOHN R. HOTCHKISS, Jr., LLUIS BLANCH, GASTON MURIAS, ALEXANDER B. ADAMS, DOUG A. OLSON, O. D. WANGENSTEEN, PERRY H. LEO, and JOHN J. MARINI

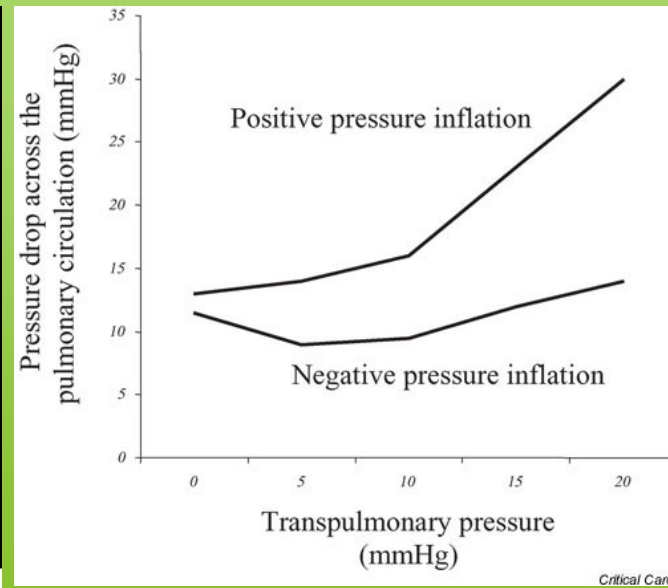
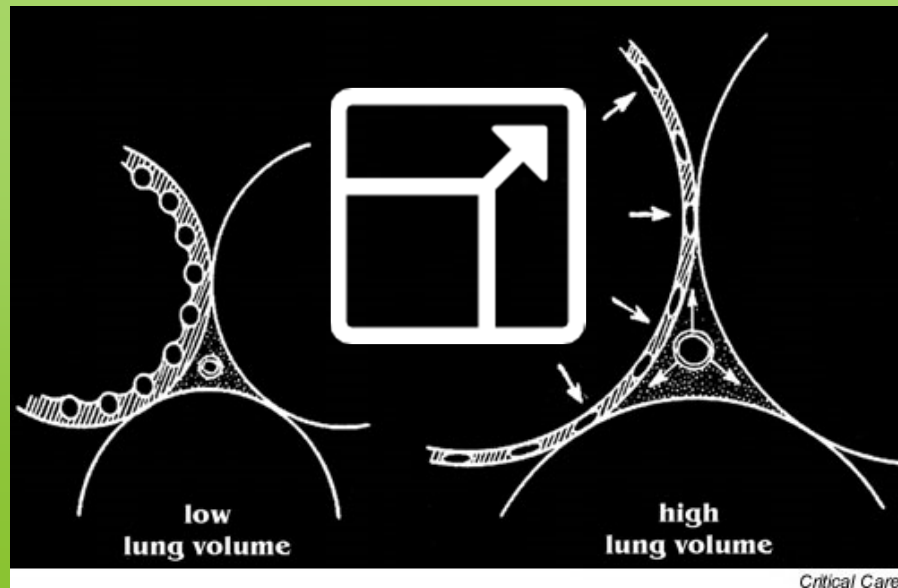
FRÉQUENCE RESPIRATOIRE



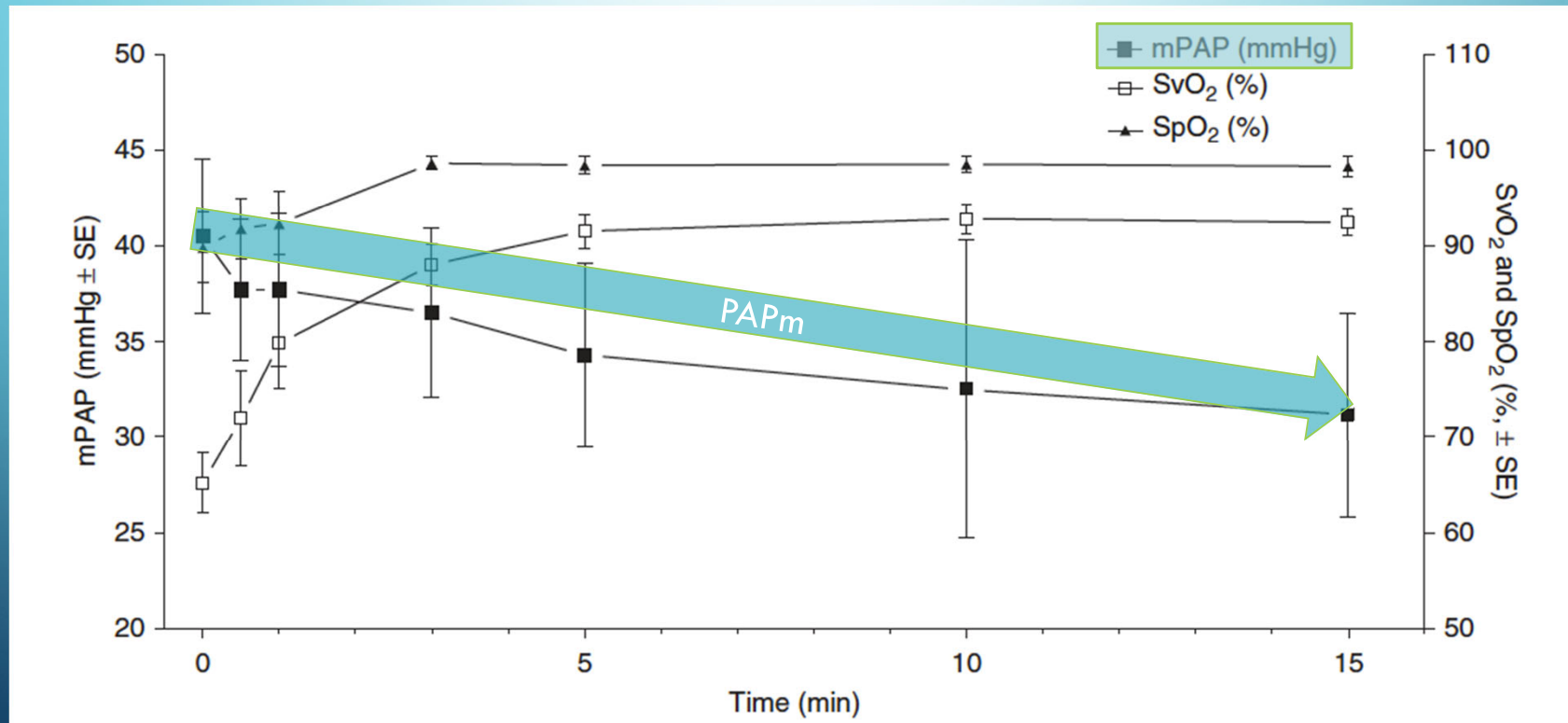
PVO₂ ELEVÉE SOUS ECMO-VV INHIBE LA VPH



Dans cette étude la ventilation n'a pas été modifiée sous ECMO !!



Right Ventricular Unloading after Initiation of Venovenous Extracorporeal Membrane Oxygenation

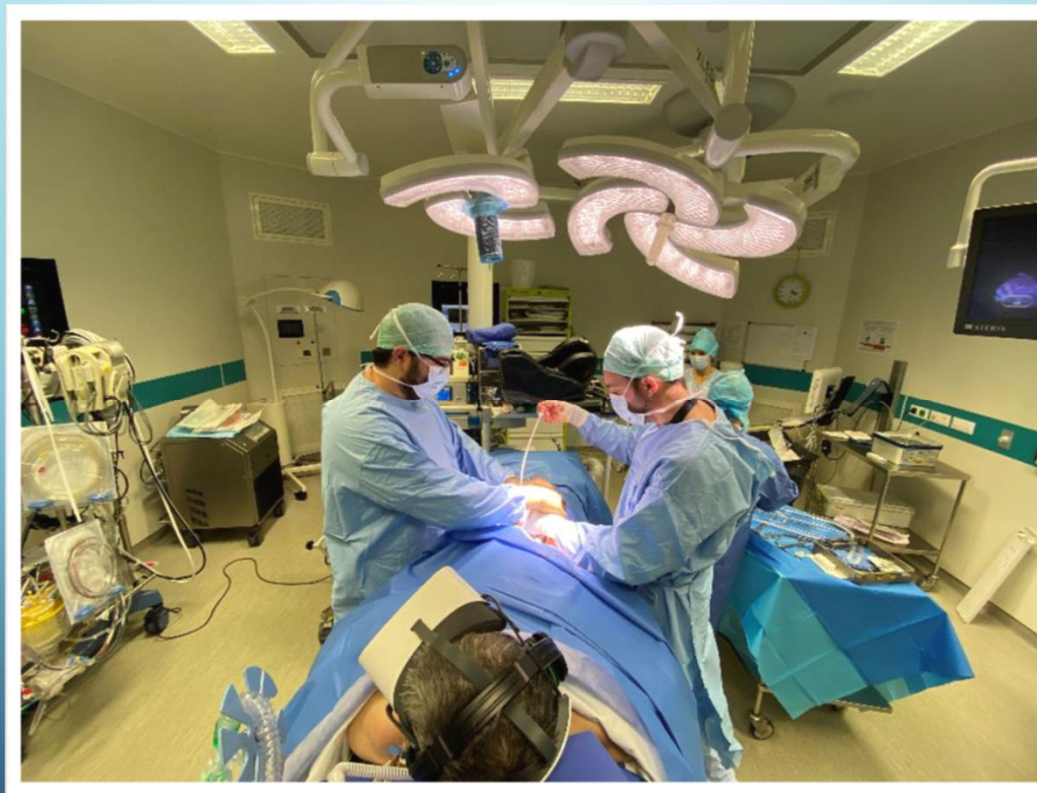


Miranda et al. AJRCCM 2015



Pression motrice
25 cmH₂O

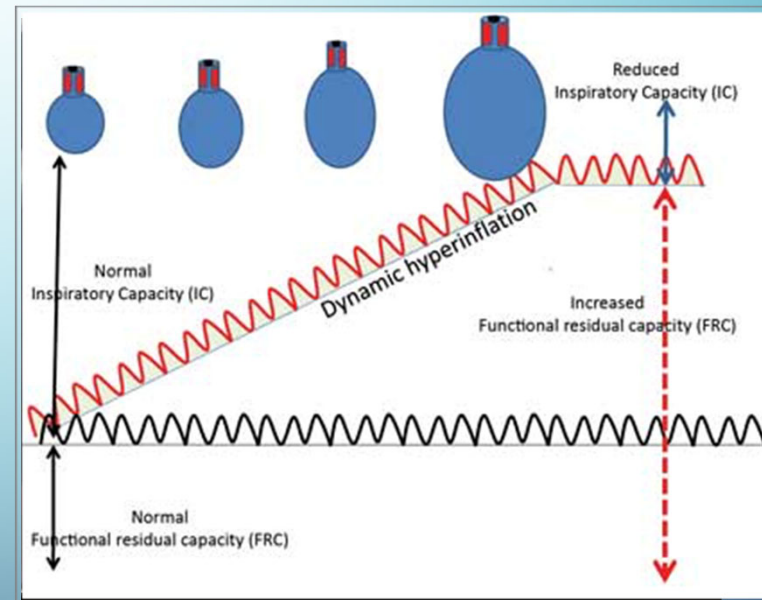
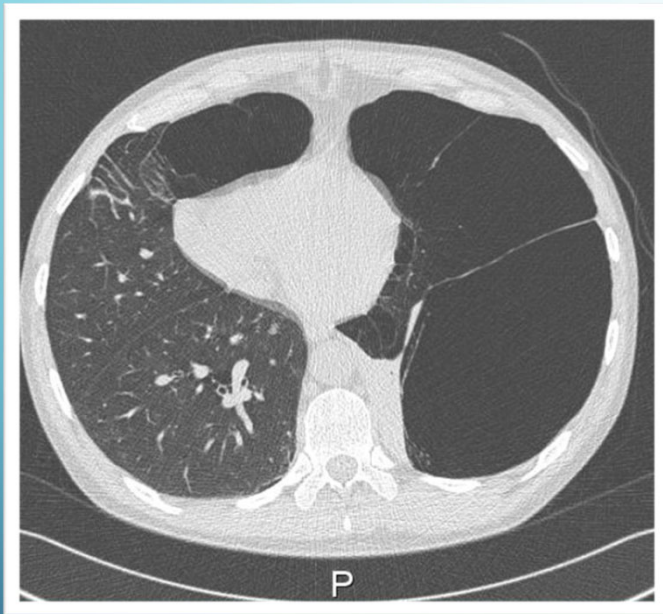
POSE SOUS HYPNOSE : RTAP & EMPHYSEME



DLD

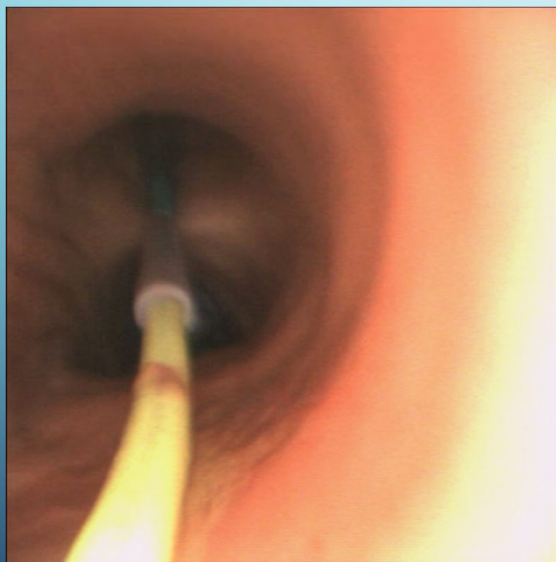


CHIRURGIE DE L'EMPHYSÈME

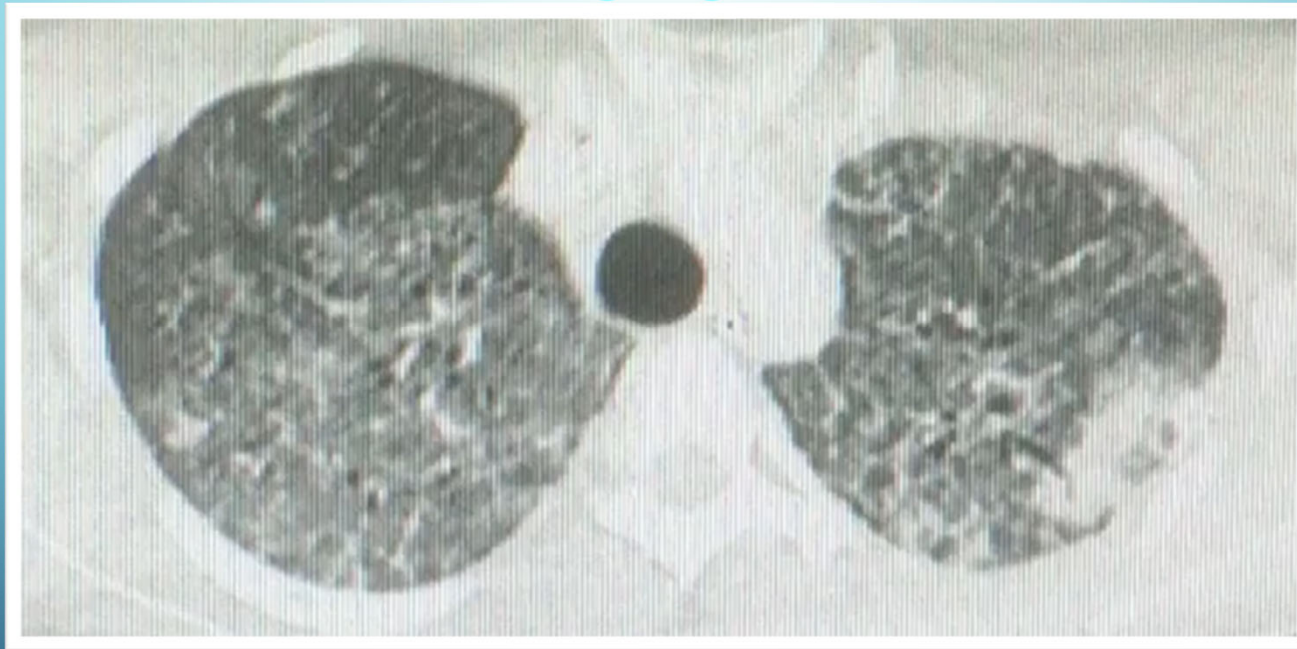


Hypoxémie, Hypercapnie, O_2 à domicile, VEMS < 50% Théo, TLCO > 30%, Cœur Pulmonaire Chronique?

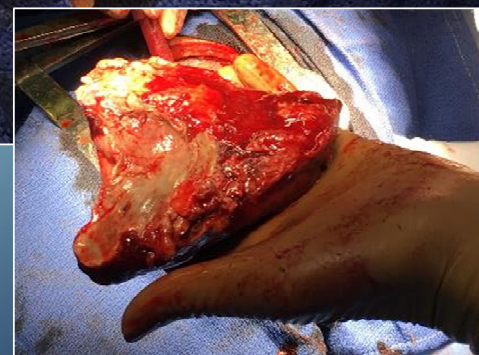
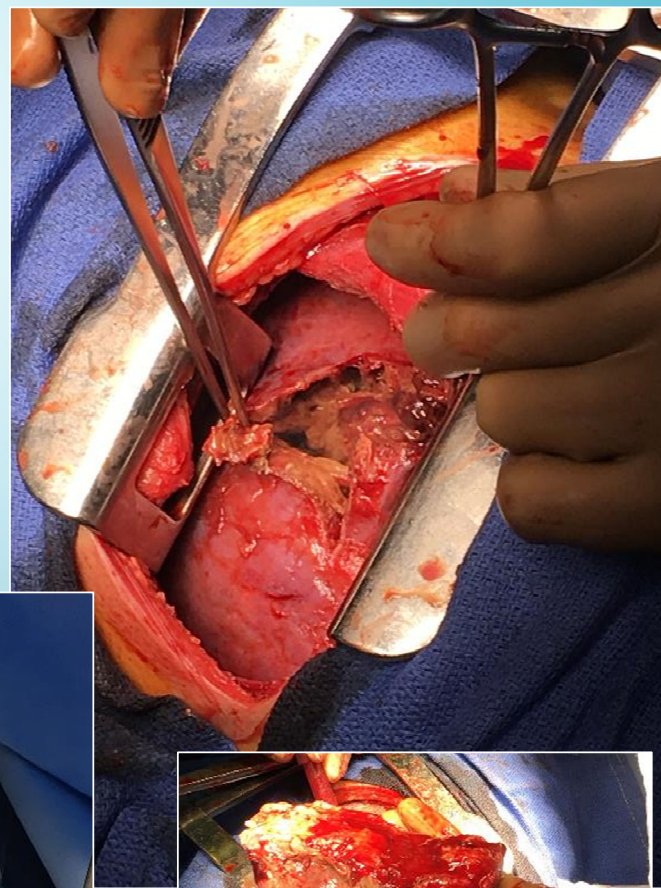
Sécurité pour l'hématose et le risque de tamponnade gazeuse



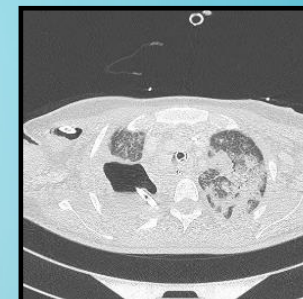
CHIRURGIE DE PROPRIÉTÉ



Contusion / abcès fistule / bronchopleurale

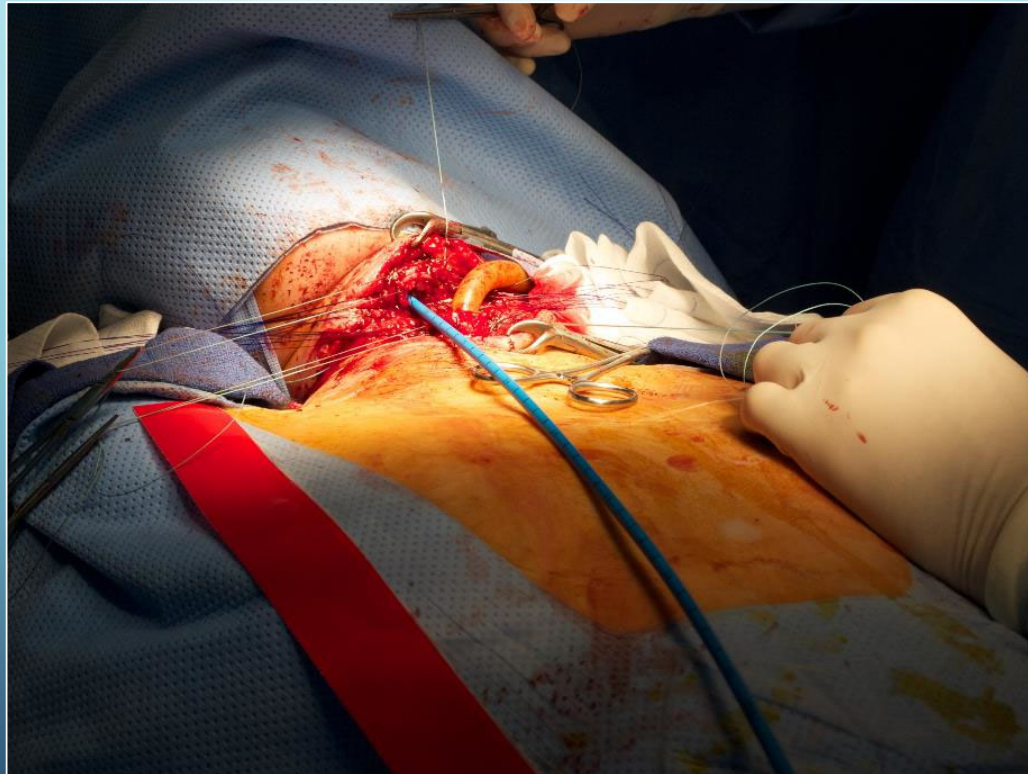


FISTULES BRONCHO PLEURALES



V_D/V_T

CHIRURGIE DE LA TRACHÉE



Flexible bronchoscopic excision of a tracheal mass under extracorporeal membrane oxygenation

Jae Jun Kim¹, Seok Whan Moon², Yong Hwan Kim¹, Si Young Choi¹, Seong Cheol Jeong¹

¹Department of Thoracic and Cardiovascular Surgery, Uijeongbu St. Mary's Hospital, College of Medicine, the Catholic University of Korea, Seoul, South Korea; ²Department of Thoracic and Cardiovascular Surgery, St. Paul's Hospital, College of Medicine, the Catholic University of Korea, Seoul, South Korea

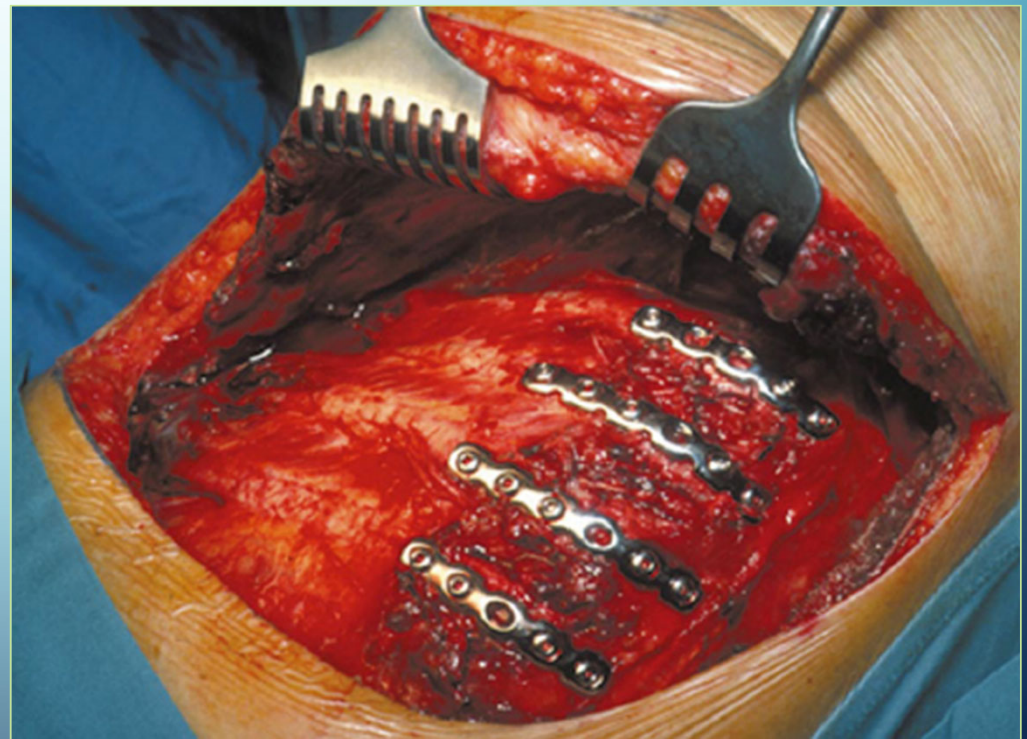
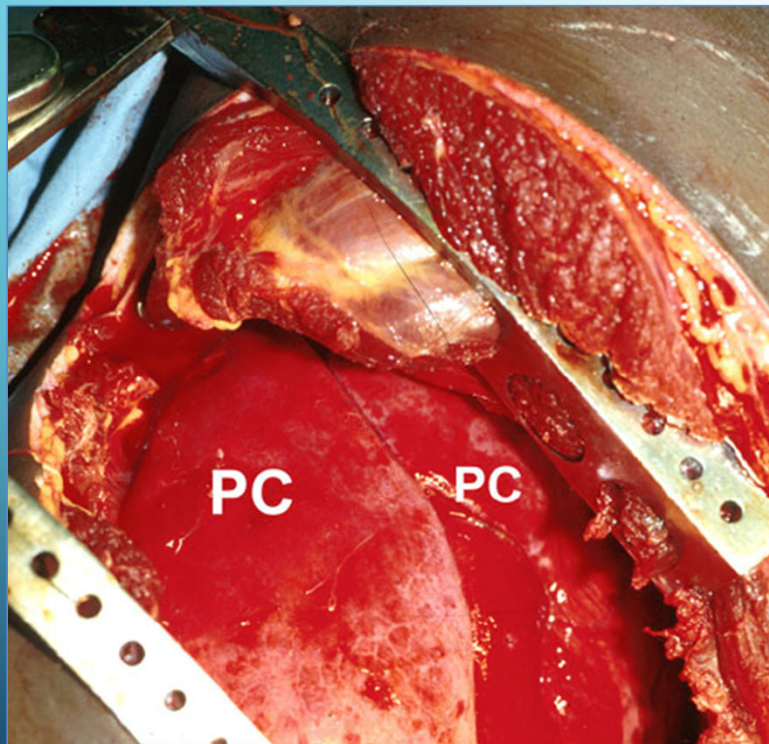
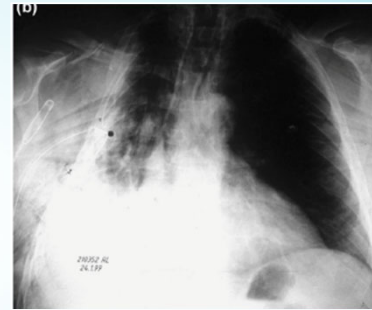


World J Surg (2010) 34:1959–1970
DOI 10.1007/s00268-010-0599-9

World Journal
of Surgery

Pulmonary Contusion: An Update on Recent Advances in Clinical Management

Stephen M. Cohn · Joseph J. DuBose



Risque hémorragique parfois TC associé donc pas trop d'héparine donc circuit ECMO bolus puis stop

Extracorporeal membrane oxygenation in severe trauma patients with bleeding shock[☆]

Matthias Arlt*, Alois Philipp, Sabine Voelkel, Leopold Rupperecht, Thomas Mueller, Michael Hilker, Bernhard M. Graf, Christof Schmid

Patient/ gender/age	ECMO type	Trauma	Diagnosis	Scores ISS/SOFA	paO ₂ /FIO ₂ pre-ECMO	PaCO ₂ [mm Hg] pre-ECMO	Norepinephrine [mg/h] pre-ECMO	Treatment on ECMO	Blood transfusion units on ECMO	Days on ECMO	Outcome
H.R./m/22 years	v-v	Car crash	Polytrauma Bleeding shock ARDS	66/13	41	50	5.0	Damage control surgery CT-scan	PRBC: 33 FFP: 54 PLTC: 6 PRBC: 2	4	Survived without handicap
K.M./m/30 years	v-v	Car crash	Polytrauma Bleeding shock ARDS	75/14	39	80	1.0	Damage control surgery CT-scan	PRBC: 10 FFP: 22 PLTC: 3	6	Survived without handicap
D.V./m/56 years	v-v	Car crash	Aspiration Polytrauma ICB Bleeding shock ARDS	75/12	58	59	1.1	Kinetic therapy Damage control surgery CT-scan	PRBC: 12 FFP: 19 PLTC: 2	5	Survived without handicap
B.S./m/27 y	v-v	Car crash	Polytrauma Bleeding shock ARDS	75/14	64	36	1.4	CT-scan Kinetic therapy	PRBC: 54 FFP: 102 PLTC: 11	2	Died 20 days post-ECMO in septic multiple organ failure
W.T./m/21 years	v-v	Car crash	Polytrauma Bleeding shock ARDS	75/10	36	84	2.0	Damage control surgery CT-scan	PRBC: 10 FFP: 27 PLTC: 2	3	Died on ECMO in septic multiple organ failure
K.P./m/17 years	v-v	Motorcycle crash	Polytrauma Open chest Bleeding shock ARDS	75/12	48	67	13.5	Kinetic therapy CT-scan Kinetic therapy	PRBC: 7	5	Survived without handicap
K.N./f/24 years	v-v	Car crash	Polytrauma Bleeding shock ARDS	66/12	69	38	1.0	Laparotomy Trauma surgery	PRBC: 12 FFP: 24 PLTC: 2 PRBC: 25 FFP: 12	7	Survived without handicap
T.P./m/39 years	v-a	Truck crash	Polytrauma Bleeding shock ARDS	75/10	46	53	5.6	Trauma surgery Kinetic therapy CT-scan	PRBC: 12 FFP: 3	7	Survived without handicap
P.S./f/23 years	v-a	Suicid fall	Polytrauma ICB Bleeding shock ARDS	75/10	40	85	5.0	Damage control surgery		0.5	Died on ECMO intractable retroperitoneal bleeding
A.S./m/62 years	v-a	Open chest trauma	CPR open heart Bleeding shock	29/11	105	89 g	4.0	Damage control chest surgery		11	Survived without handicap



☐ [The use of extracorporeal membrane oxygenation therapy in the delayed surgical repair of a tracheal injury.](#)

1. Sian K, McAllister B, Brady P.

Ann Thorac Surg. 2014 Jan;97(1):338-40. doi: 10.1016/j.athoracsur.2013.04.126.

PMID: 24384192

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☐ [Extracorporeal membrane oxygenation-assisted resection of goiter causing severe extrinsic airway compression.](#)

2. Shao Y, Shen M, Ding Z, Liang Y, Zhang S.

Ann Thorac Surg. 2009 Aug;88(2):659-61. doi: 10.1016/j.athoracsur.2008.12.073.

PMID: 19632436

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☐ [Flexible bronchoscopic excision of a tracheal mass under extracorporeal membrane oxygenation.](#)

3. Kim JJ, Moon SW, Kim YH, Choi SY, Jeong SC.

J Thorac Dis. 2015 Mar;7(3):E54-7. doi: 10.3978/j.issn.2072-1439.2015.01.26.

PMID: 25922751

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BIOPSIE CHIRURGICALE SOUS ECMO

L'objectif est de trouver un diagnostic de défaillance respiratoire

Difficulté et risque des biopsies transbronchiques

ECMO VV posée avant le geste et pour SDRA: Biopsie +LBA

Risque hémorragique donc arrêt des anticoagulants

Peu de barotraumatisme si peu d'aération



ASSISTANCE VEINO ARTERIELLE

- Objectif garantir l'hématose: CaO_2 , et aussi une assistance du débit TaO_2 avec toujours une extraction du CO_2
- Possibilité de diminuer la ventilation minute: Volume et fréquence
- Possibilité d'être protecteur avec une pression motrice contrôlée
- Possibilité d'être protecteur de la circulation pulmonaire

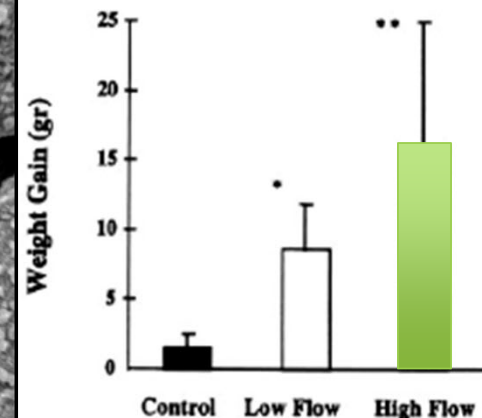
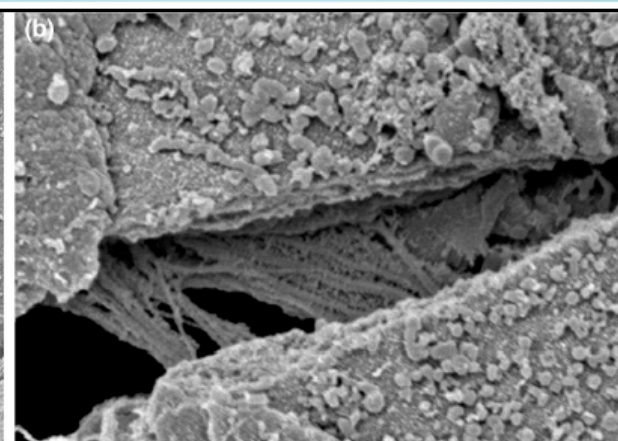
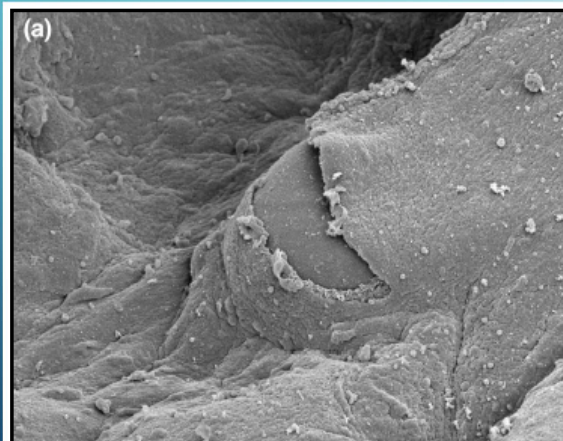
Consequences of Vascular Flow on Lung Injury Induced by Mechanical Ventilation

Lapins avec poumons lésés

ALAIN F. BROCCARD, JOHN R. HOTCHKISS, NAOTO KUWAYAMA, DOUGLAS A. OLSON, SABA JAMAL, DOUGLAS O. WANGENSTEEN, and JOHN J. MARINI

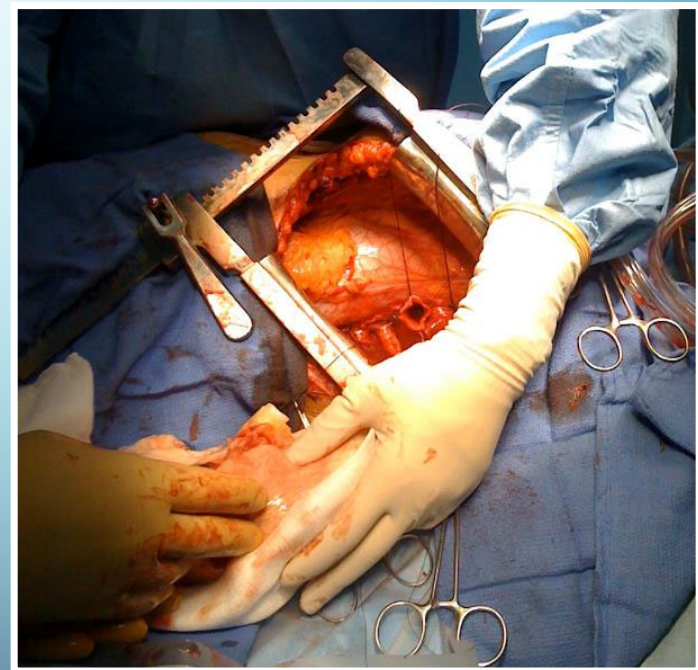
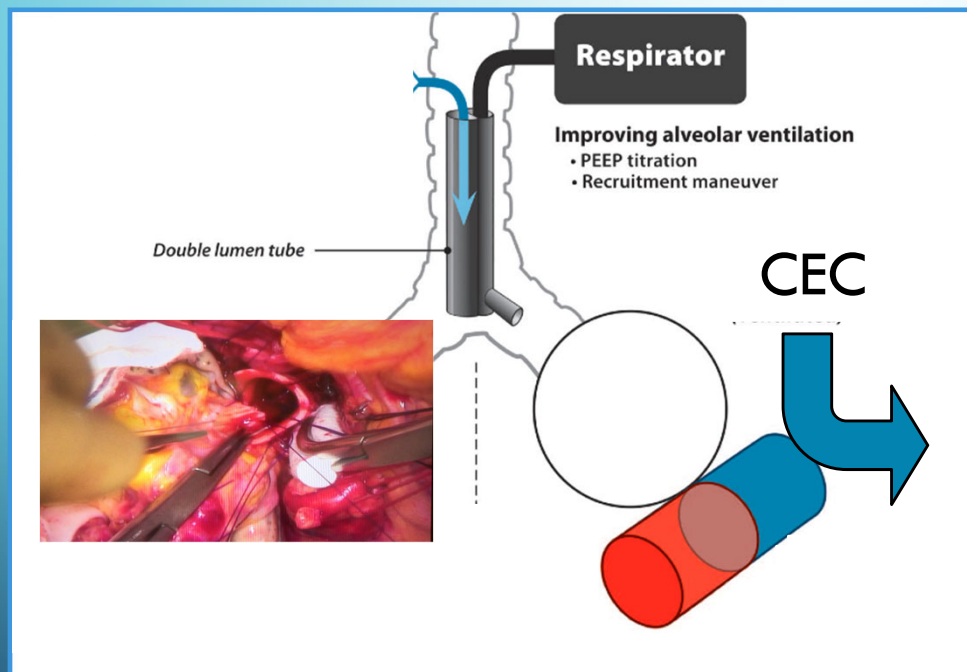
Division of Pulmonary and Critical Care Medicine, University of Minnesota, Minneapolis/St. Paul; and Department of Laboratory Medicine and Pathology, Regions Hospital, St. Paul, Minnesota

	Control Group	Low-flow Group
Start of ventilation		Débit sanguin p
Pplat	15.2 ± 0.4	29.9 ± 0.2
PEEP total	5.4 ± 0.2	1.2 ± 0.4
V _T , ml	13 ± 4 [†]	96 ± 12 [‡]
Pap mean, mm Hg	21.6 ± 6.2	22.8 ± 3.7

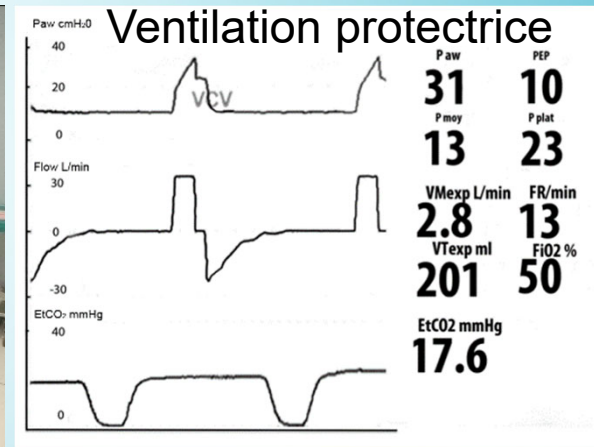


AM J RESPIR CRIT CARE MED 1998;157:1935-1942.

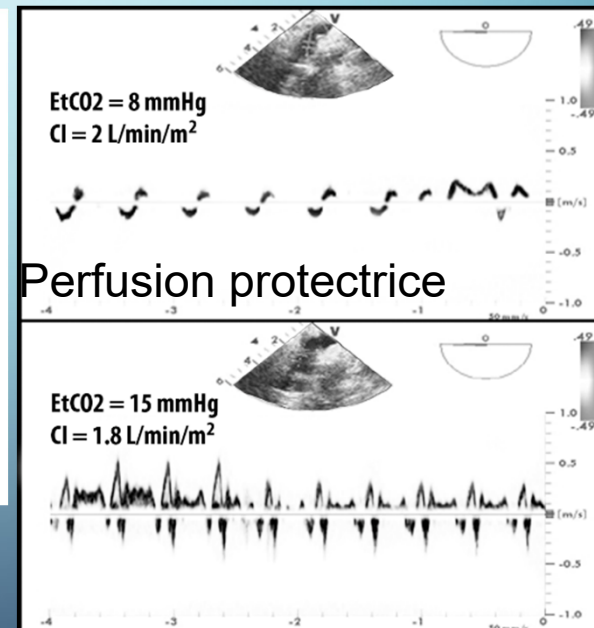
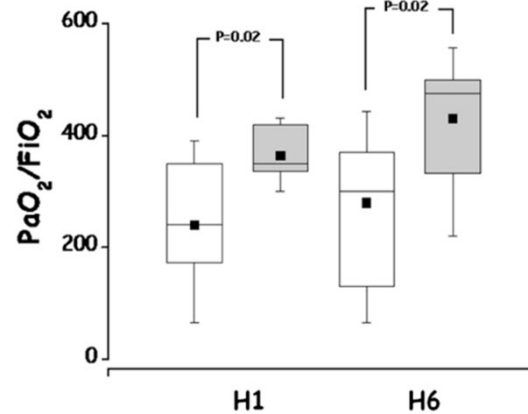
VENTILATION ET PERFUSION PROTECTRICES



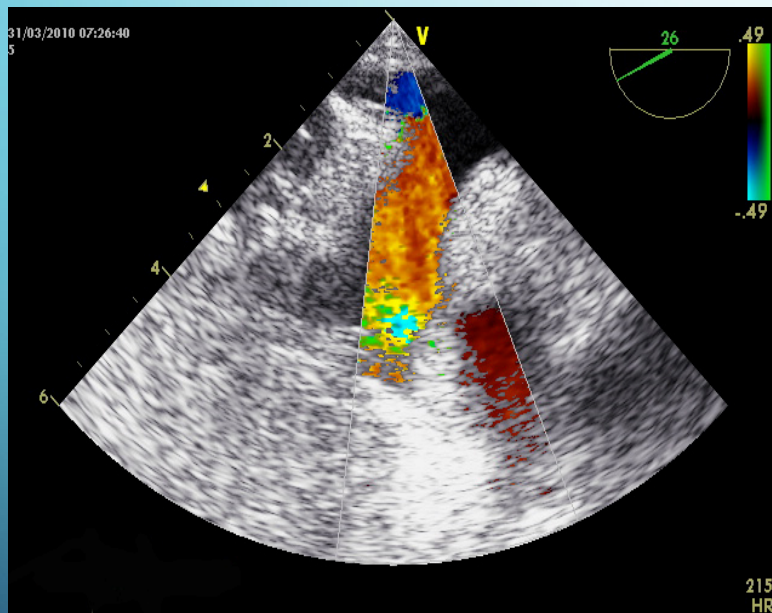
Contrôler le débit de perfusion du premier greffon



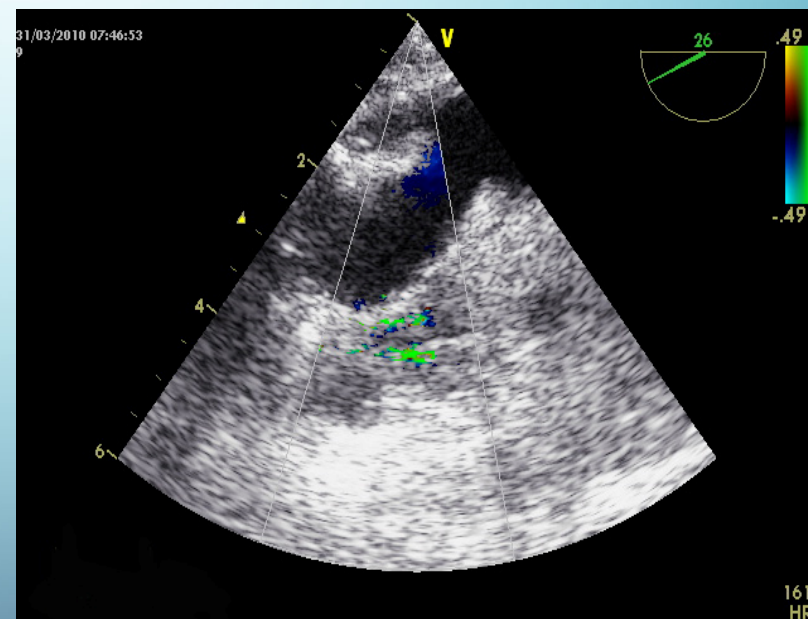
En réa post greffe



RETOUR VEINEUX PULMONAIRE CONTRÔLÉ

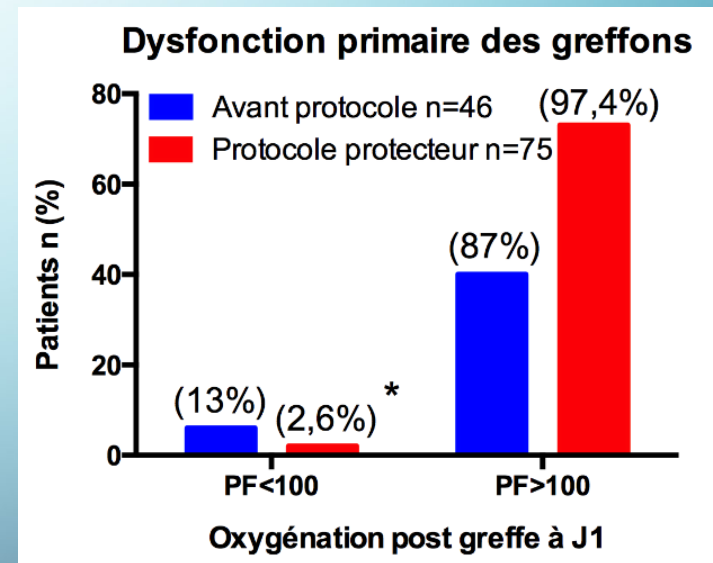
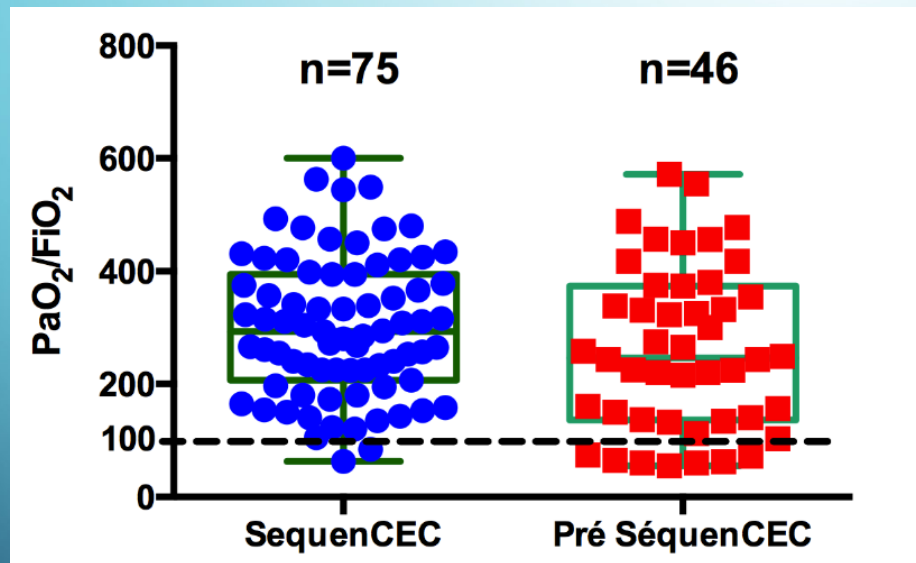


Avant CEC

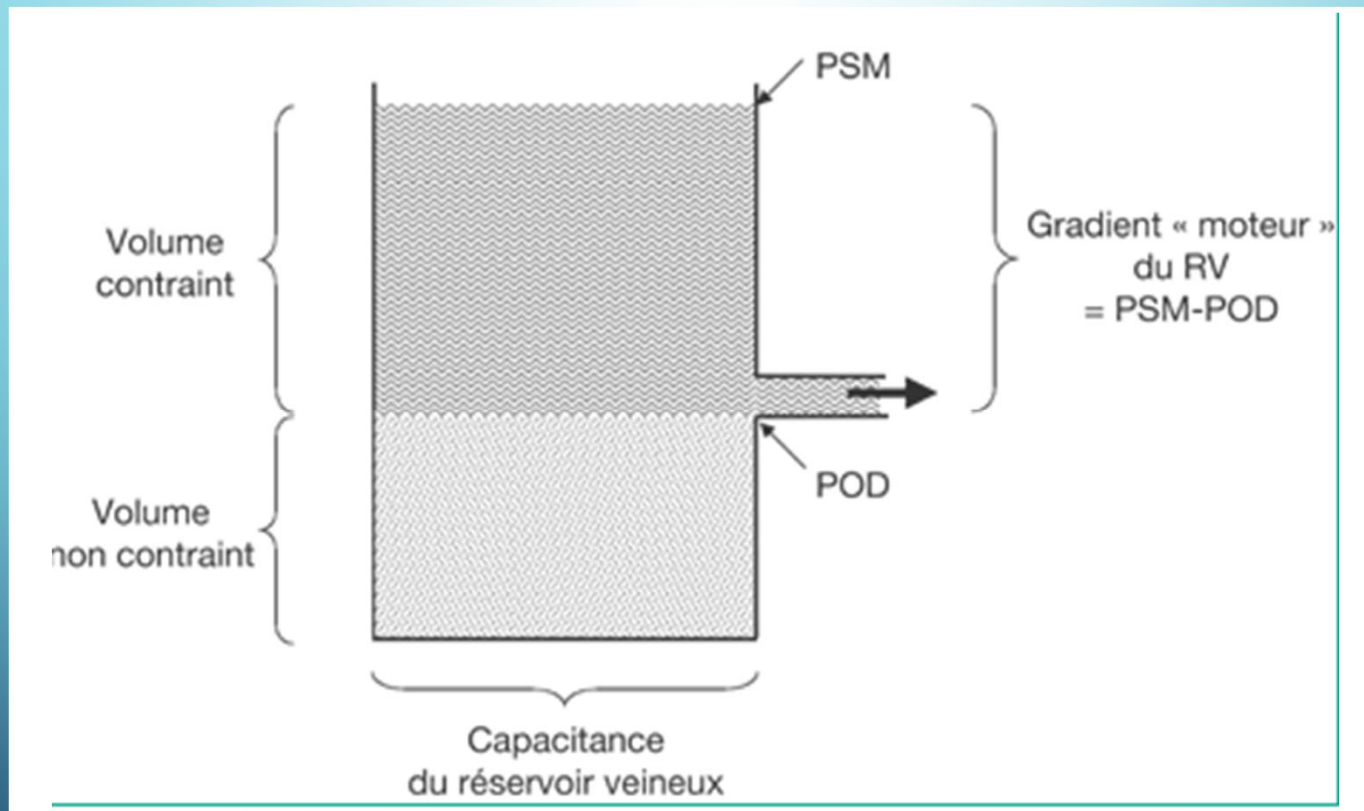


Sous CEC

CEC ET GREFFE PULMONAIRE EN 2017 (N=131)

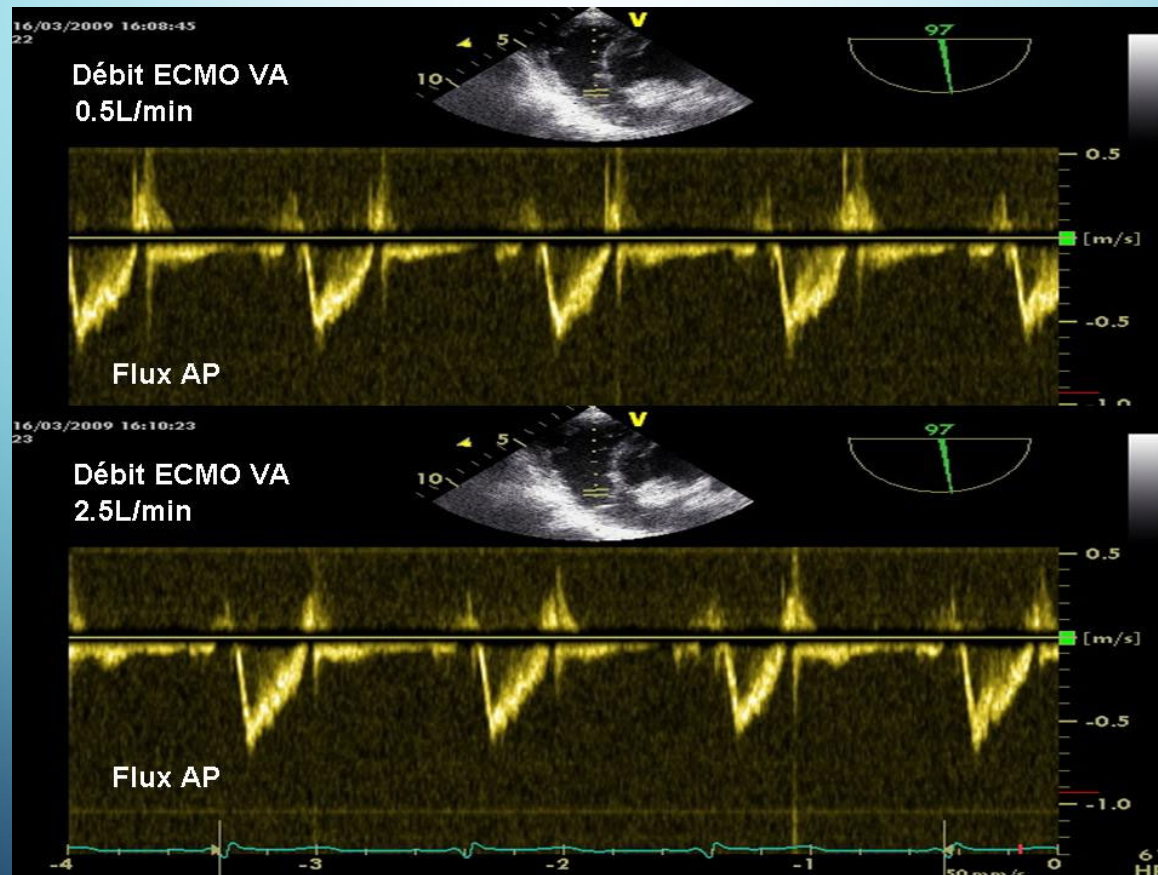


POMPES CENTRIFUGES



La pompe centrifuge est un accélérateur de flux lié à un gradient de pression

ITV SOUS 2 DEBITS D'ECMO CHEZ UN MUOCO



The NEW ENGLAND JOURNAL of MEDICINE

Normothermic Ex Vivo Lung Perfusion in Clinical Lung Transplantation

N Engl J Med 2011;364:1431-40.

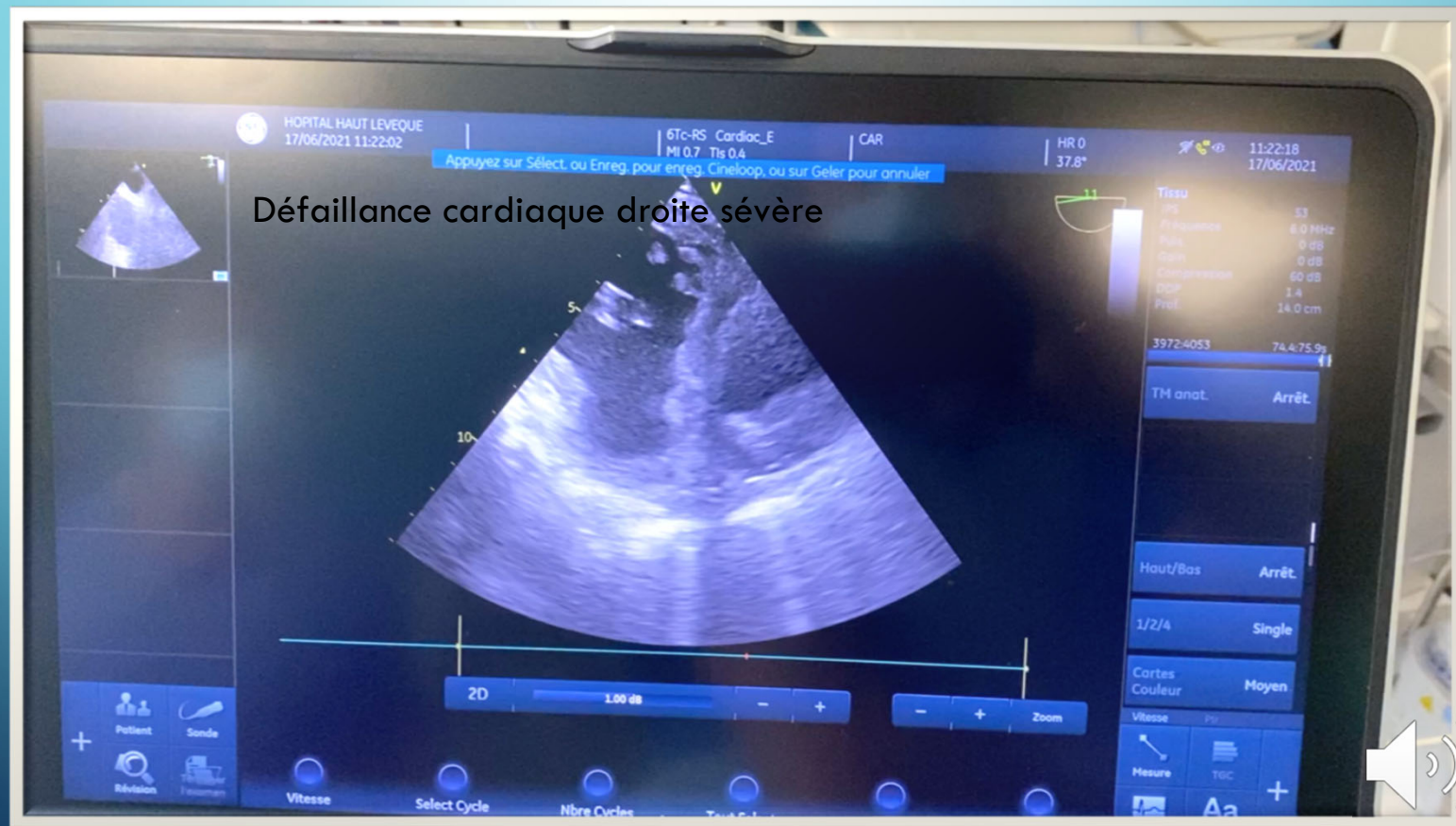
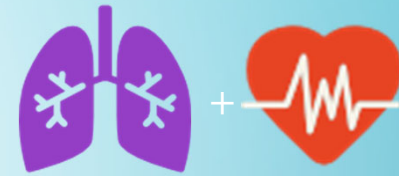
CEC EX VIVO PRE GREFFE PULMONAIRE



HTAP EN CHIRURGIE THORACIQUE

- Contre indication a la chirurgie d'exérèse du poumon
- Autres chirurgie, recours à l'assistance ou pas ...
- Transplantation pulmonaire pour HTAP: ECMO VA pre induction si septum paradoxal PAPs > 90 mmHg
- Protection de la circulation pulmonaire (TBP) post greffe

ECMO Hybride VV + VA

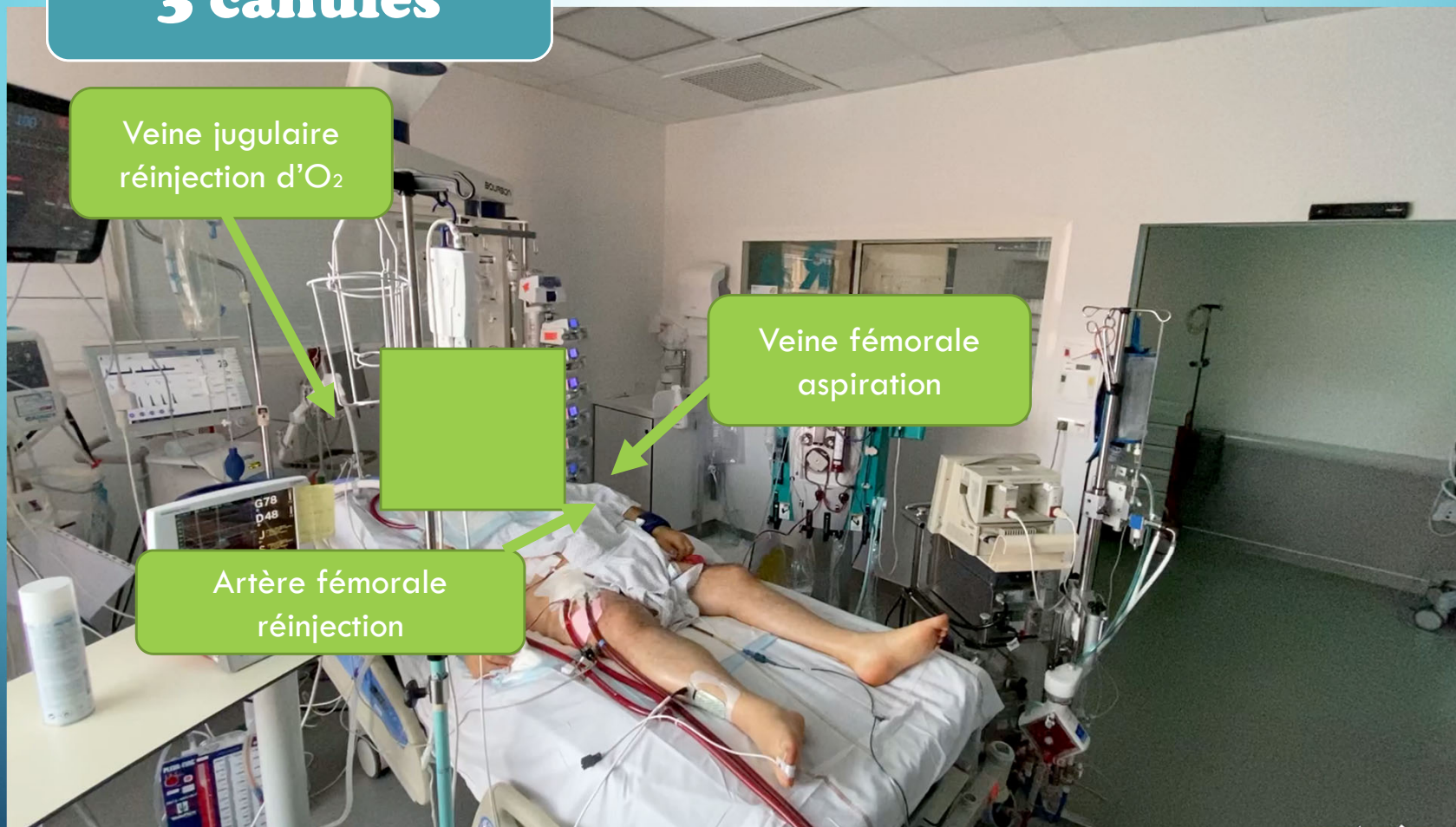


3 canules

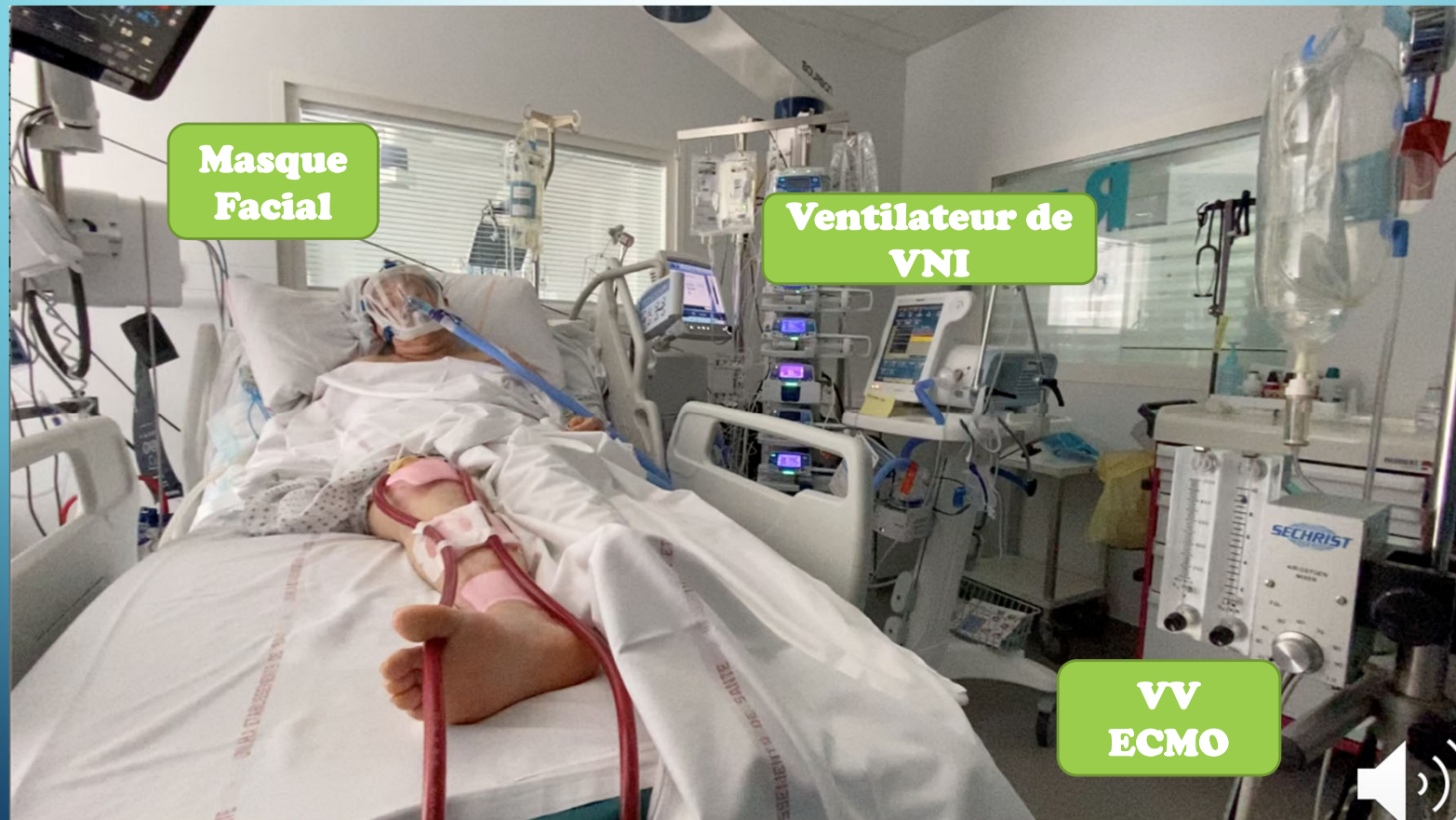
Veine jugulaire
réinjection d'O₂

Veine fémorale
aspiration

Artère fémorale
réinjection



ECMO et VNI



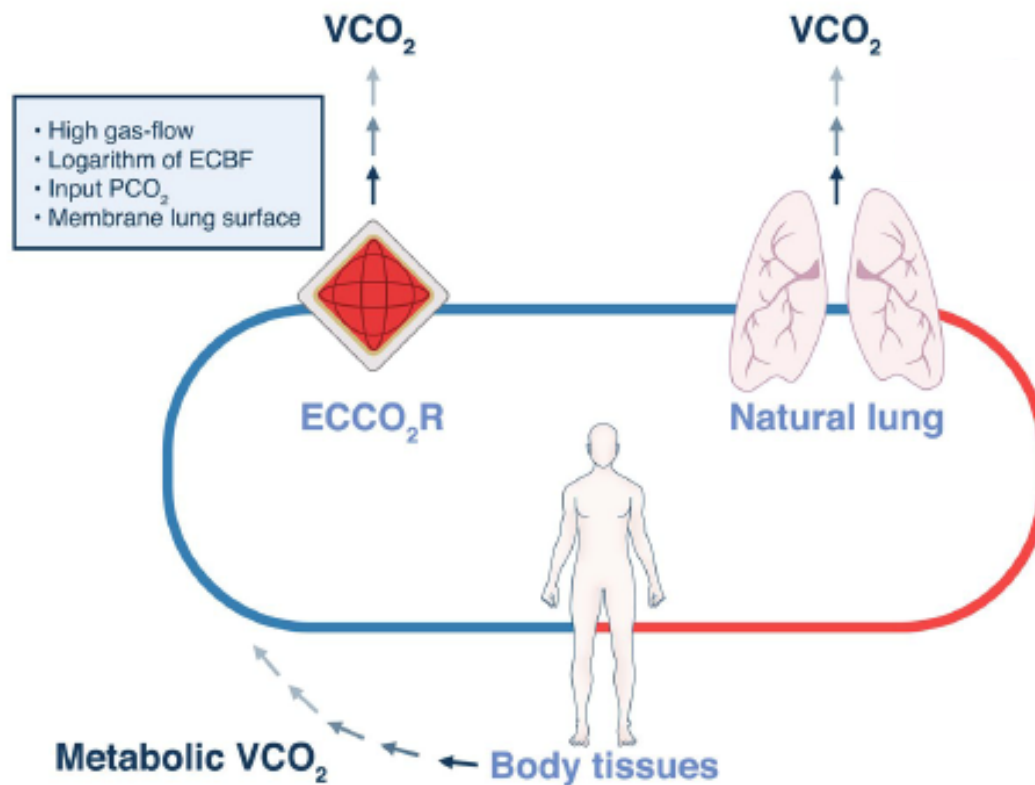
Canule double courant (fémorale)



SPECIAL ISSUE INSIGHT

Physiology of extracorporeal CO₂ removal

Luciano Gattinoni^{1*}, Silvia Coppola² and Luigi Camporota³



UNDERSTANDING THE DISEASE

Understanding hypoxemia on ECCO₂R: back to the alveolar gas equation

Jean-Luc Diehl^{1,2*}, Alain Mercat³ and Antonio Pesenti^{4,5}



$$P_{AO_2} = P_iO_2 - \frac{P_A CO_2}{R}$$

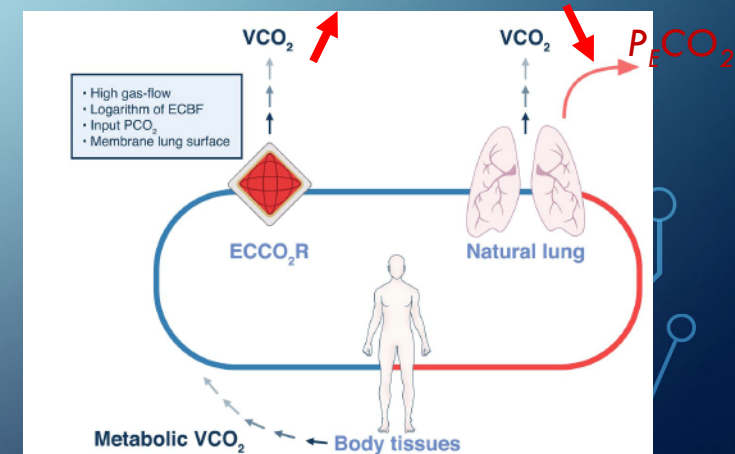
R le quotient respiratoire peut être << 0,8

$$R = \frac{P_E CO_2 \times (1 - FiO_2)}{P_iO_2 - PEO_2 - (PECO_2 \times FiO_2)}$$

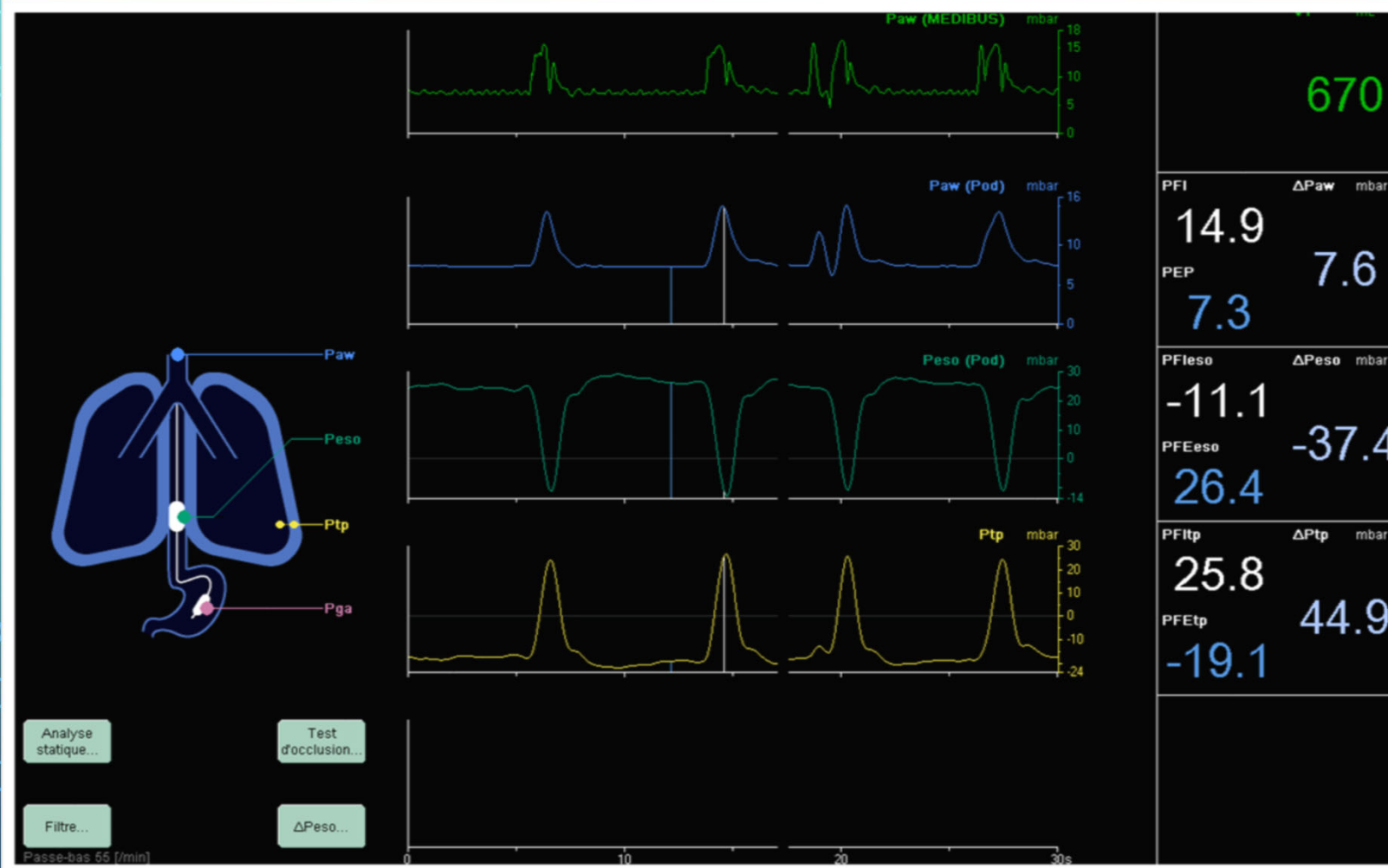
R diminue avec la PAO₂ puis la PaO₂

R = 0,8
R = 0,3

	Immediately before ECCO ₂ R	ECCO ₂ R day 7
PaO ₂ /FiO ₂	251	145
PaO ₂ (mmHg) simplified	186	360
PaO ₂ (mmHg) exact	–	248
DA-aO ₂ (mmHg) simplified	98	273
DA-aO ₂ (mmHg) exact	–	161
R (native lungs) measured by the ventilator	–	0.3
pH	7.31	7.38
PaO ₂ (mmHg)	88	87
PaCO ₂ (mmHg)	51	54
Ventilatory mode	ACV	ACV
VT (mL/kg IBW)	6	6
RR (/min)	12	10
PEEP (cmH ₂ O)	0	5
FiO ₂	0.35	0.6



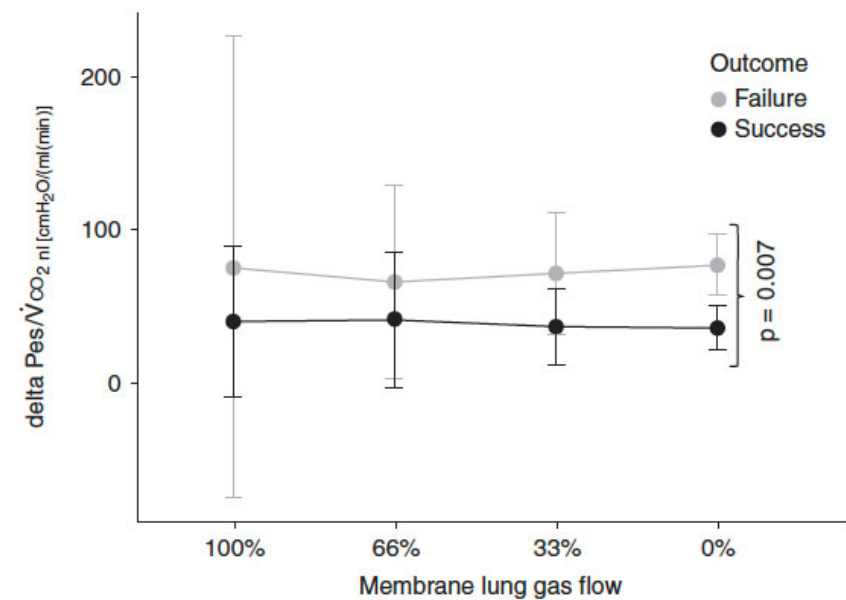
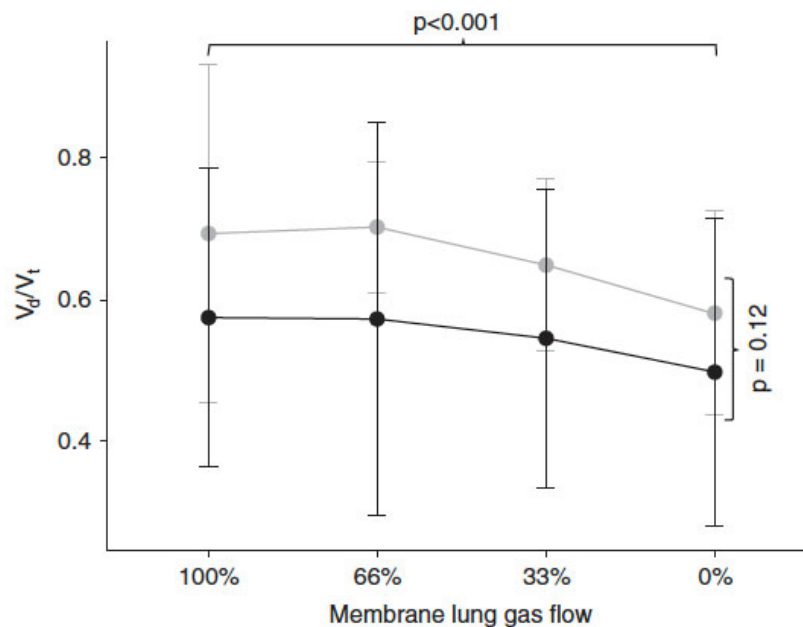
Compliance TP courbe PV débit lent
PEEP 6 à 20 ml.cmH₂O⁻¹



ORIGINAL ARTICLE

End-Tidal to Arterial P_{CO_2} Ratio as Guide to Weaning from Venovenous Extracorporeal Membrane Oxygenation

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AU FINAL

- Cas par cas, indications, objectifs, type d'assistance, Timing de la pose.
- Sevrage sur table ou en réanimation
- Anticoagulation sous ECMO en Réa post op peut être stoppée si saignement puis on cible 200 ui/kg/j on ne regarde pas trop l'activité AntiXa (nuage de points).