université de BORDEAUX

CEC EN CHIRURGIE THORACIQUE

PR HADRIEN ROZÉ

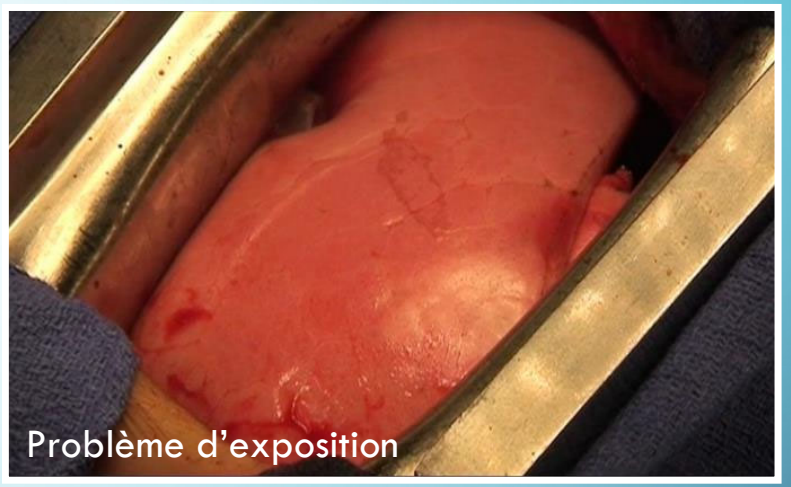
DU CEC MAI 2026

EXPOSITION CHIRURGICALE

MAINTIEN DE L'HÉMATOSE
MAINTIEN DU DÉBIT CARDIAQUE

PROTECTION VENTILATION

PROTECTION PERFUSION



Problème d'exposition

Problème d'hématose

CARDIAQUE ET/OU PULMONAIRE

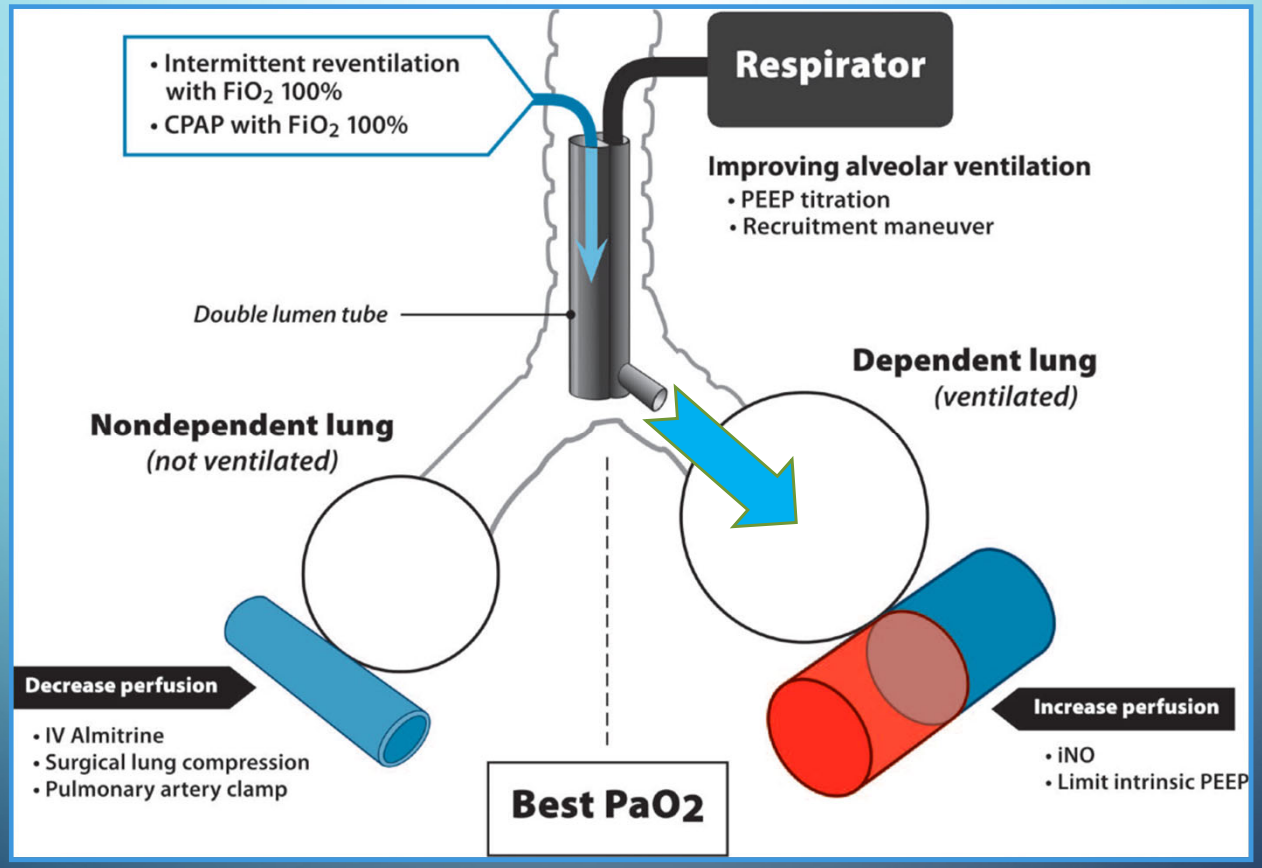
- **Assistance cardiaque**
- Hématose 100% CEC
  - Oxygénation
  - Décarboxylation
- +/-Ventilation alvéolaire
  - De 0 à 100%

* **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



Roze et al. Anesthesiology 2011

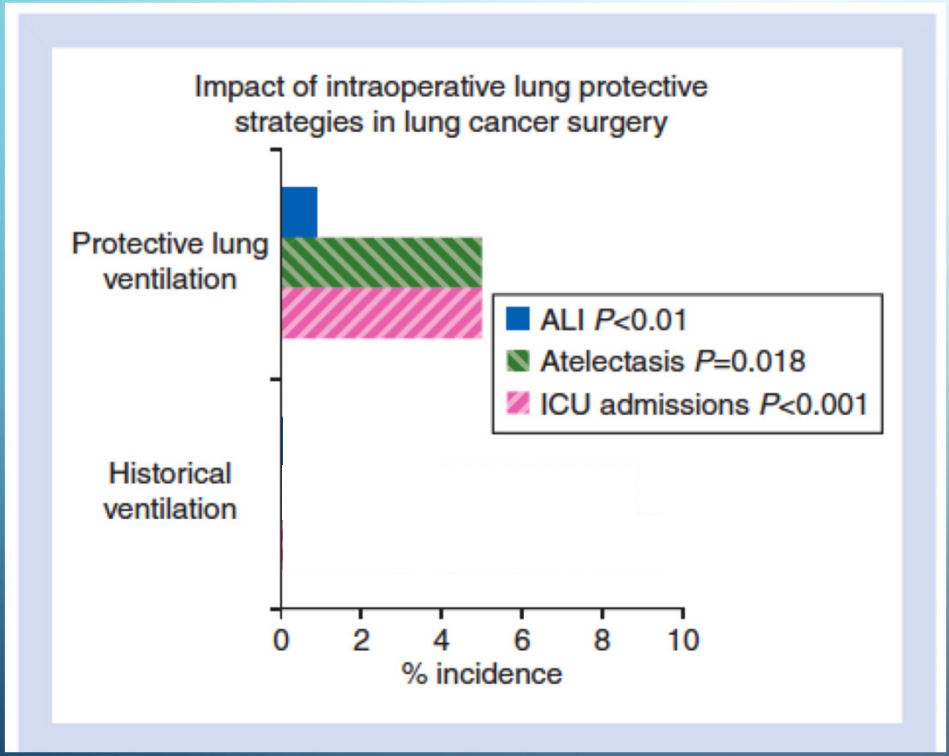
British Journal of Anaesthesia **105** (S1): i108–i116 (2010)
doi:10.1093/bja/aeq299

BJA

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'hématose (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

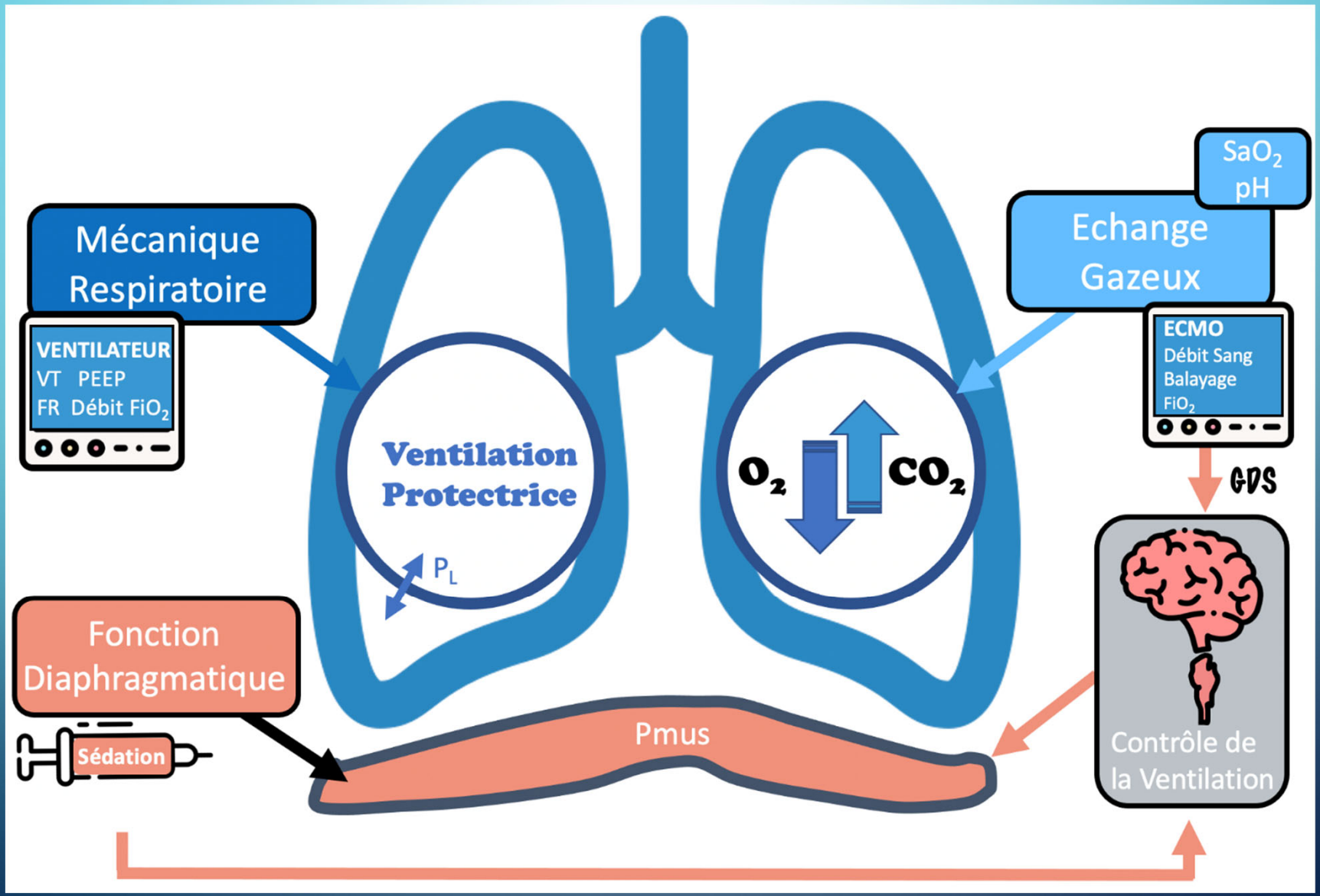
VENTILATION SOUS ECMO VV

Poumons lésés

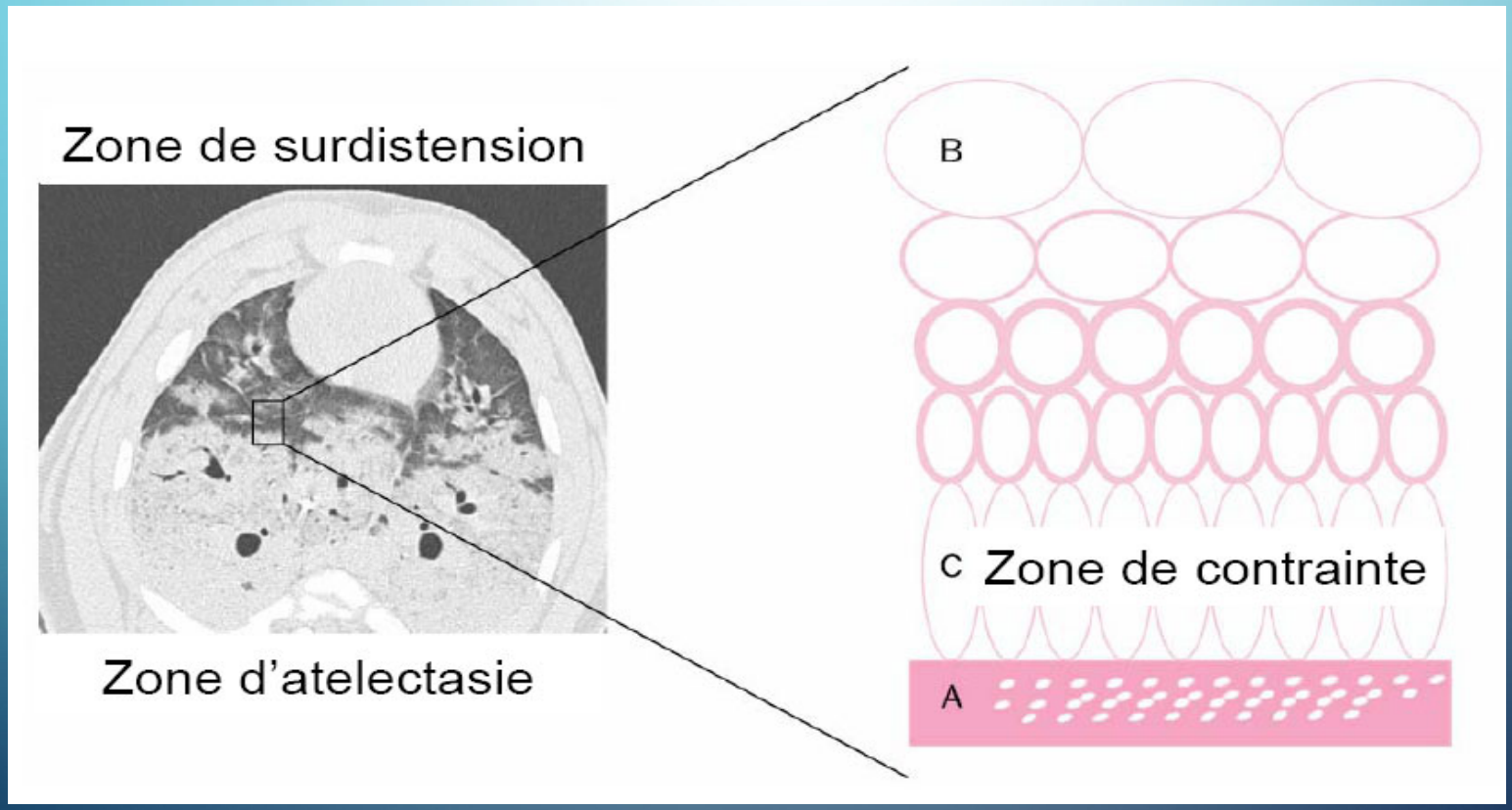
- Hématose
  - Oxygénation
  - Décarboxylation

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

Dissociation


Mécanique Respiratoire
VENTILATEUR
VT PEEP
FR Débit FiO2
Ventilation Protectrice
PL
O2
CO2
SaO2
pH
Echange Gazeux
ECMO
Débit Sang
Balayage
FiO2
GDS
Fonction Diaphragmatique
Sédation
Pmus
Contrôle de la Ventilation

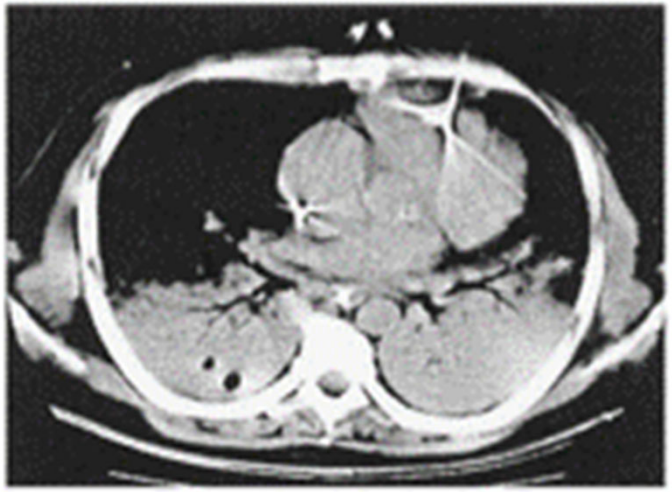
LÉSIONS ALVEOLAIRES DE LA VENTILATION




Etirement Alvéolaire

VOLUME PULMONAIRE AÉRÉ N'EST PAS LA CPT SI LÉSIONS

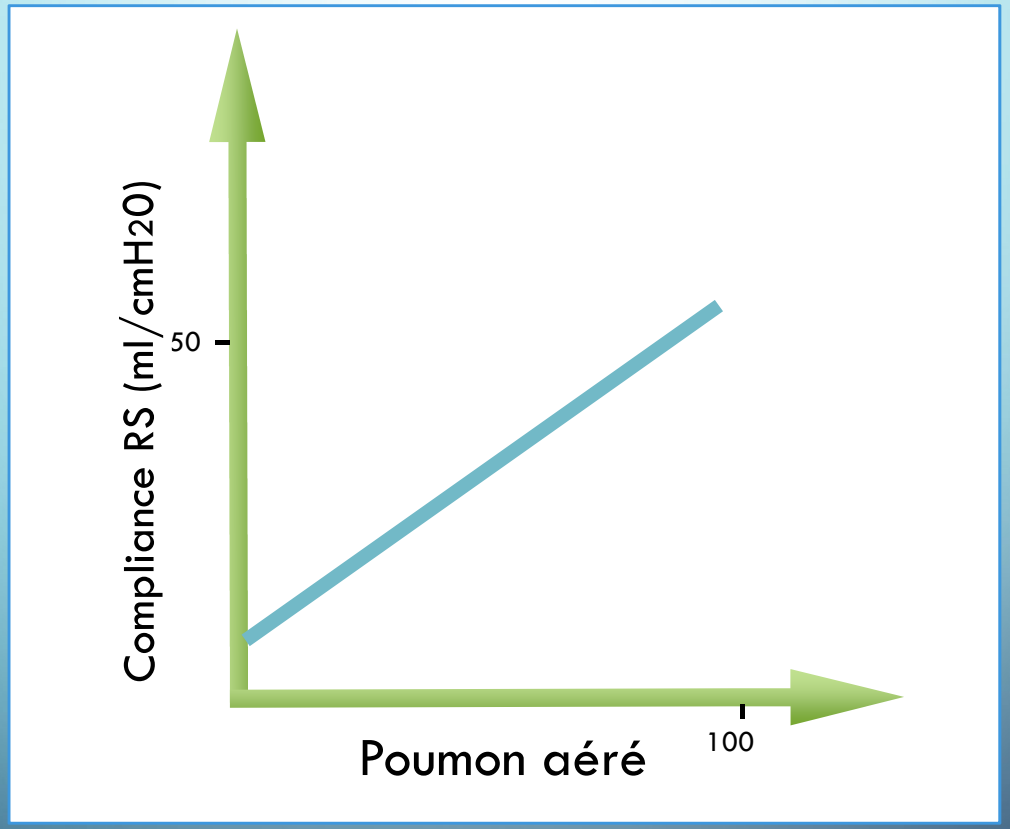
Tissu non aéré = 11,7%
PaO2/FiO2 =350



Tissu non aéré = 55,6%
PaO2/FiO2 =100

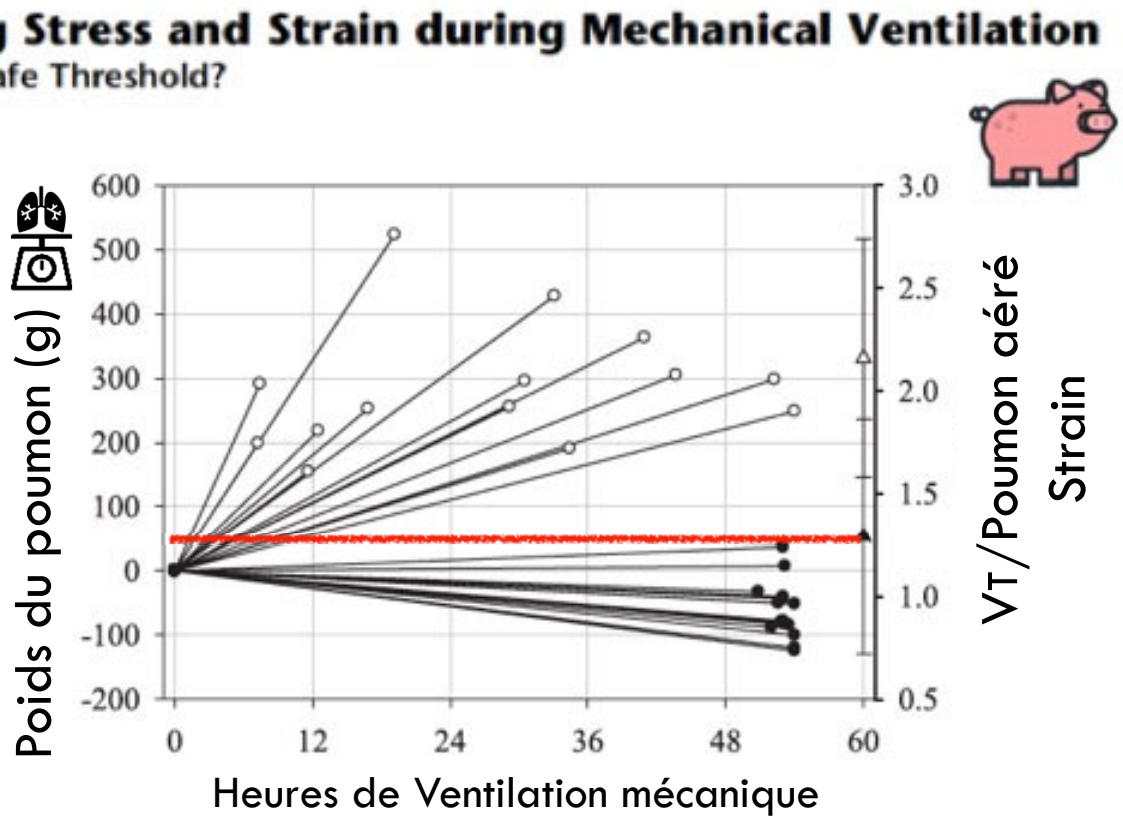
Faut il donner le même V_T ?

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



Gattinoni et al. Am rev Respir Dis 1987;136:730-736

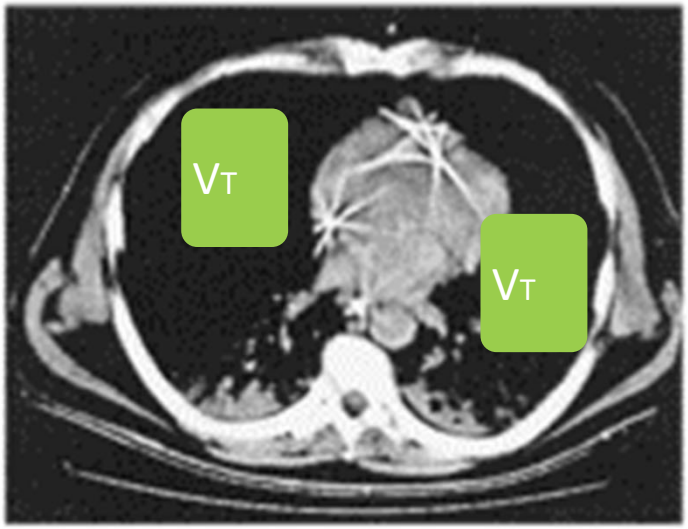
EFFETS DU RATIO VT/POUMON AÉRÉ SUR L'OEDEME

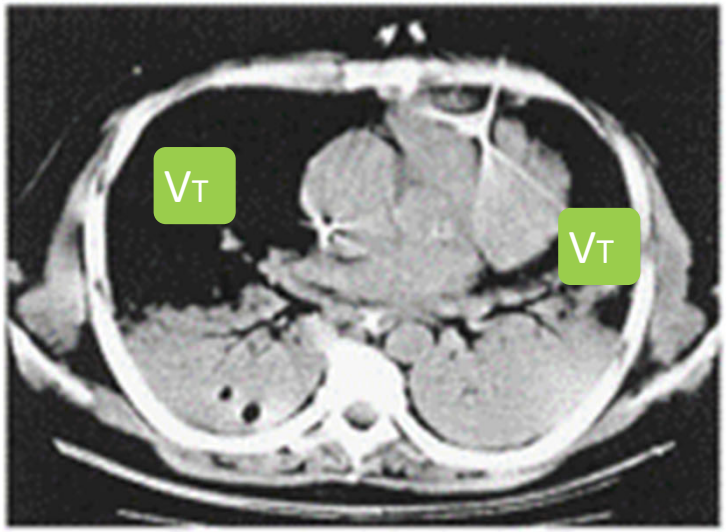


Am J respir Crit Care Med 2011;183:1354-1362

ON DOIT ADAPTÉ LE VT AU POUMON AÉRÉ (BABYLUNG)

Espace mort : VD/VT





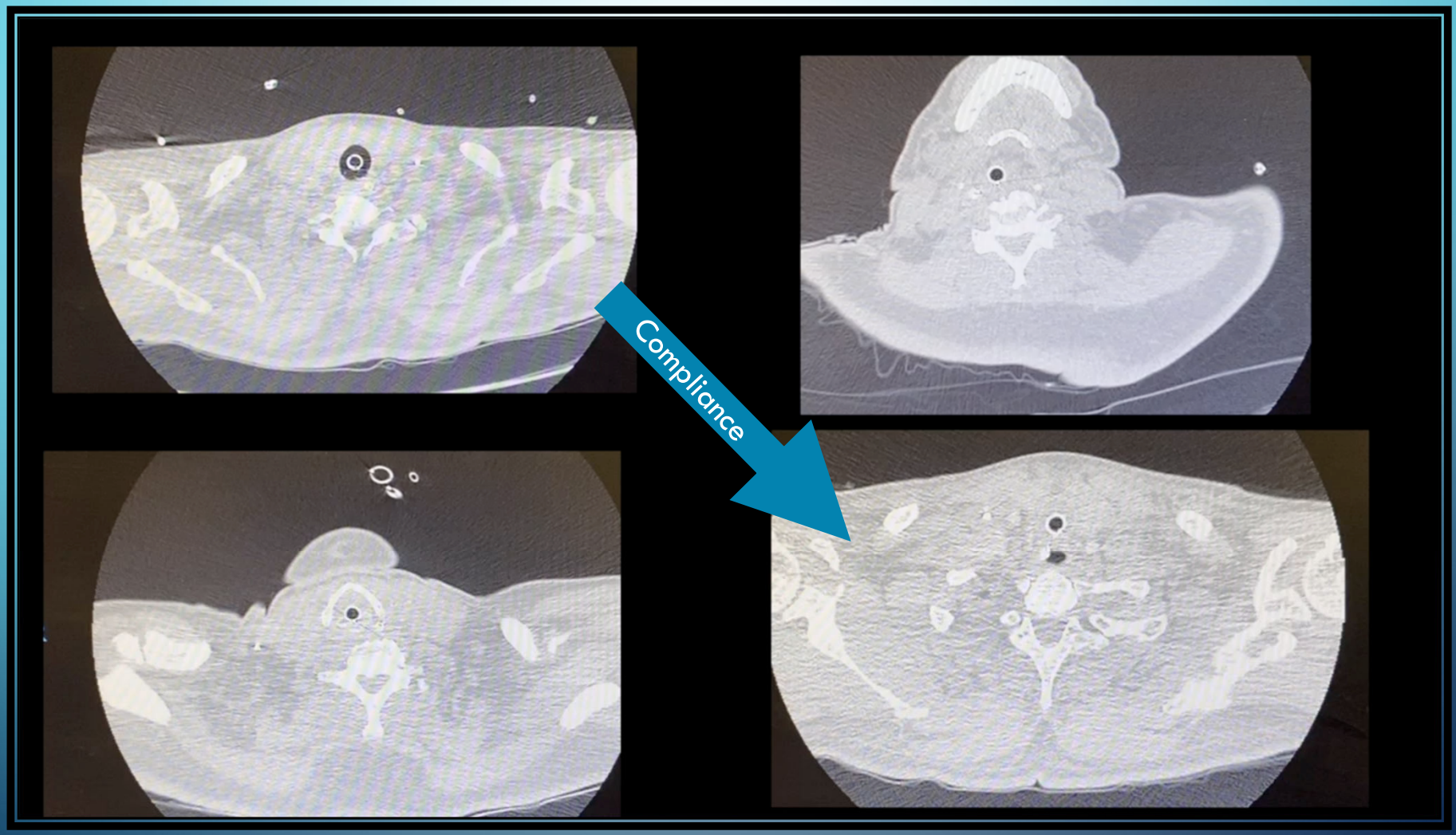
Tissu non aéré = 11,7% PaO2/FiO2 =350	Tissu non aéré = 55,6% PaO2/FiO2 =100

Hypercapnie permissive dans une certaine limite : 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 (Crs)
- VT normalisé à la Crs = VT/Crs = ~~VT~~ / (~~VT~~/Pplat-PEEPtot)

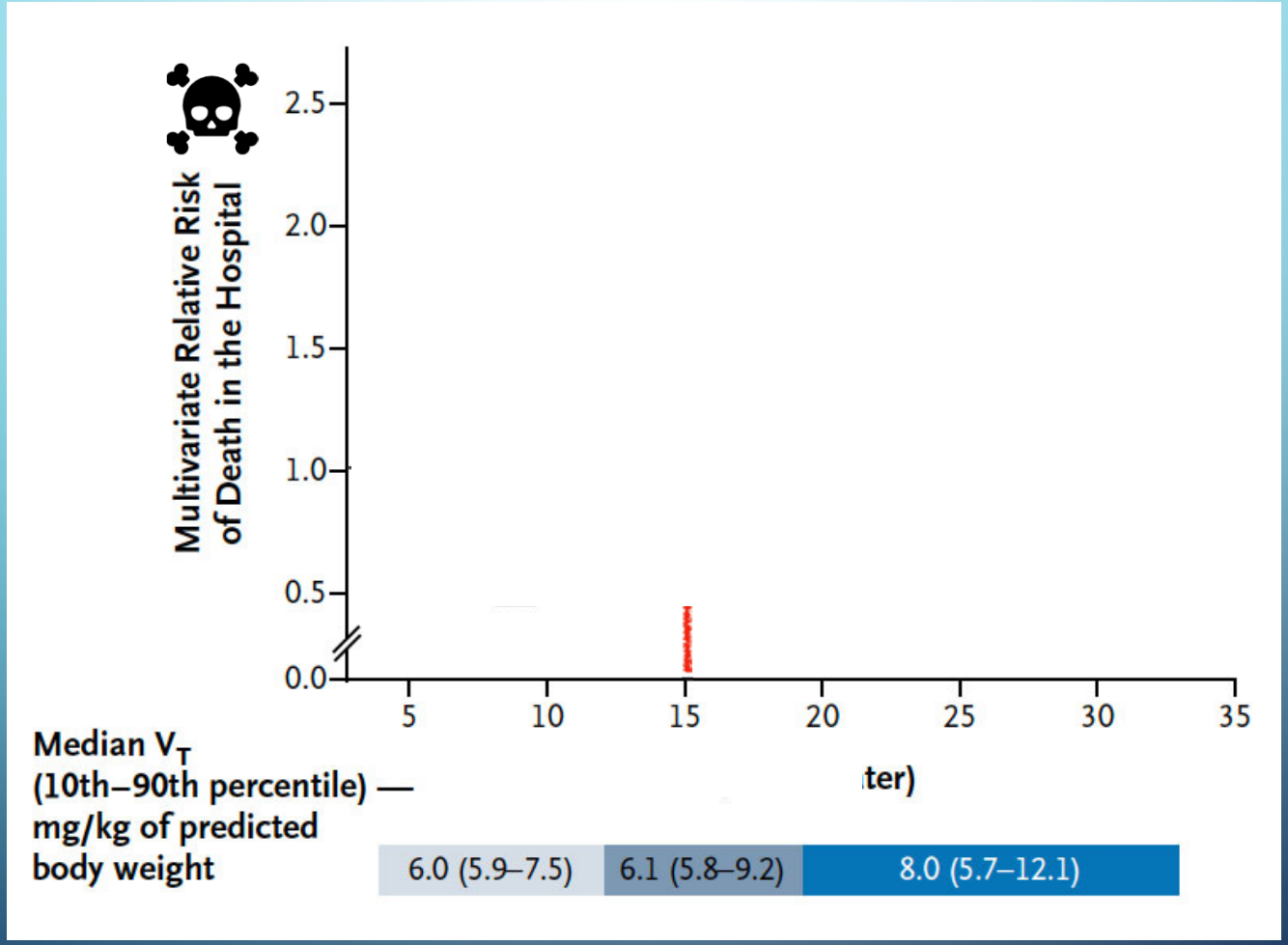
Donc

V_T/Crs= Plat-PEEPtot = Pression Motrice



SDRA COVID-19

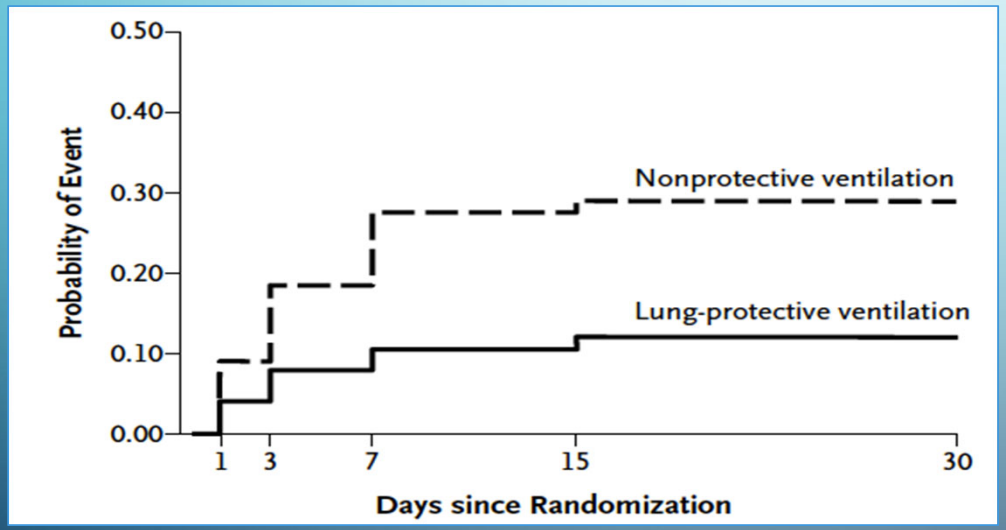
DIMINUER LA PRESSION MOTRICE DIMINUE LE RISQUE DE



Amato et al. NEJM 2015

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 cmH20
et MRA: PEEP 30 cmH2O pendant 30 sec toutes les 30 minutes



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

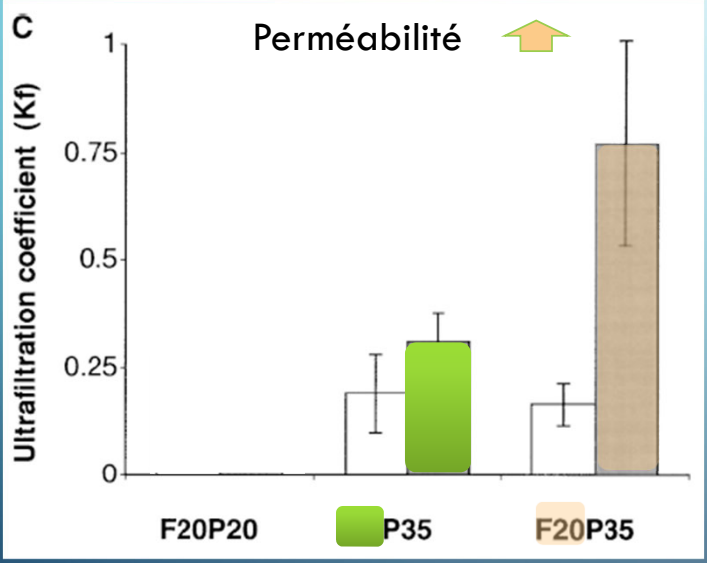
Ventilation protectrice améliore le pronostic post opératoire respiratoire

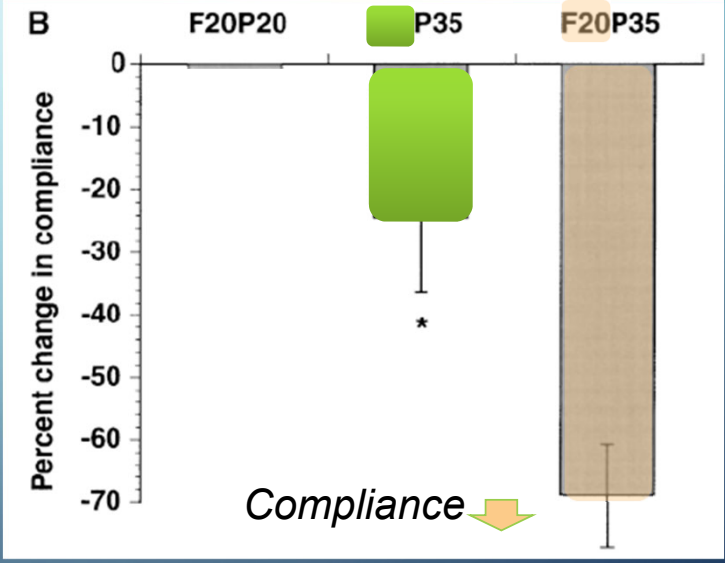
Futier et al. NEJM 203;369:428-37

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

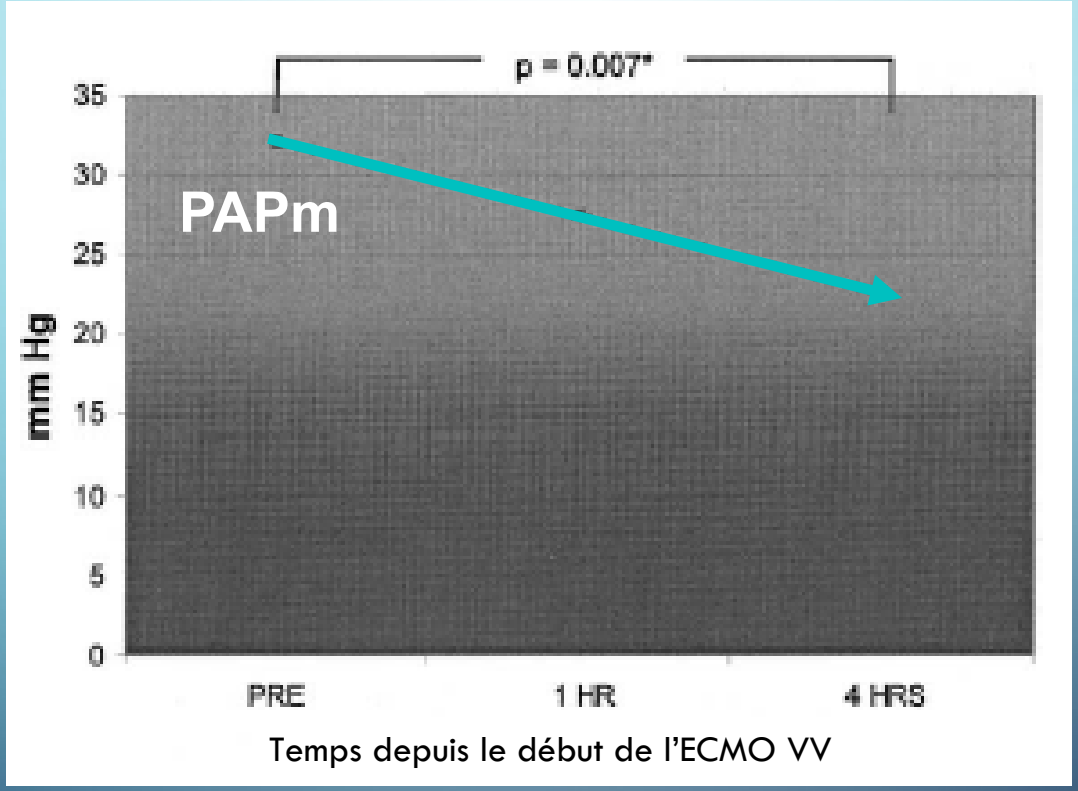
FRÉQUENCE RESPIRATOIRE





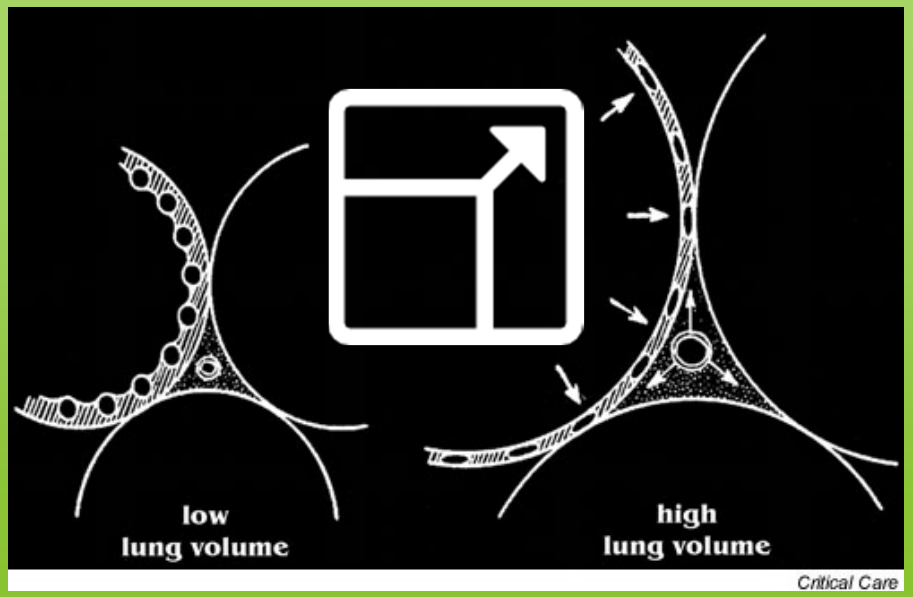
AM J RESPIR CRIT CARE MED 2000;161:463–468.

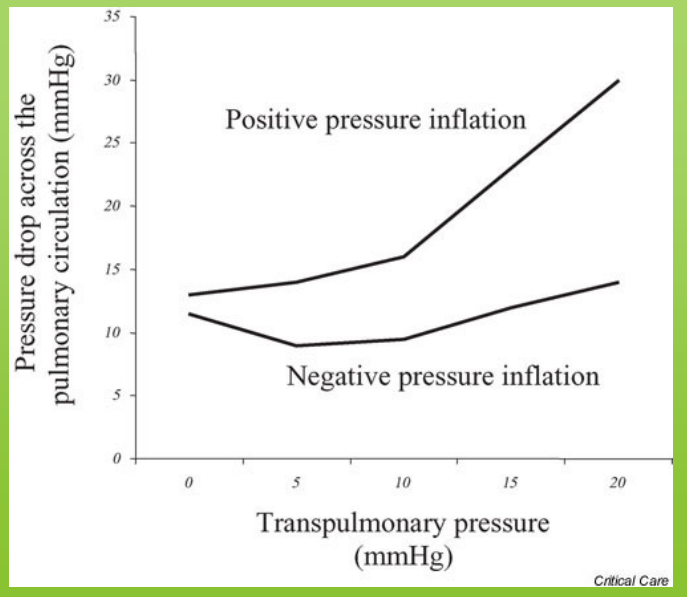
PVO_2 ELEVÉE SOUS ECMO-VV INHIBE LA VPH



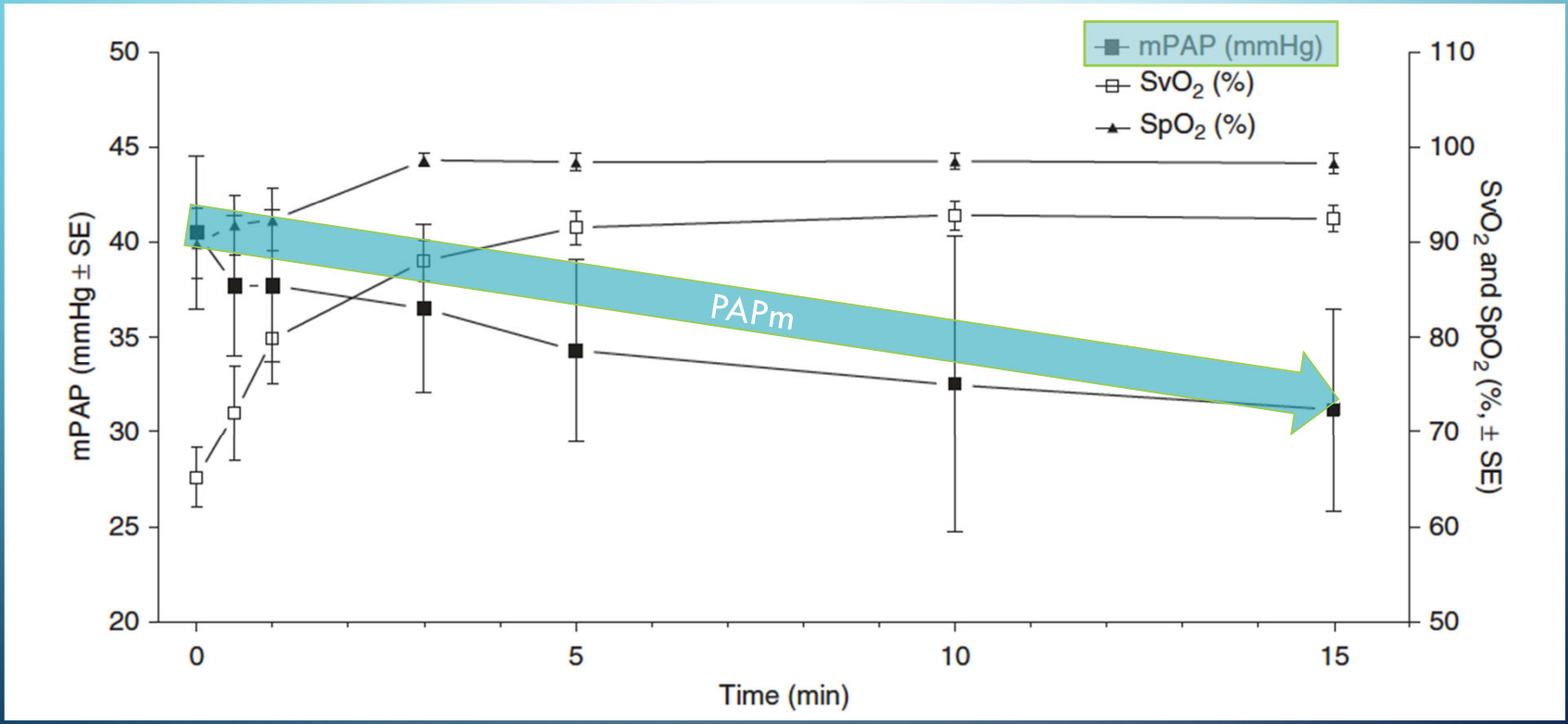
Dans cette étude la ventilation n'a pas été modifié sous ECMO !!

Ann Thorac Surg 2005;80:1872–80


low
lung volume
high
lung volume
Critical Care


Pressure drop across the pulmonary circulation (mmHg)
35
30
25
20
15
10
5
0
Positive pressure inflation
Negative pressure inflation
0
5
10
15
20
Transpulmonary pressure (mmHg)
Critical Care

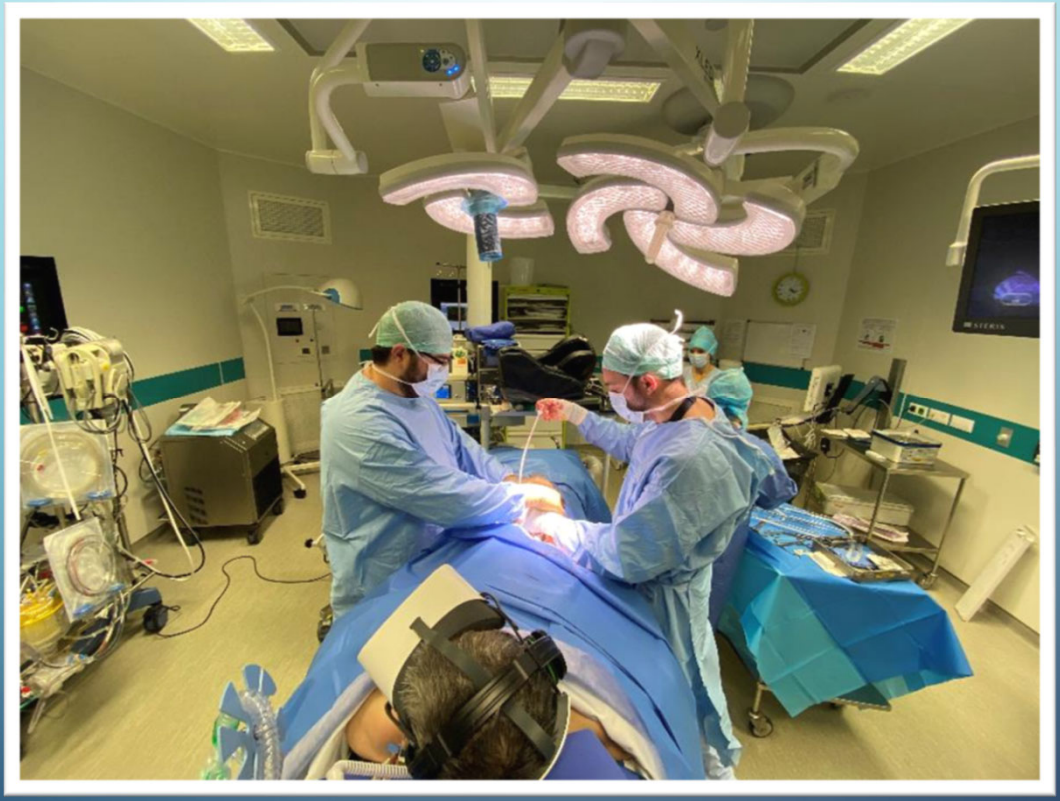
Right Ventricular Unloading after Initiation of Venovenous Extracorporeal Membrane Oxygenation



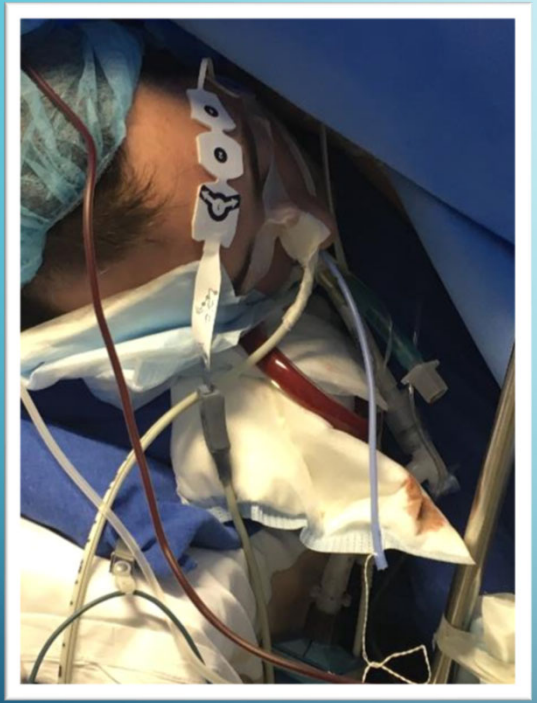
Miranda et al. AJRCCM 2015

Pression motrice
25 cmH_2O

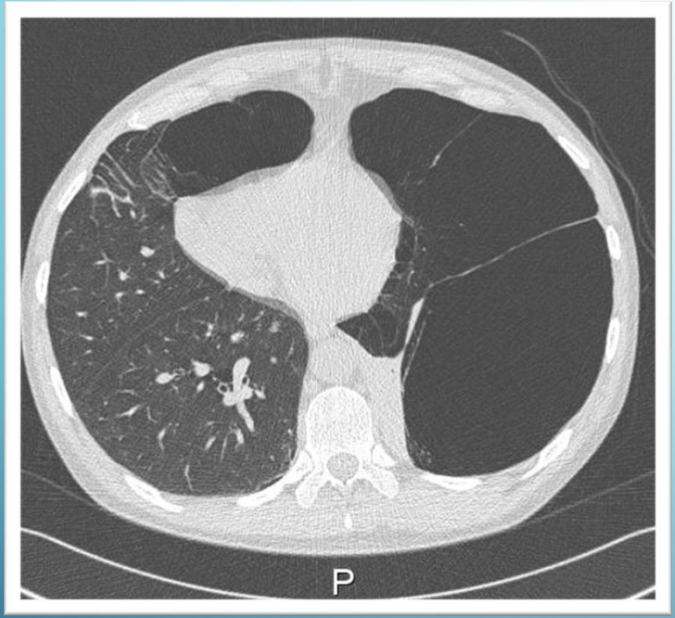
POSE SOUS HYPNOSE : HBAP & EMPHYSEME

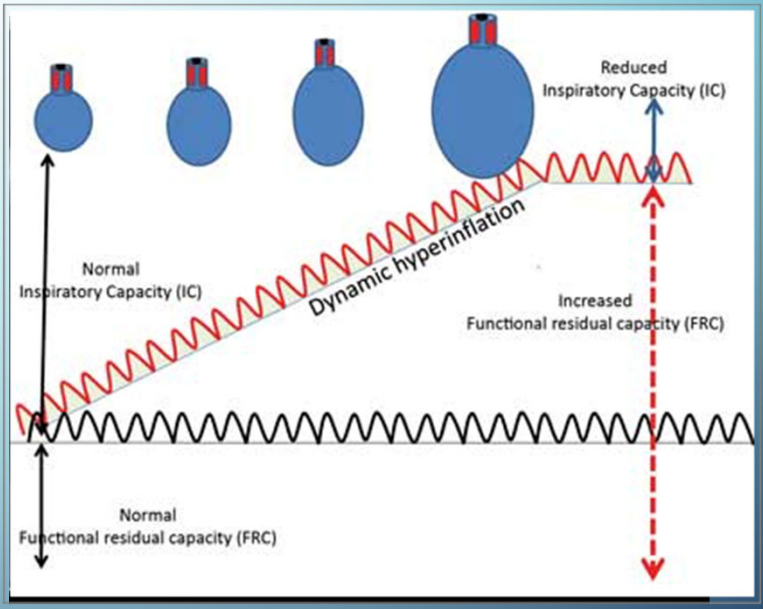


DLD



CHIRURGIE DE L'EMPHYSÈME

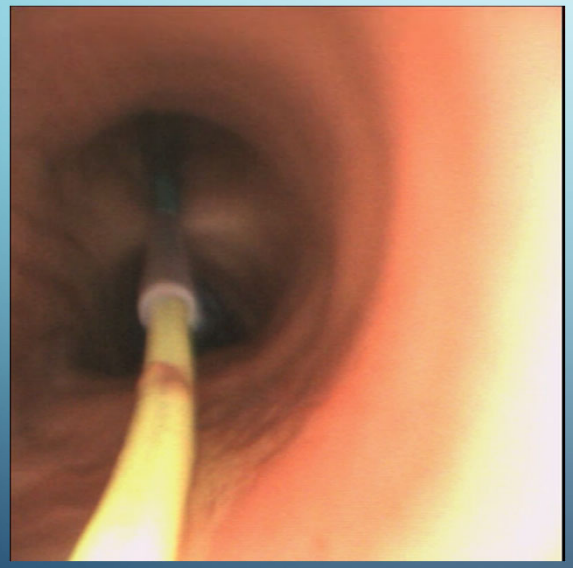


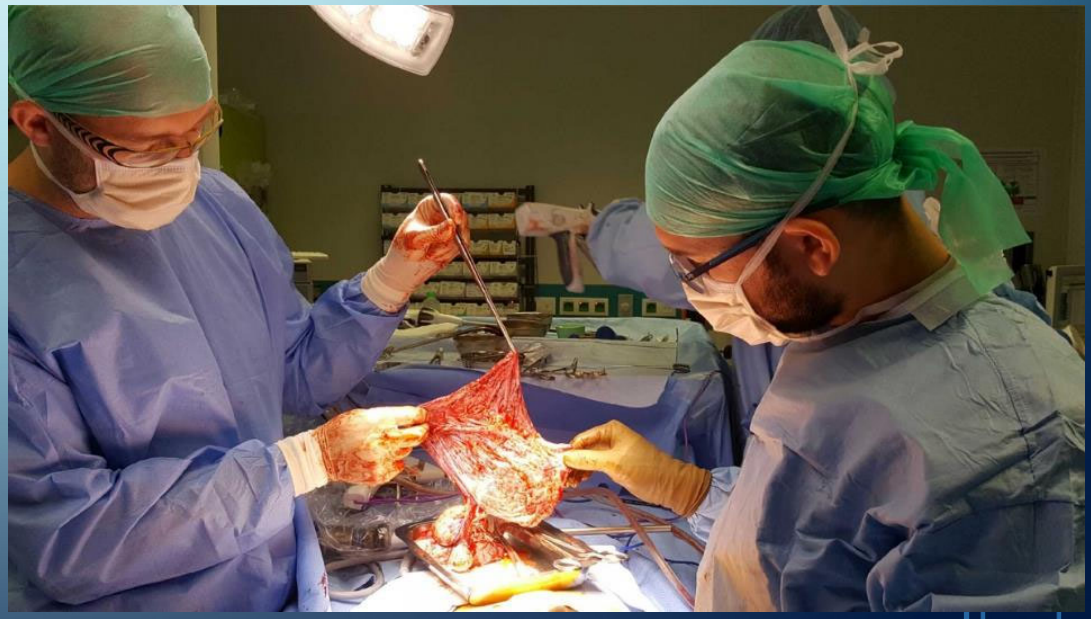


Hypoxémie, Hypercapnie, O_2 à domicile, VEMS<50%Théo, TLCO >30%, Cœur Pulmonaire Chronique?

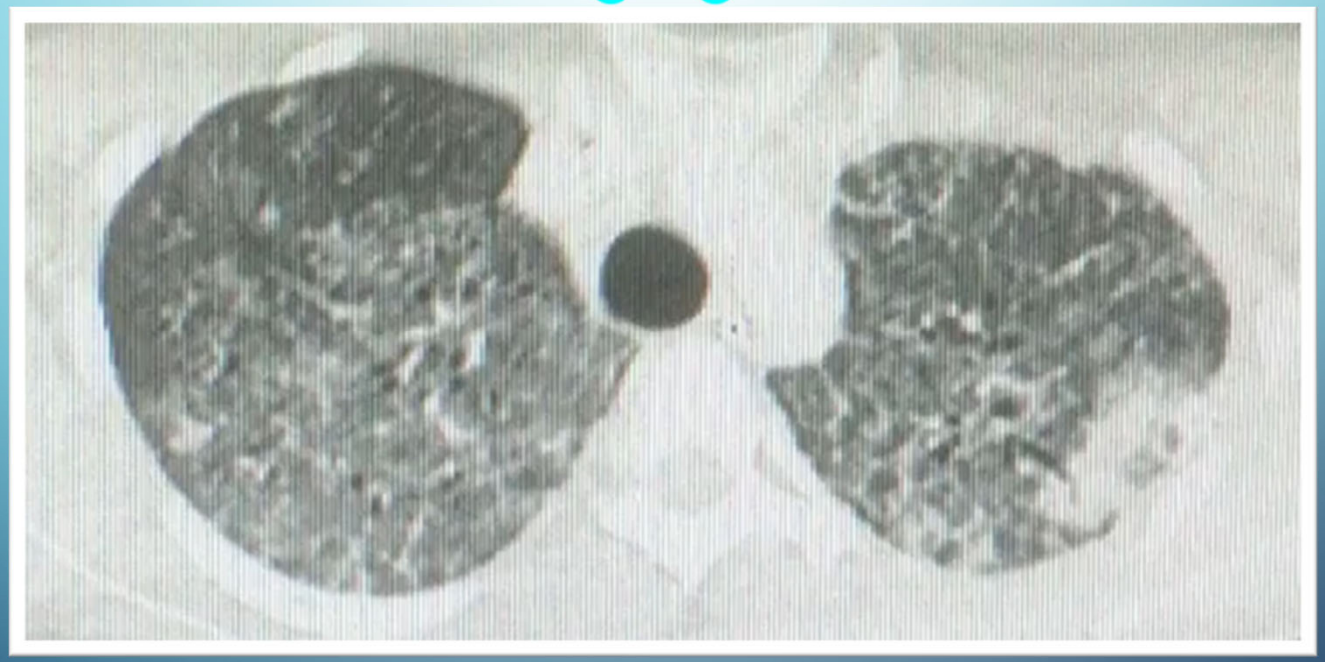
Sécurité pour l'hématose et le risque de tamponnade gazeuse


VOLUME CONTROLE
MAQUET

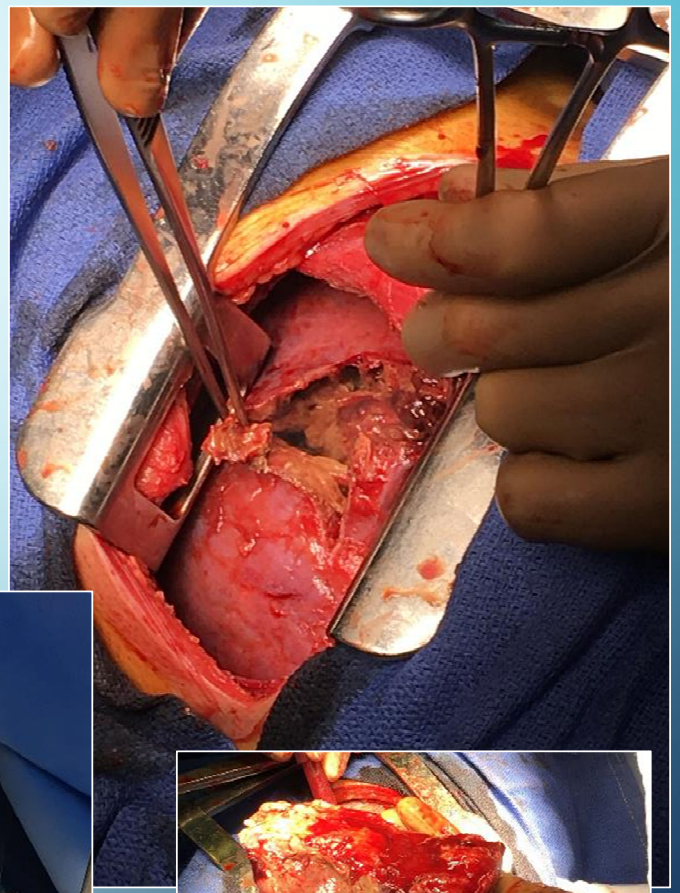


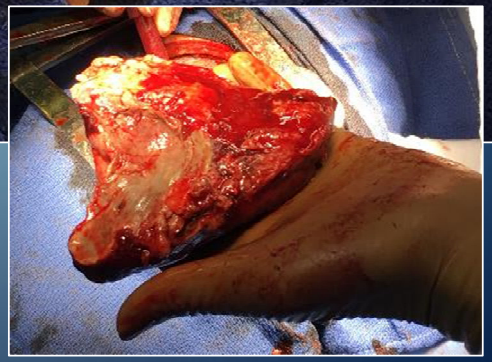


CHIRURGIE DE PROPRETÉ



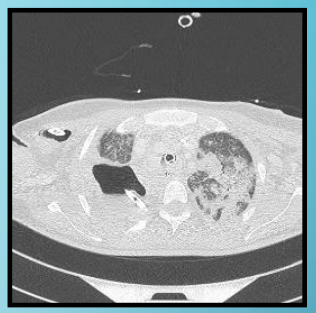
Contusion / abcès fistule / bronchopleurale





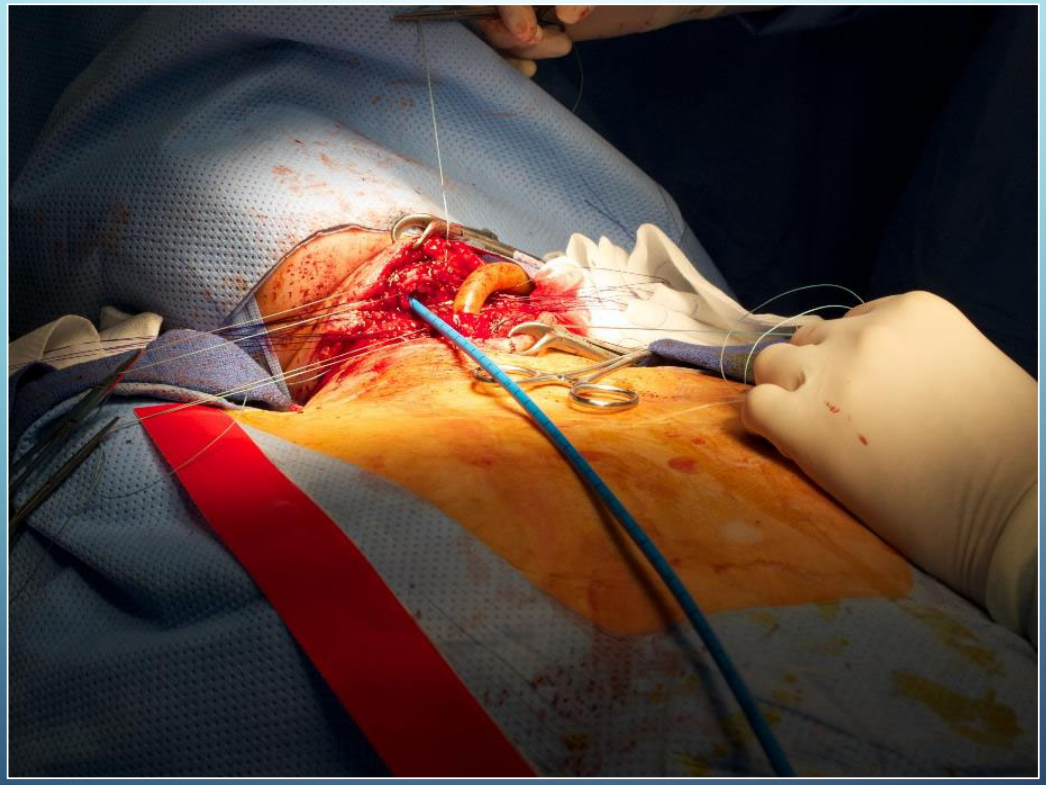
FISTULES BRONCHO PLEURALES

V_D/V_T



Rozé et al. Intensive Care Med. 2012;38:922-3

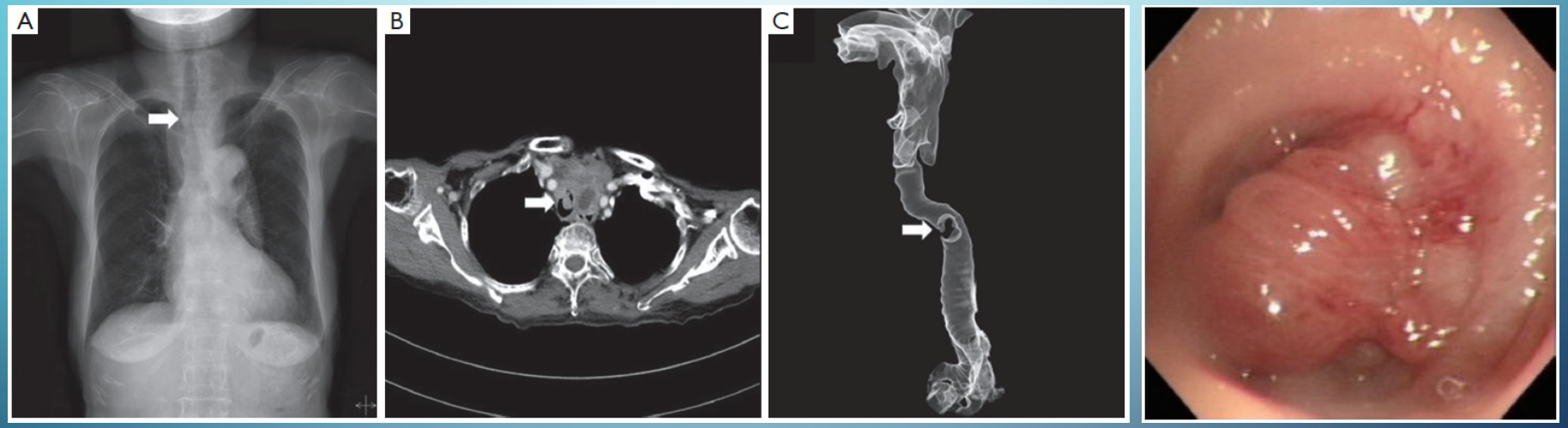
CHIRURGIE DE LA TRACHÉE



Flexible bronchoscopic excision of a tracheal mass under extracorporeal membrane oxygenation

Jae Jun Kim[1], Seok Whan Moon[2], Yong Hwan Kim[1], Si Young Choi[1], Seong Cheol Jeong[1]

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



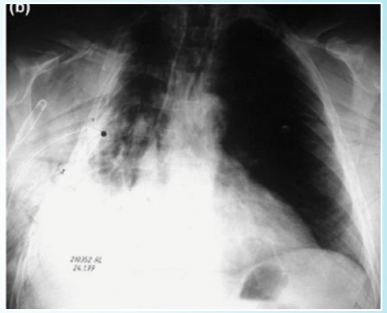
J Thorac Dis 2015;7(3):E54-E57

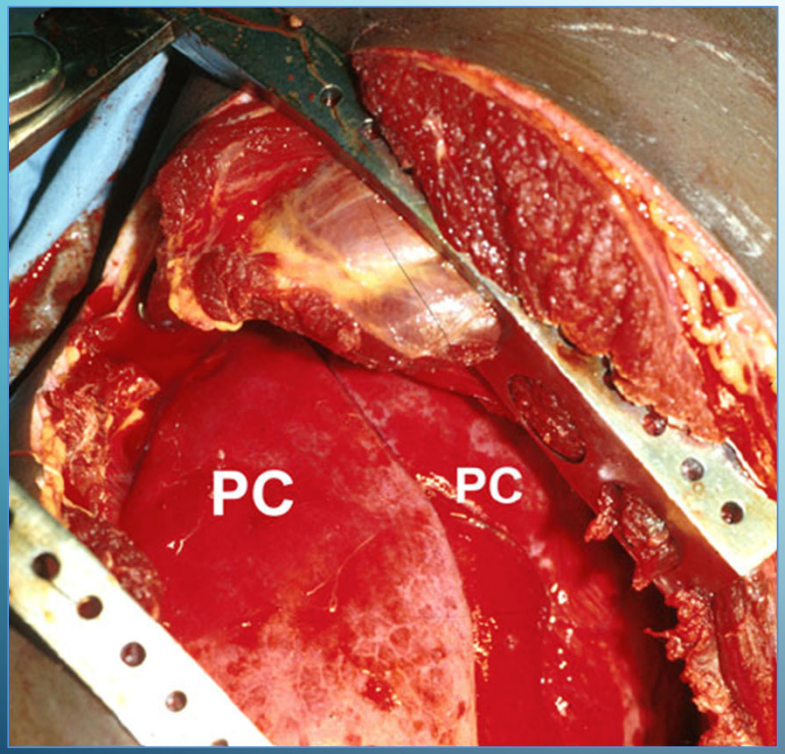
World J Surg (2010) 34:1959–1970
DOI 10.1007/s00268-010-0599-9

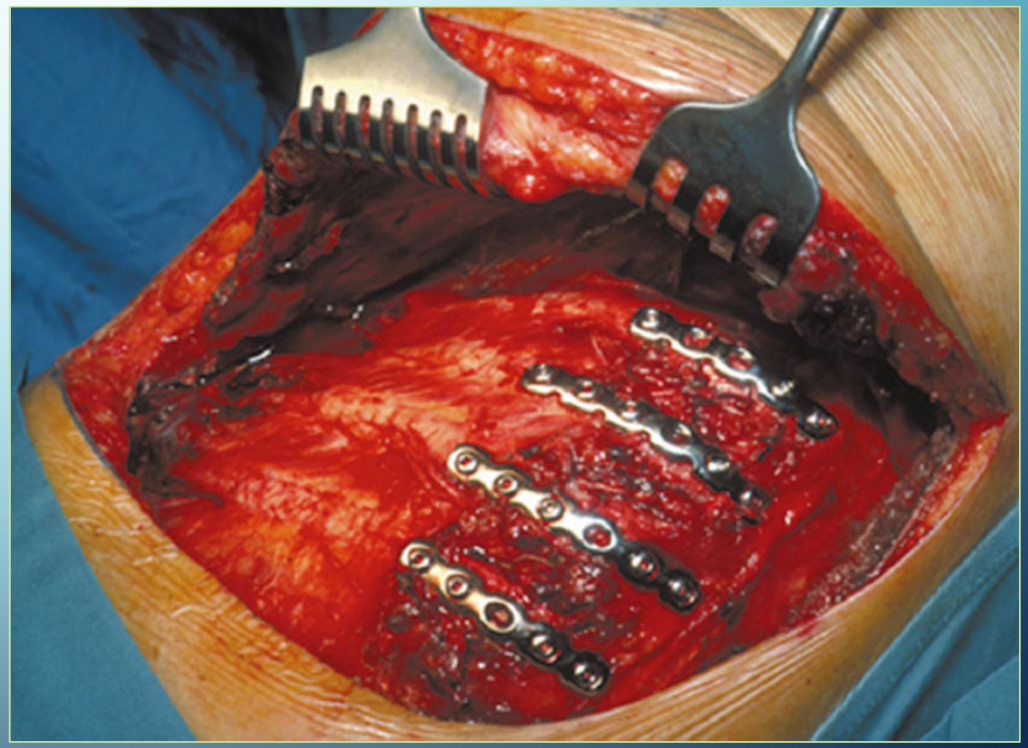
World Journal of Surgery

Pulmonary Contusion: An Update on Recent Advances in Clinical Management

Stephen M. Cohn · Joseph J. DuBose





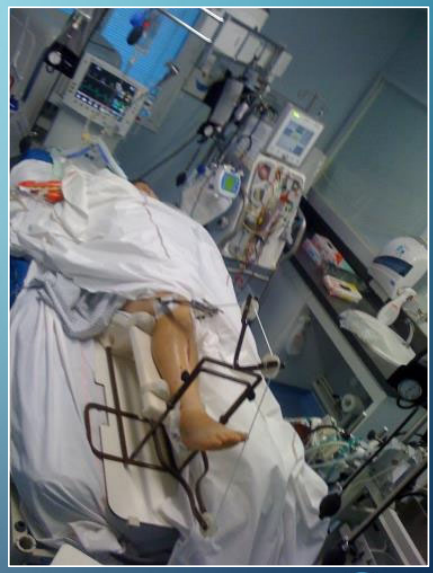


Risque hémorragique parfois TC associé donc pas trop d'héparine donc circuit ECMO bolus puis stop

Extracorporeal membrane oxygenation in severe trauma patients with bleeding shock☆

Matthias Arlt*, Alois Philipp, Sabine Voelkel, Leopold Rupprecht, 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	4	Survived without handicap
K.M./m/30 years	v-v	Car crash	Polytrauma Bleeding shock ARDS Aspiration	75/14	39	80	1.0	Damage control surgery CT-scan Kinetic therapy	PRBC: 2	6	Survived without handicap
D.V./m/56 years	v-v	Car crash	Polytrauma ICB Bleeding shock ARDS	75/12	58	59	1.1	Damage control surgery CT-scan	PRBC: 10 FFP: 22 PLTC: 3	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: 12 FFP: 19 PLTC: 2	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 Kinetic therapy	PRBC: 54 FFP: 102 PLTC: 11	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	CT-scan Kinetic therapy	PRBC: 10 FFP: 27 PLTC: 2	5	Died on ECMO in septic multiple organ failure
K.N./f/24 years	v-v	Car crash	Polytrauma Bleeding shock ARDS	66/12	69	38	1.0	Laparatomy Trauma surgery	PRBC: 7	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: 24 PLTC: 2	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	PRBC: 25 FFP: 12	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	PRBC: 12 FFP: 3	11	Survived without handicap



M. Arlt et al. / Resuscitation 81 (2010) 804–809

1. The use of extracorporeal membrane oxygenation therapy in the delayed surgical repair of a tracheal injury.
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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2. Extracorporeal membrane oxygenation-assisted resection of goiter causing severe extrinsic airway compression.
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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3. Flexible bronchoscopic excision of a tracheal mass under extracorporeal membrane oxygenation.
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.
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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

Roze et al. Intensive Care Medicine 2014

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 un pression motrice contrôlée
- Possibilité d'etre protecteur de la circulation pulmonaire

Consequences of Vascular Flow on Lung Injury Induced by Mechanical Ventilation

Lapins avec poumons lésés

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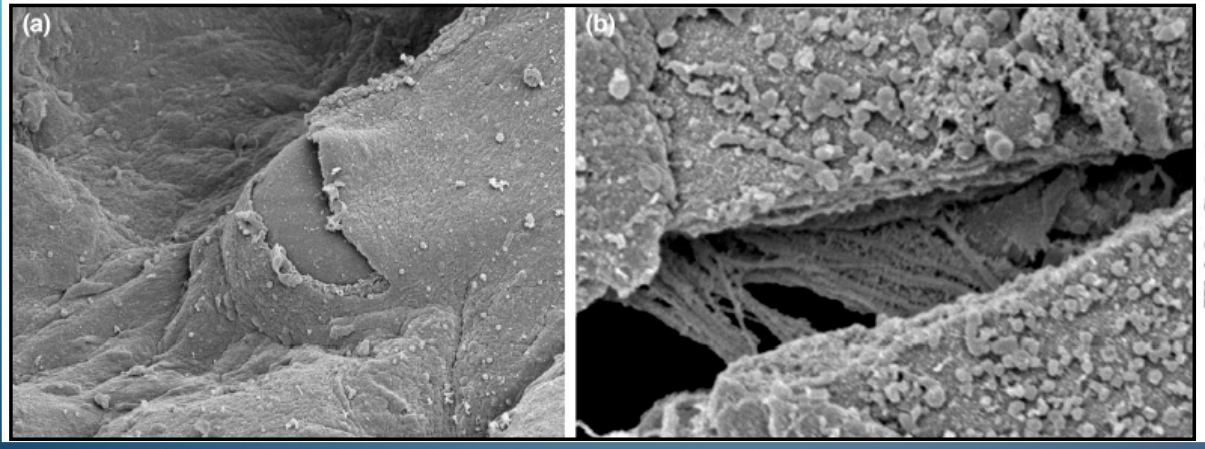
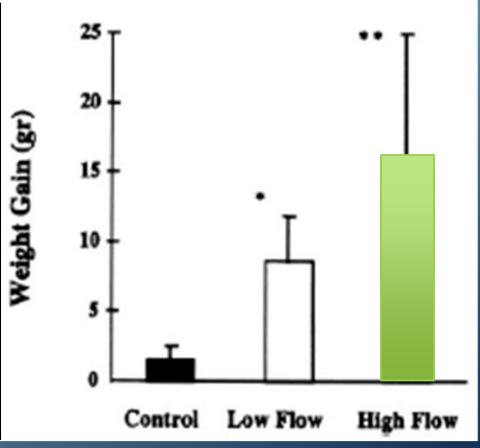
	Control Group	Low-flow Group
Start of ventilation		
Pplat	15.2 ± 0.4	29.9 ± 0.2
PEEP total	5.4 ± 0.2	1.2 ± 0.4
V_T, ml	13 ± 4†	96 ± 12‡
Pap mean, mm Hg	21.6 ± 6.2	22.8 ± 3.7

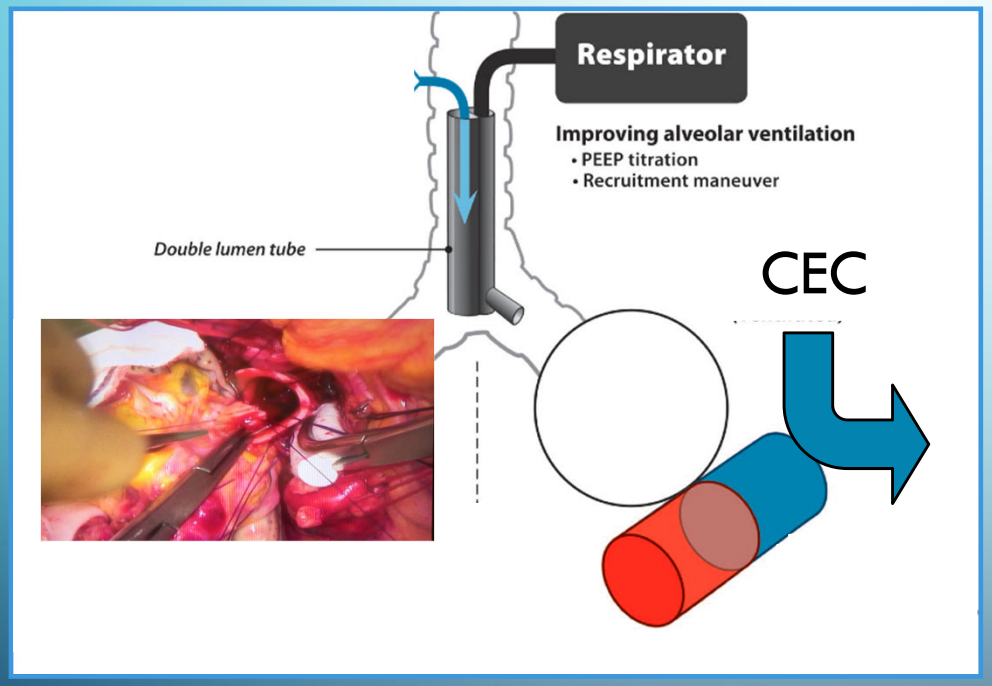
Débit sanguin p

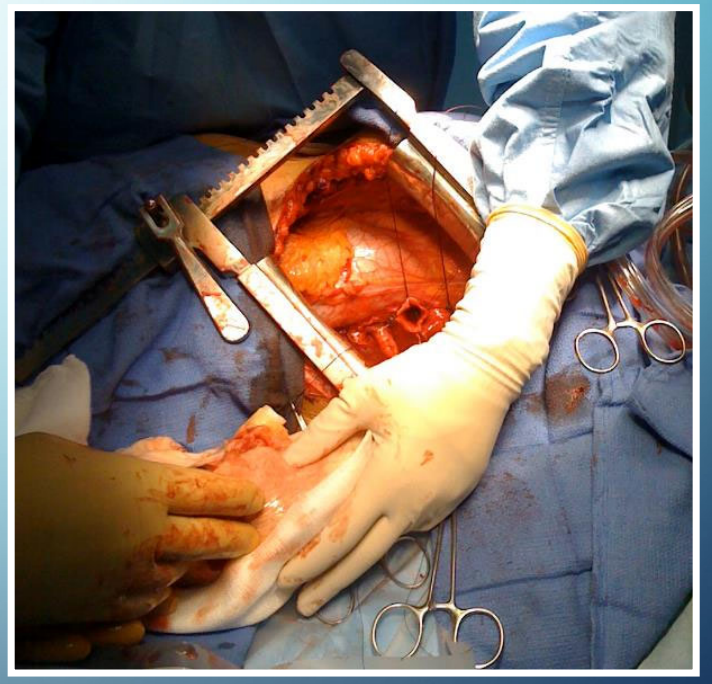




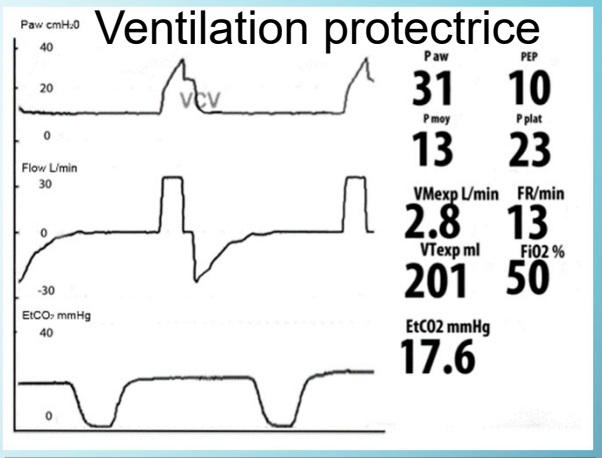
AM J RESPIR CRIT CARE MED 1998;157:1935–1942.

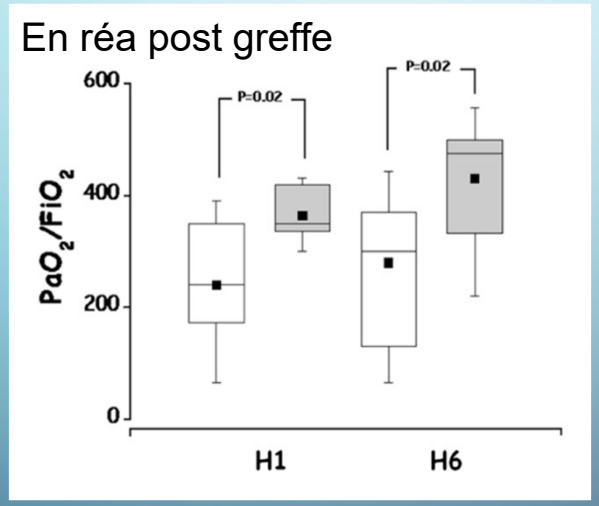
VENTILATION ET PERFUSION PROTECTRICES

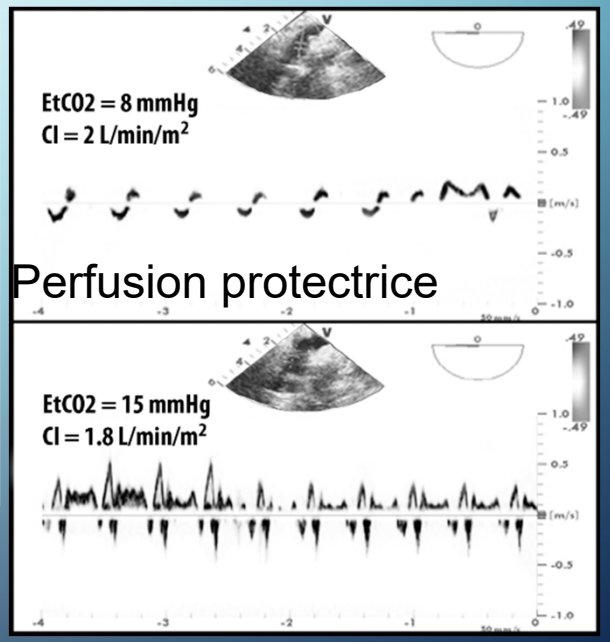




Contrôler le débit de perfusion du premier greffon

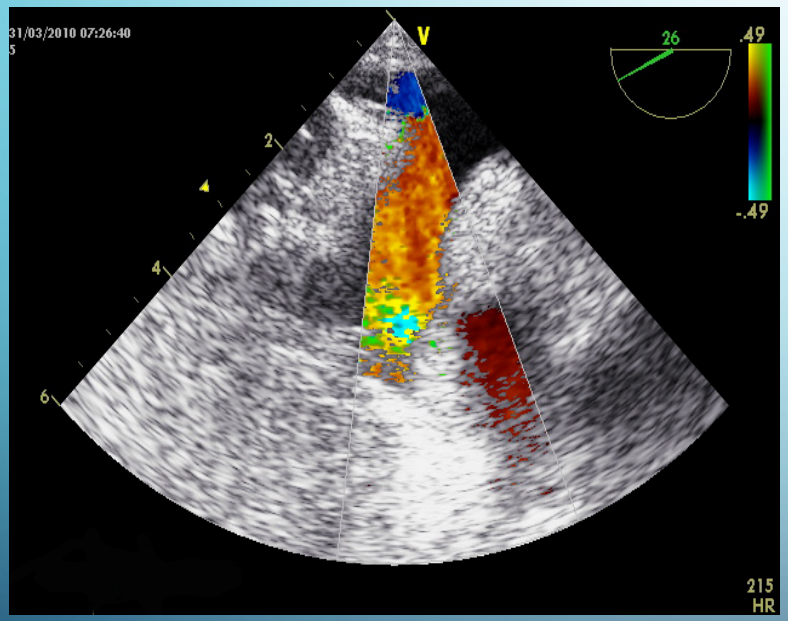




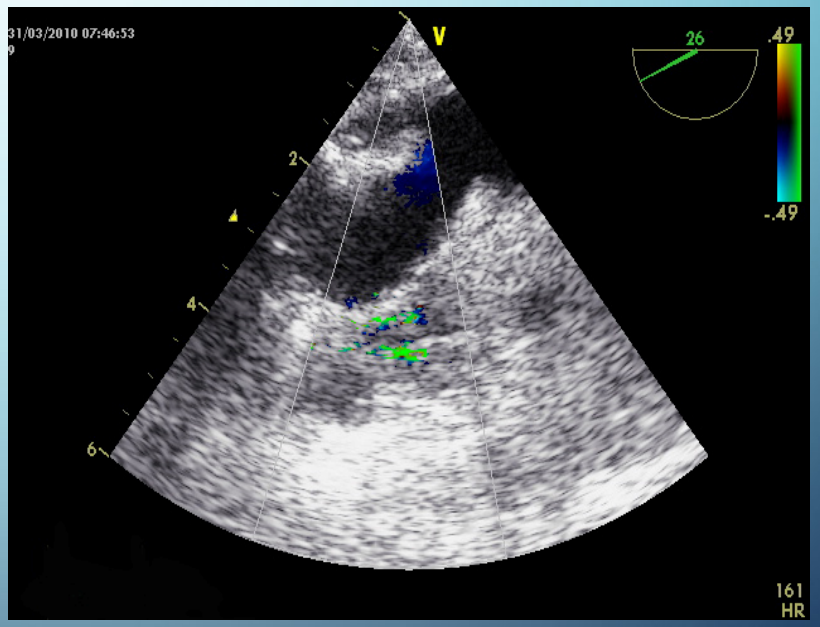


Roze et al. J Cardiothorac Vasc Anesth. 2013;27:467-73.

RETOUR VEINEUX PULMONAIRE CONTRÔLÉ

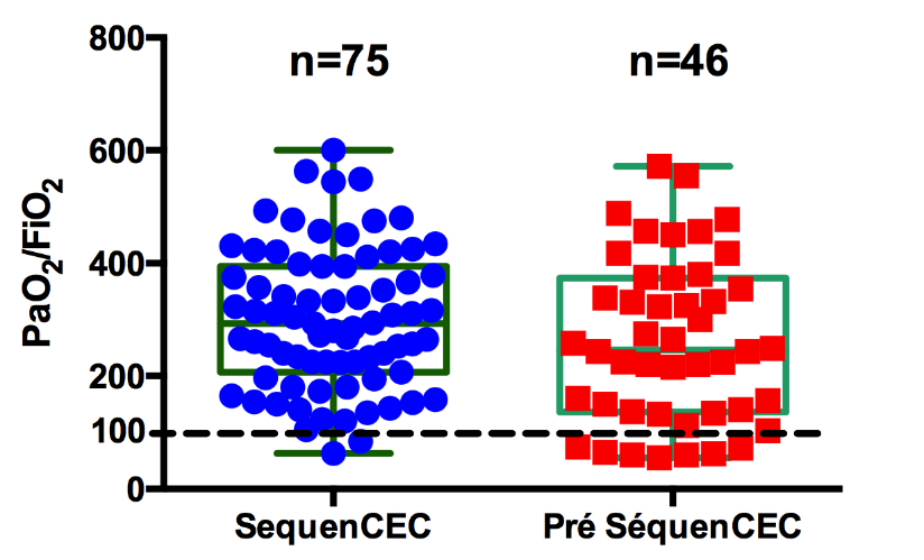


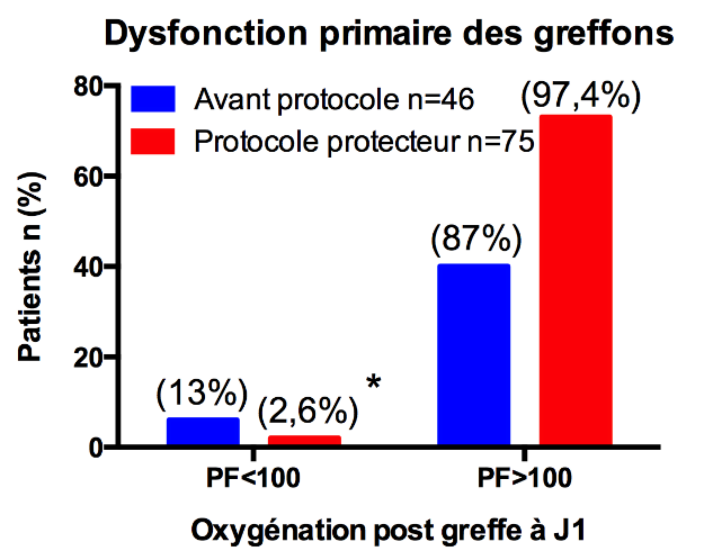
Avant CEC



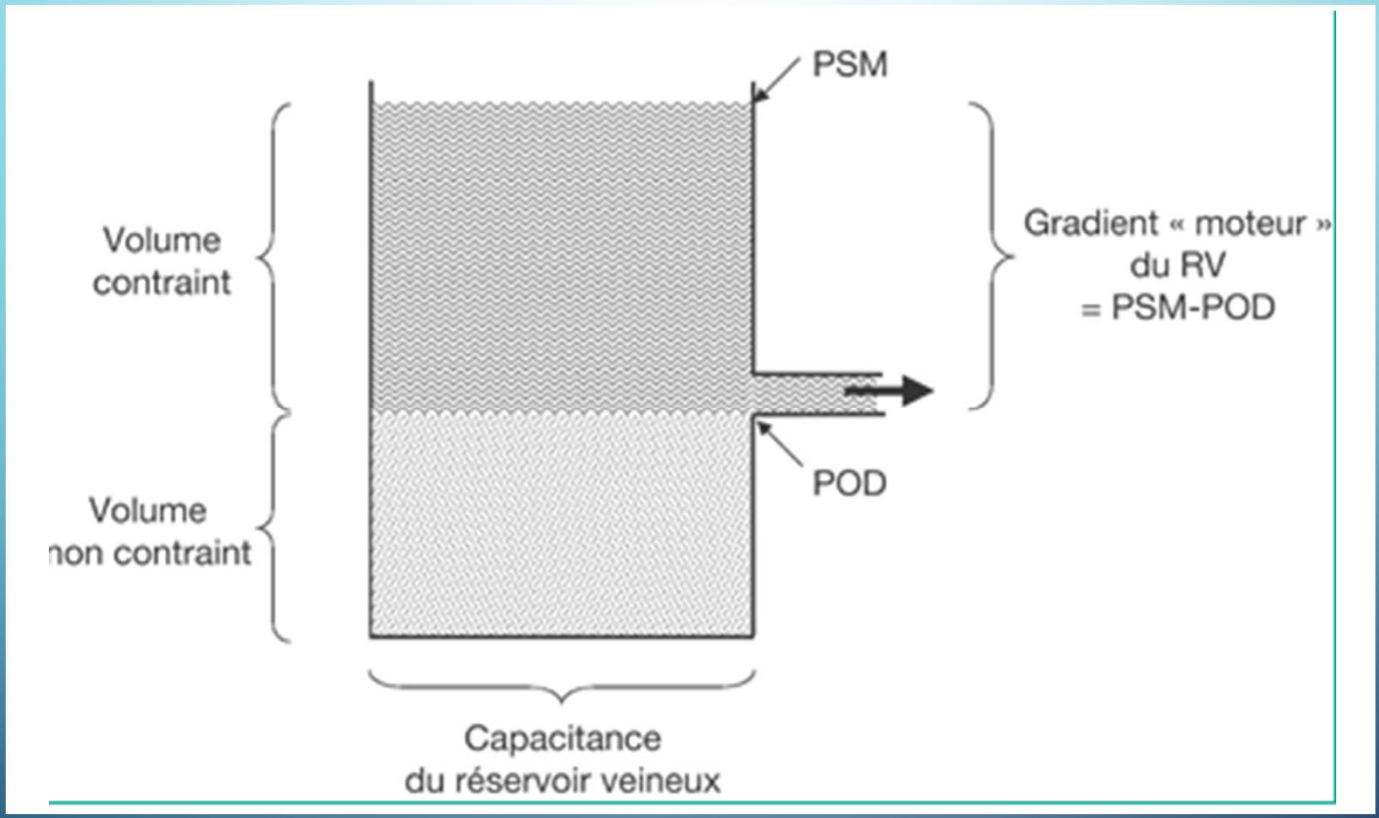
Sous CEC

CEC ET GREFFE PULMONAIRE EN 2017 (N=131)



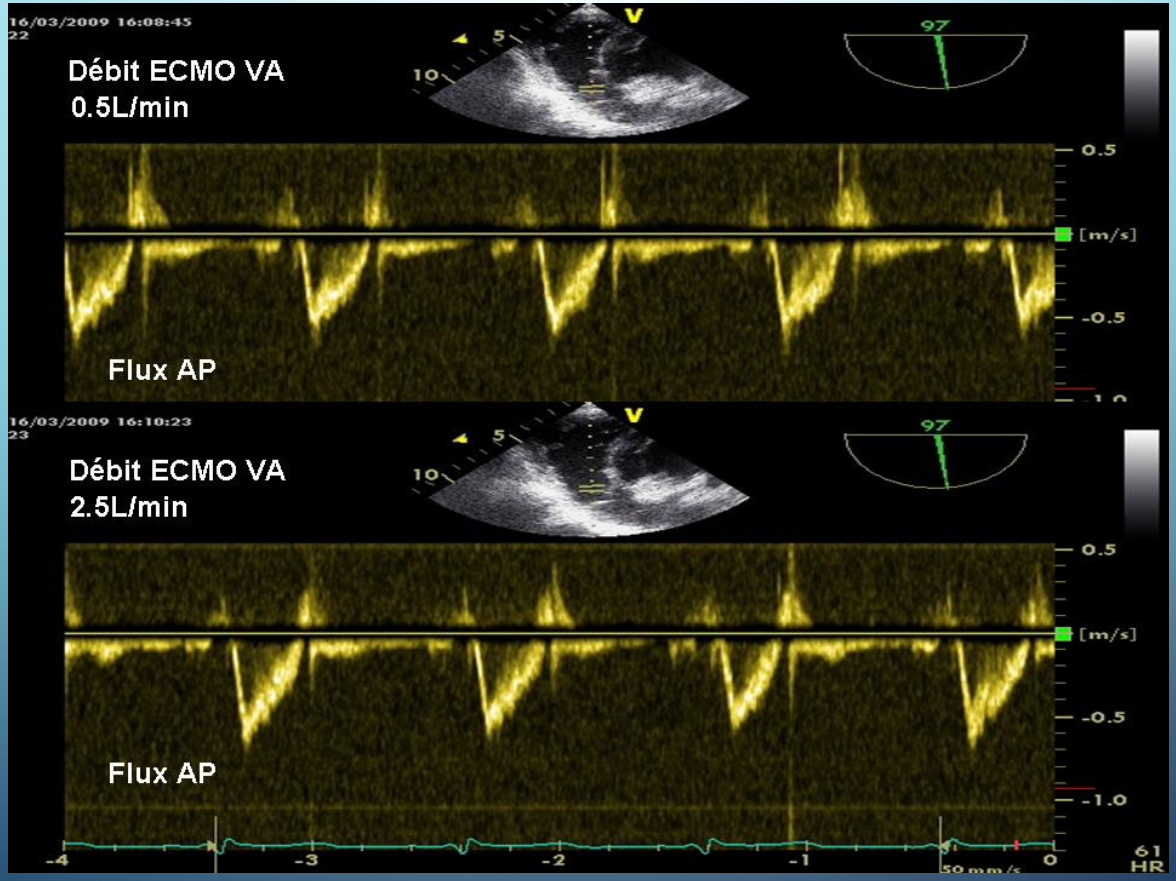


POMPES CENTRIFUGES



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

ITV SOUS 2 DEBITS D'ECMO CHEZ UN MUCO



The NEW ENGLAND JOURNAL of MEDICINE

Normothermic Ex Vivo Lung Perfusion in Clinical Lung Transplantation

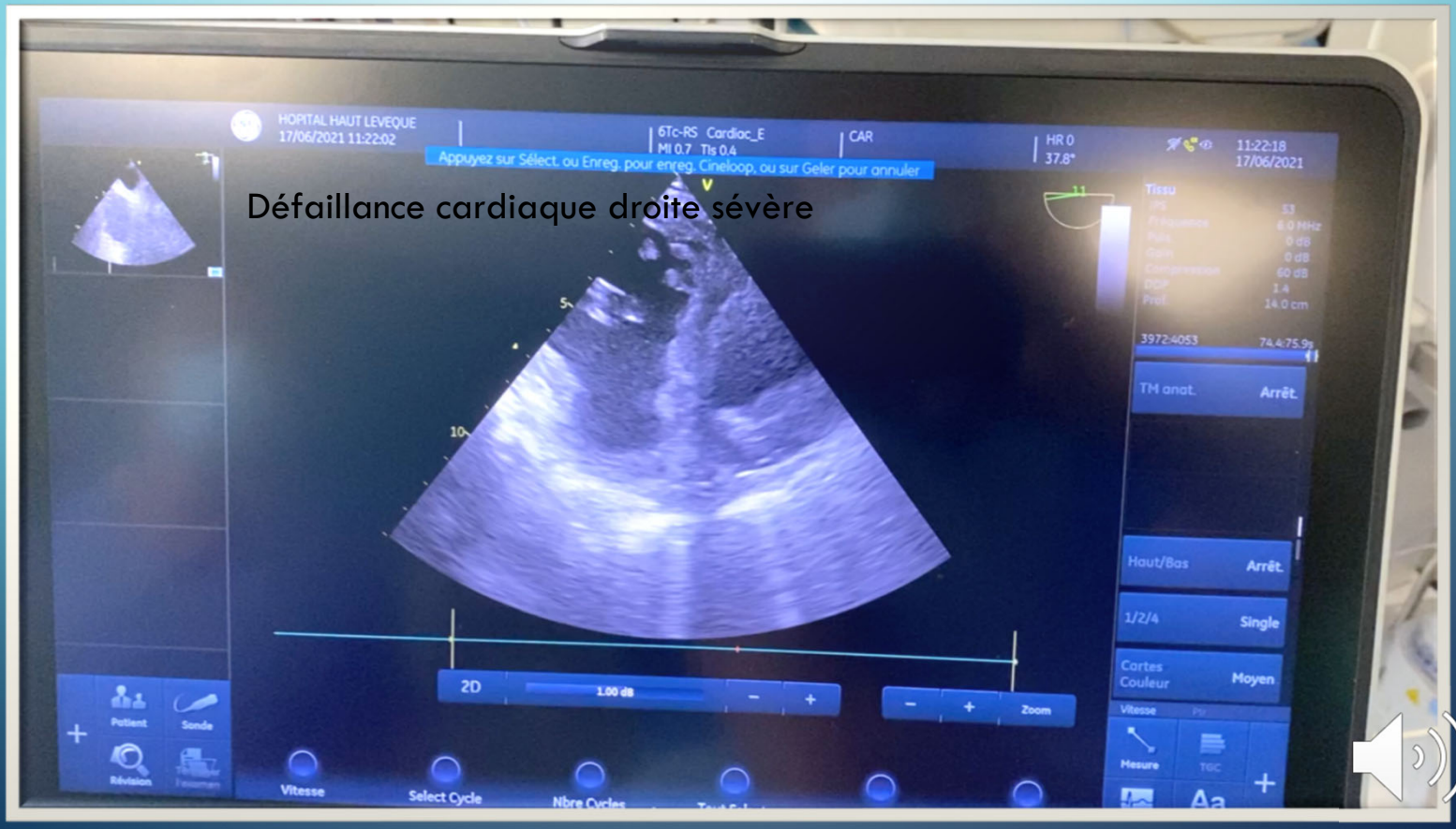
N Engl J Med 2011;364:1431-40.

CEC EX VIVO PRE GREFFE PULMONAIRE

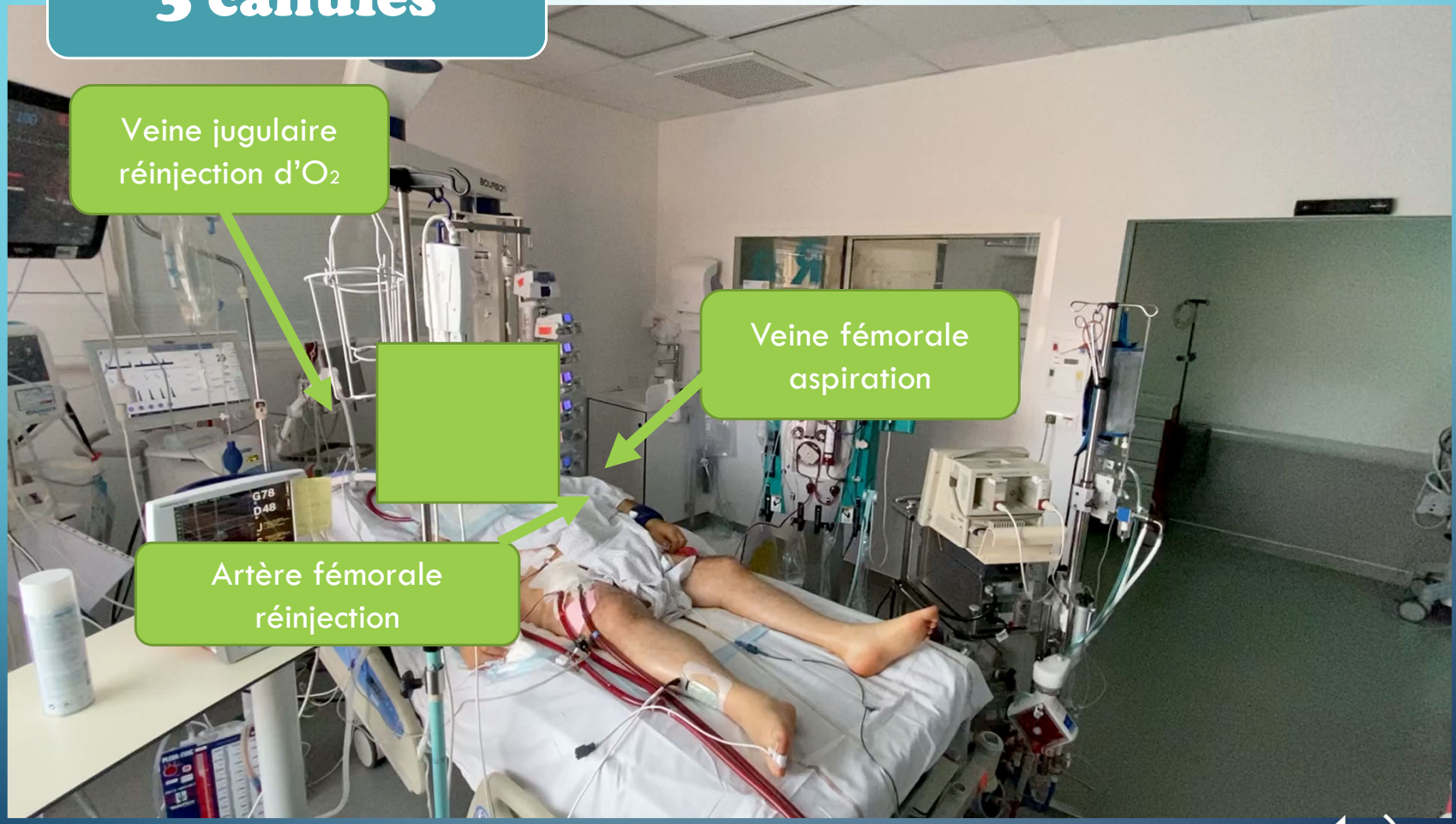
HTAP EN CHIRURGIE THORACIQUE

- 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

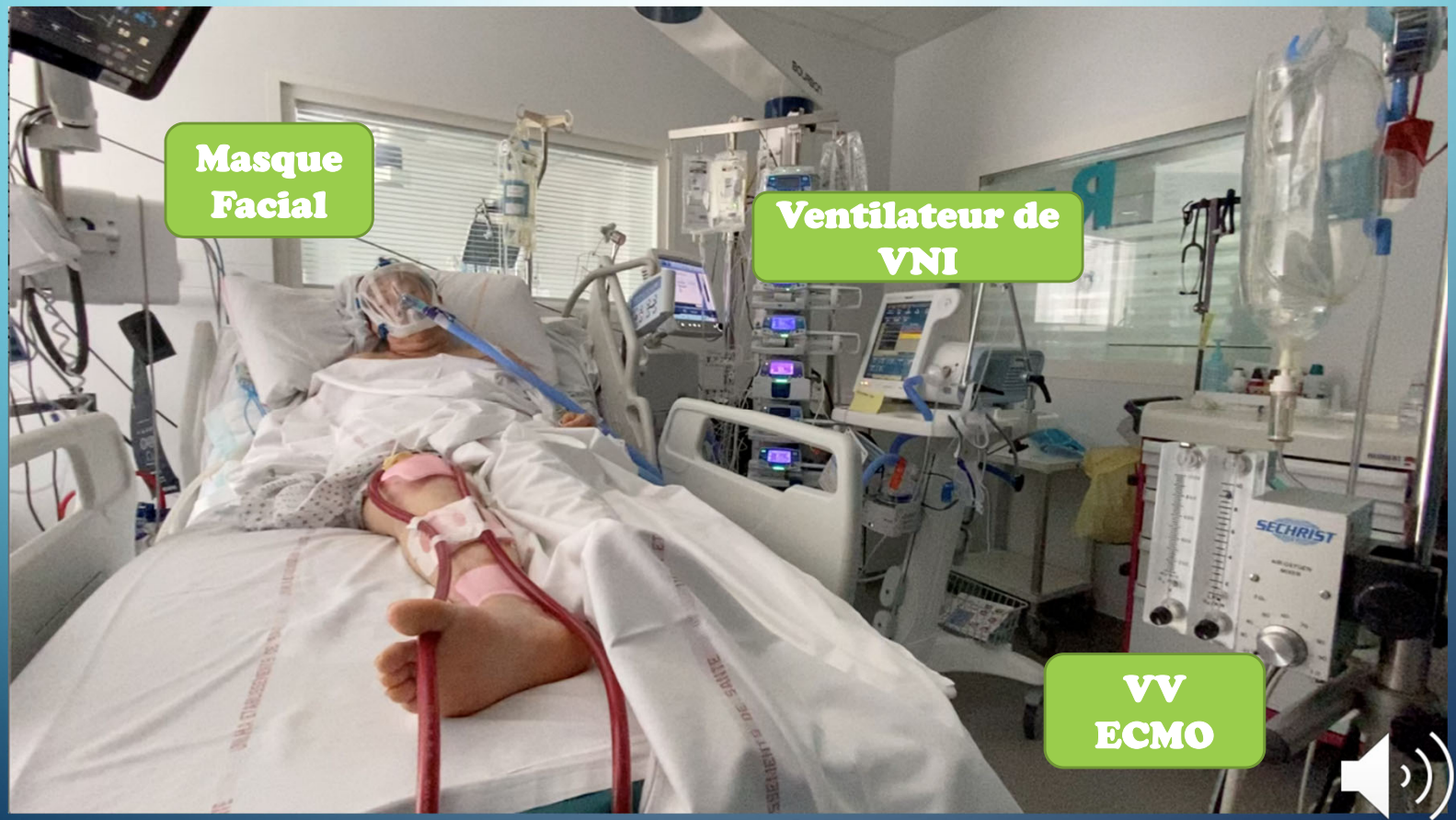
ECMO Hybride VV + VA



3 canules


Veine jugulaire réinjection d'O_2
Veine fémorale aspiration
Artère fémorale réinjection

ECMO et VNI



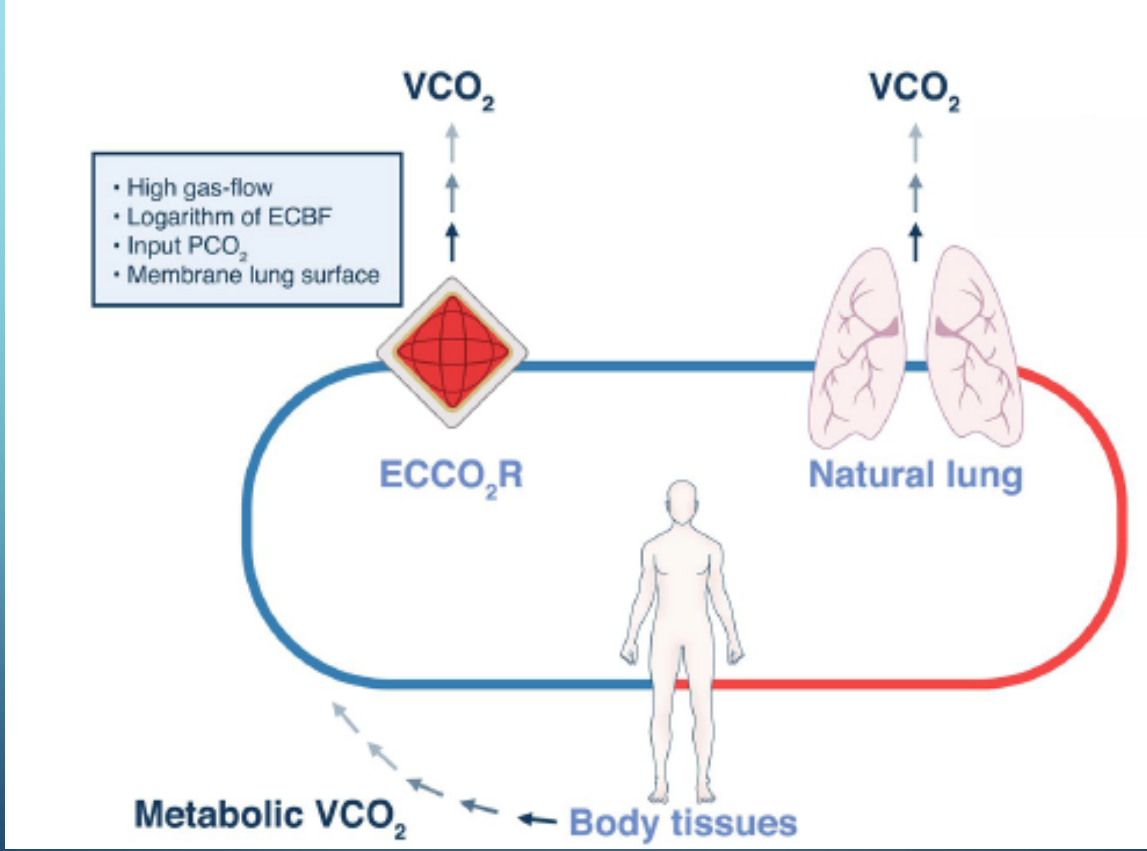
Canule double courant (fémorale)

Intensive Care Med
https://doi.org/10.1007/s00134-022-06827-6

SPECIAL ISSUE INSIGHT

Physiology of extracorporeal CO_2 removal

Luciano Gattinoni[1*], Silvia Coppola[2] and Luigi Camporota[3]



UNDERSTANDING THE DISEASE

Understanding hypoxemia on $ECCO_2R$: back to the alveolar gas equation

Jean-Luc Diehl[1,2*], Alain Mercat[3] and Antonio Pesenti[4,5]

R =0,8
R =0,3

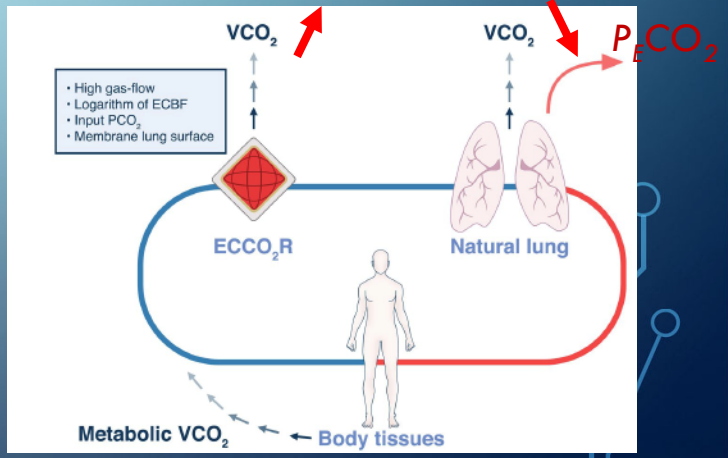
	Immediately before $ECCO_2R$	$ECCO_2R$ day 7
PaO_2/FiO_2	251	145
PA_{O_2} (mmHg) simplified	186	360
PA_{O_2} (mmHg) exact	–	248
$DA\text{-}aO_2$ (mmHg) simplified	98	273
$DA\text{-}aO_2$ (mmHg) exact	–	161
R (native lungs) measured by the ventilator	–	0.3
pH	7.31	7.38
PaO_2 (mmHg)	88	87
$PaCO_2$(mmHg)	51	54
Ventilatory mode	ACV	ACV
VT (mL/kg IBW)	6	6
RR (/min)	12	10
PEEP (cmH_2O)	0	5
FiO_2	0.35	0.6

$$P_AO_2 = P_iO_2 - \frac{P_ACO_2}{R}$$

R le quotient respiratoire peut être << 0,8

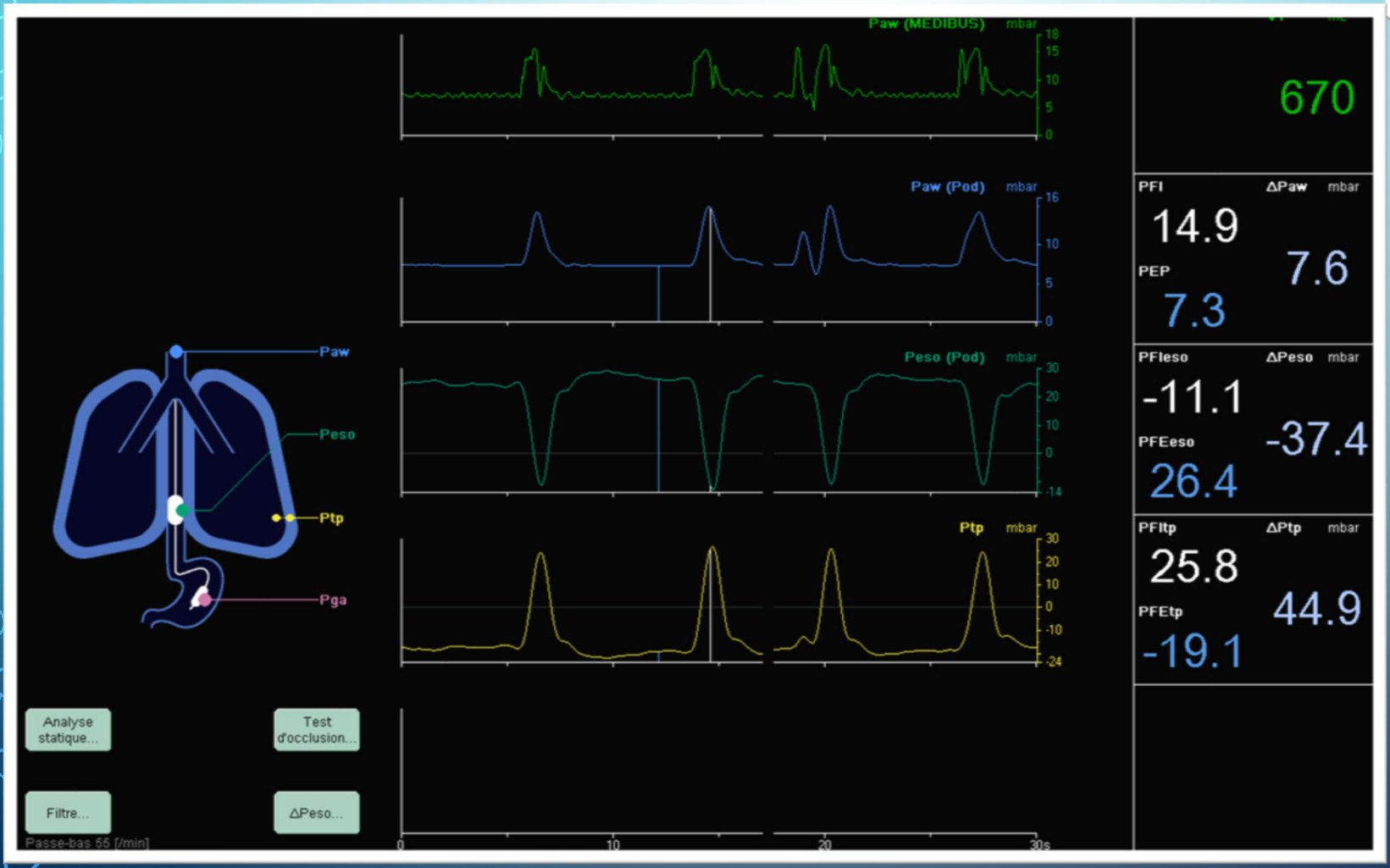
$$R = \frac{P_ECO_2 \, x \, (1 - FiO_2)}{P_iO_2 - PEO_2 - (PECO_2 x F^iO_2)}$$

R diminue avec la PAO_2 puis la PaO_2



Intensive Care Med (2019) 45:255–256

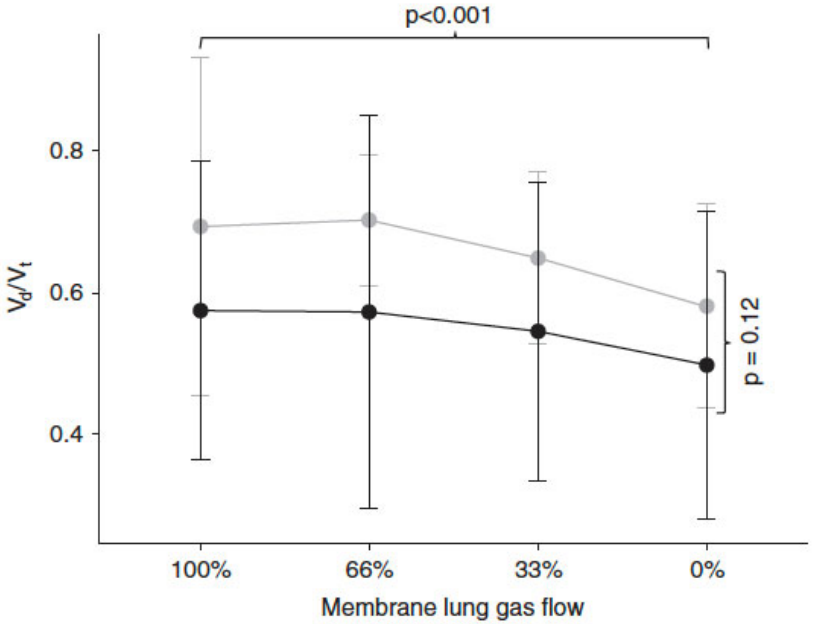
Compliance TP courbe PV débit lent
PEEP 6 à 20 ml.cmH_2O^{-1}

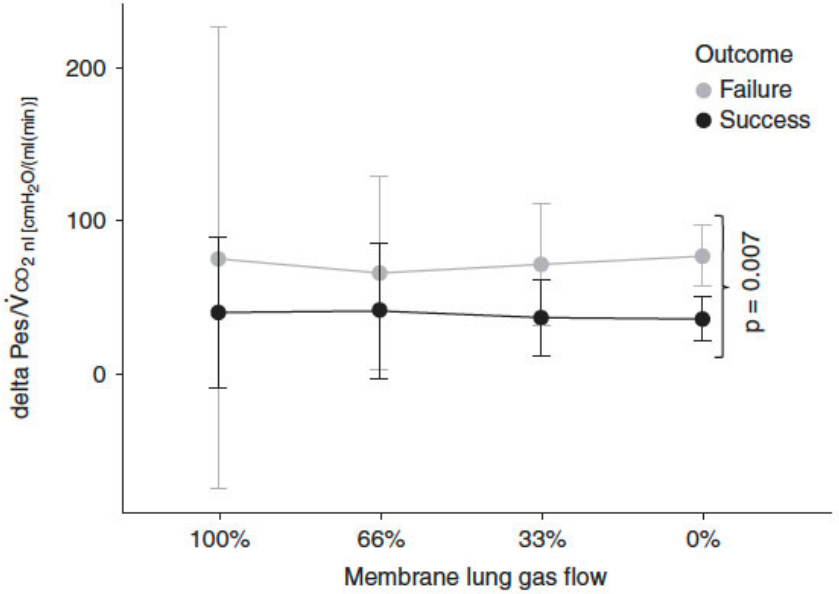


ORIGINAL ARTICLE

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

Stefano Lazzari[1,2*], Federica Romitti[1*], Mattia Busana[1], Francesco Vassalli[3], Matteo Bonifazi[1], Matteo Maria Macrí[4], Lorenzo Giosa[4], Francesca Collino[4], Daniel Heise[1], Martin Golinski[1], Simone Gattarello[2], Lars-Olav Harnisch[1], Serena Brusatori[1], Roberta Maj[1,2], Carmelo Zinnato[1], Konrad Meissner[1], Michael Quintel[1,5], Onnen Moerer[1], John J. Marini[6], Barnaby Sanderson[7], Luigi Camporota[7], and Luciano Gattinoni[1]





Am J Respir Crit Care Med Vol 206, Iss 8, pp 973–980, Oct 15, 2022

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 etre stoppée si saignement puis on cible 200 ui/kg/j on ne regarde pas trop l'activité AntiXa (nuage de points).