Mechanical ventilation on ECMO

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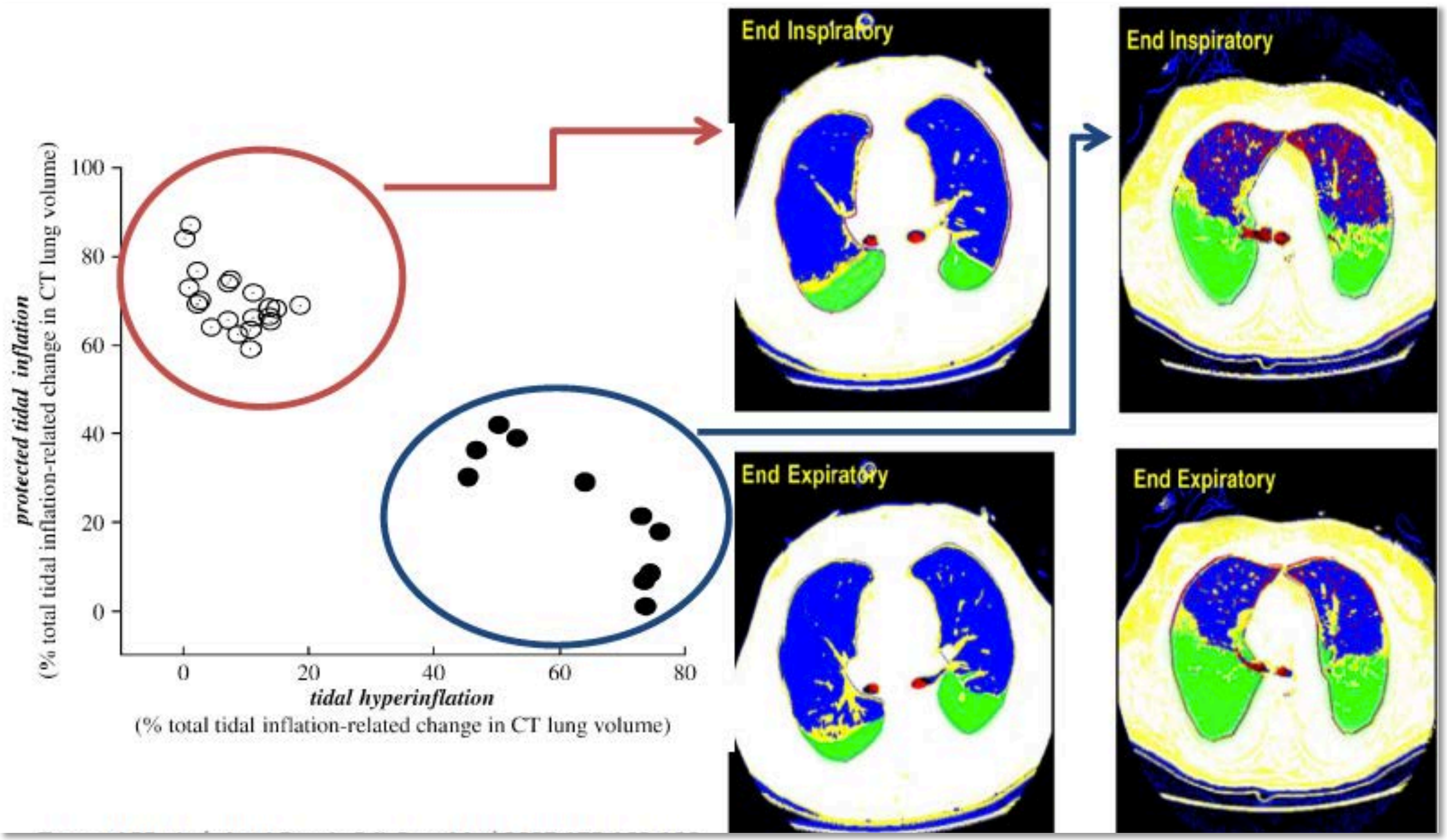
Disclosures

- Lectures fees for :
  - ✓ Dräger
  - ✓ Maquet Gettinge
  - ✓ Xenios

Tidal Hyperinflation during Low Tidal Volume Ventilation in Acute Respiratory Distress Syndrome

Pier Paolo Terragni, Giulio Rosboch, Andrea Tealdi, Eleonora Corno, Eleonora Menaldo, Ottavio Davini, Giovanni Gandini, Peter Herrmann, Luciana Mascia, Michel Quintel, Arthur S. Slutsky, Luciano Gattinoni, and V. Marco Ranieri

Am J Respir Crit Care Med 2007;175:160-166.



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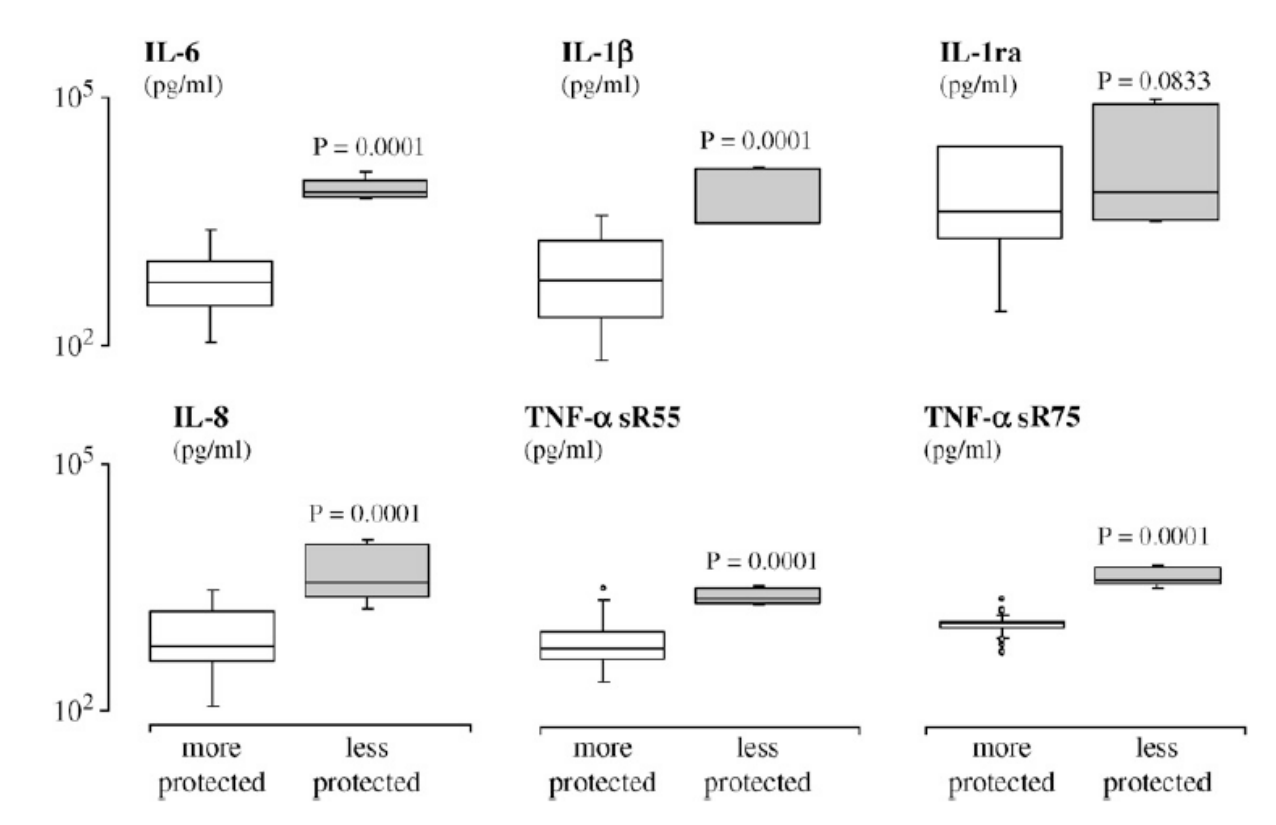


Luciano Gattinoni
Antonio Pesenti

The concept of "baby lung"

From a physiological perspective the "baby lung" helps to understand ventilator-induced lung injury. In this context, what appears dangerous is not the V_T/kg ratio but instead the V_T/"baby lung" ratio. The practical message is straightforward: the smaller the "baby lung," the greater is the potential for unsafe mechanical ventilation.

Luciano Gattinoni
Antonio Pesenti

The concept of "baby lung"

aby lung" helps to understand
entilator-induced lung injury. In this
ontext, what appears dangerous is

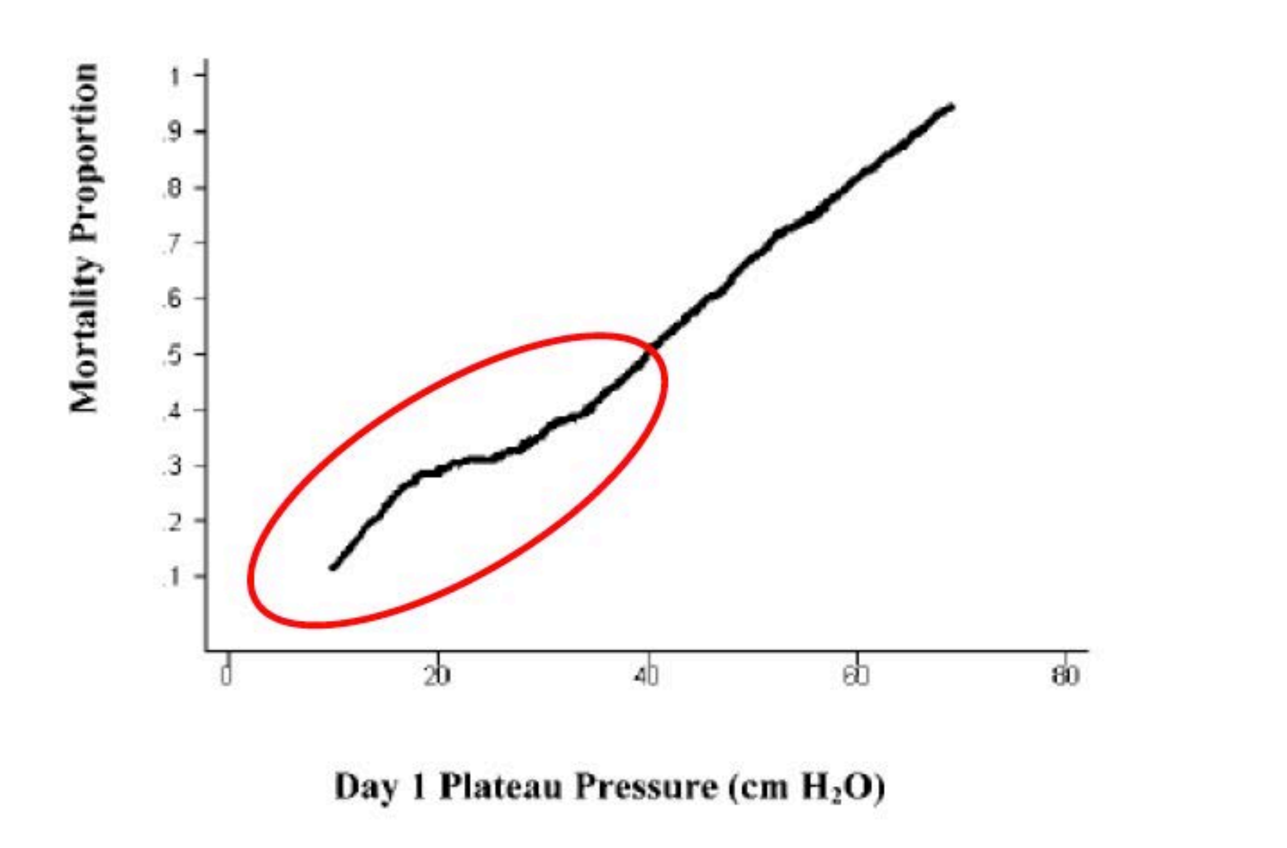
Treat the « baby lung » gently

V_T/"baby lung" ratio. The practical
essage is straightforward: the
maller the "baby lung," the greater is
he potential for unsafe mechanical
ntilation.

Tidal Volume Reduction in Patients with Acute Lung Injury When Plateau Pressures Are Not High

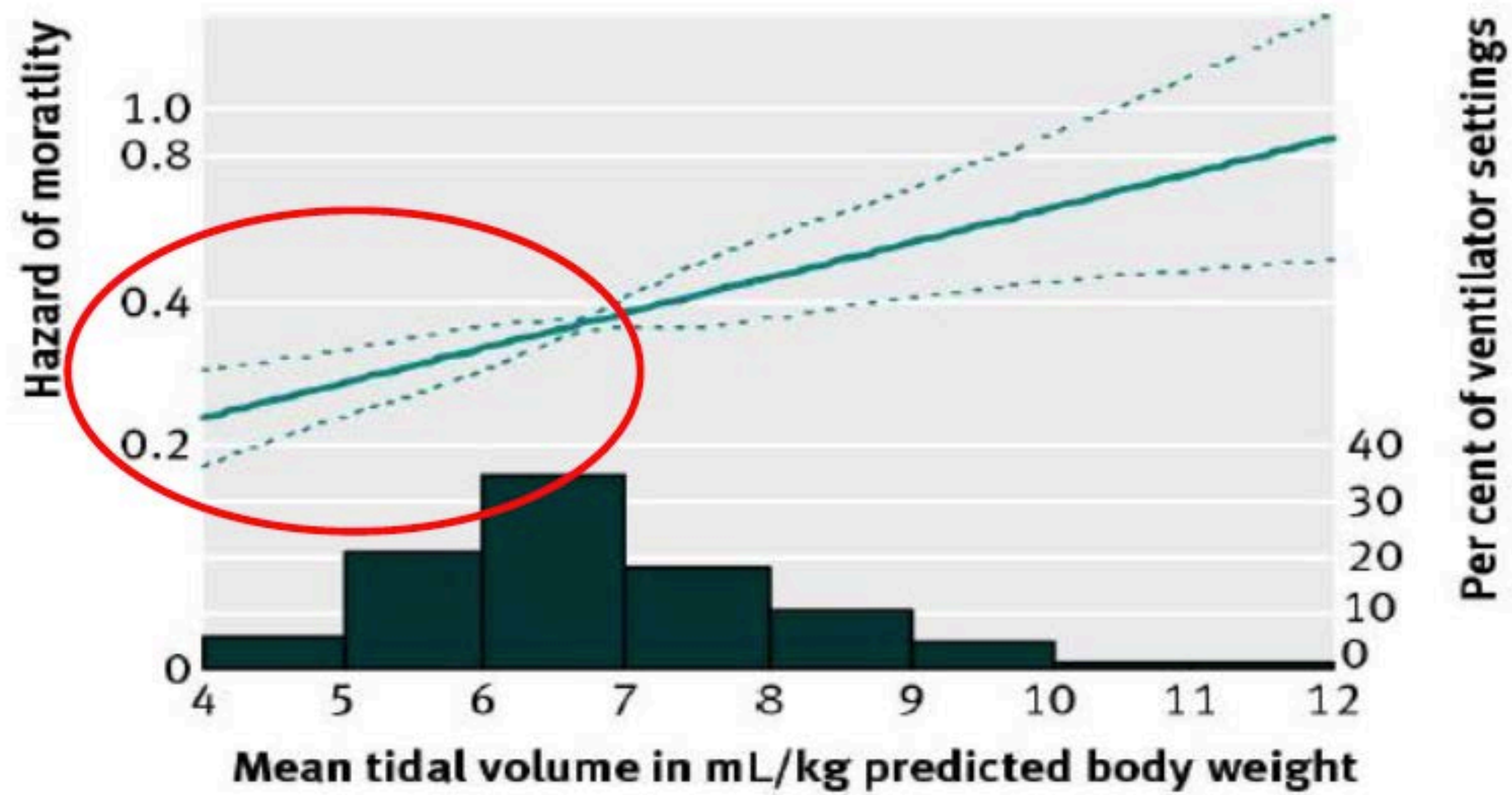
David N. Hager, Jerry A. Krishnan, Douglas L. Hayden, and Roy G. Brower for the ARDS Clinical Trials Network

Am J Respir Crit Care Med Vol 172. pp 1241–1245, 2005



Lung protective mechanical ventilation and two year survival in patients with acute lung injury: prospective cohort study

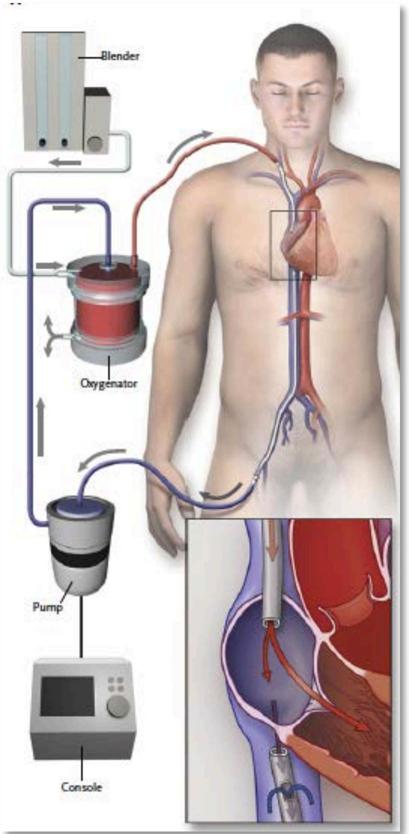
Needham DM et al., BMJ 2012;344:e2124.

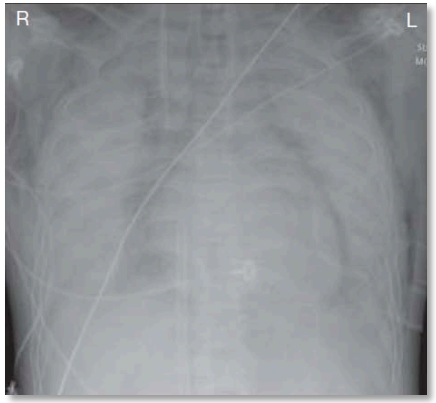


Extracorporeal Membrane Oxygenation for ARDS in Adults

Daniel Brodie, M.D., and Matthew Bacchetta, M.D.

NEJM, 2011





The principles of VV ECMO:

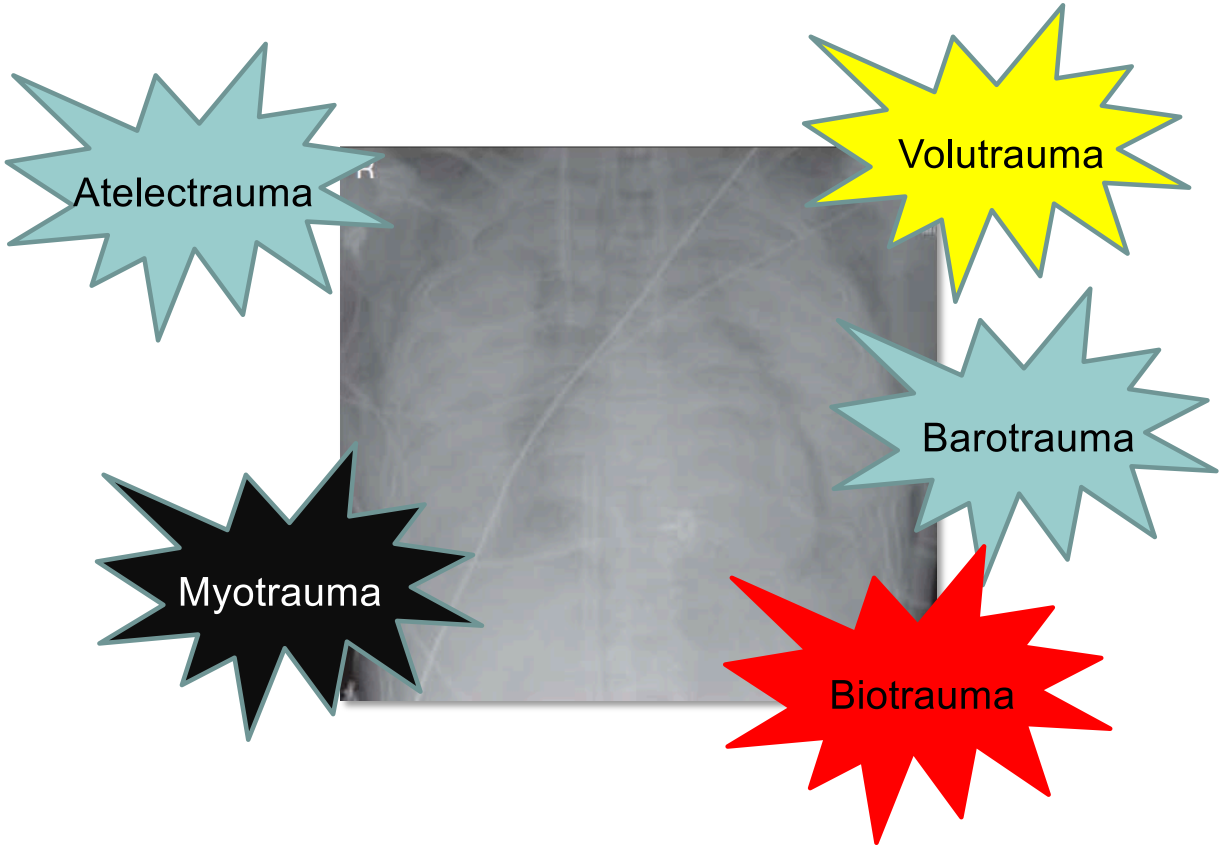
- To replace pulmonary function…
- **To allow the lung to rest…**
- **To allow healing of the lungs…**

Mechanical ventilation during extracorporeal membrane oxygenation

Matthieu Schmidt[1*], Vincent Pellegrino[2], Alain Combes[3], Carlos Scheinkestel[2], D Jamie Cooper[1,2] and Carol Hodgson[1,2]

Schmidt *et al. Critical Care* 2014, 18:203

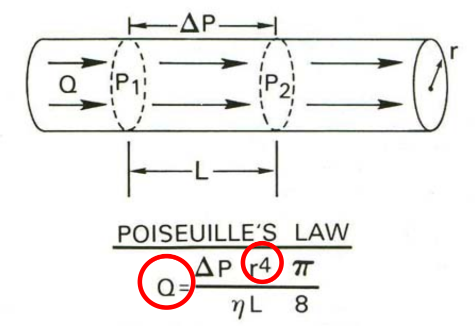
What harms the respiratory system?

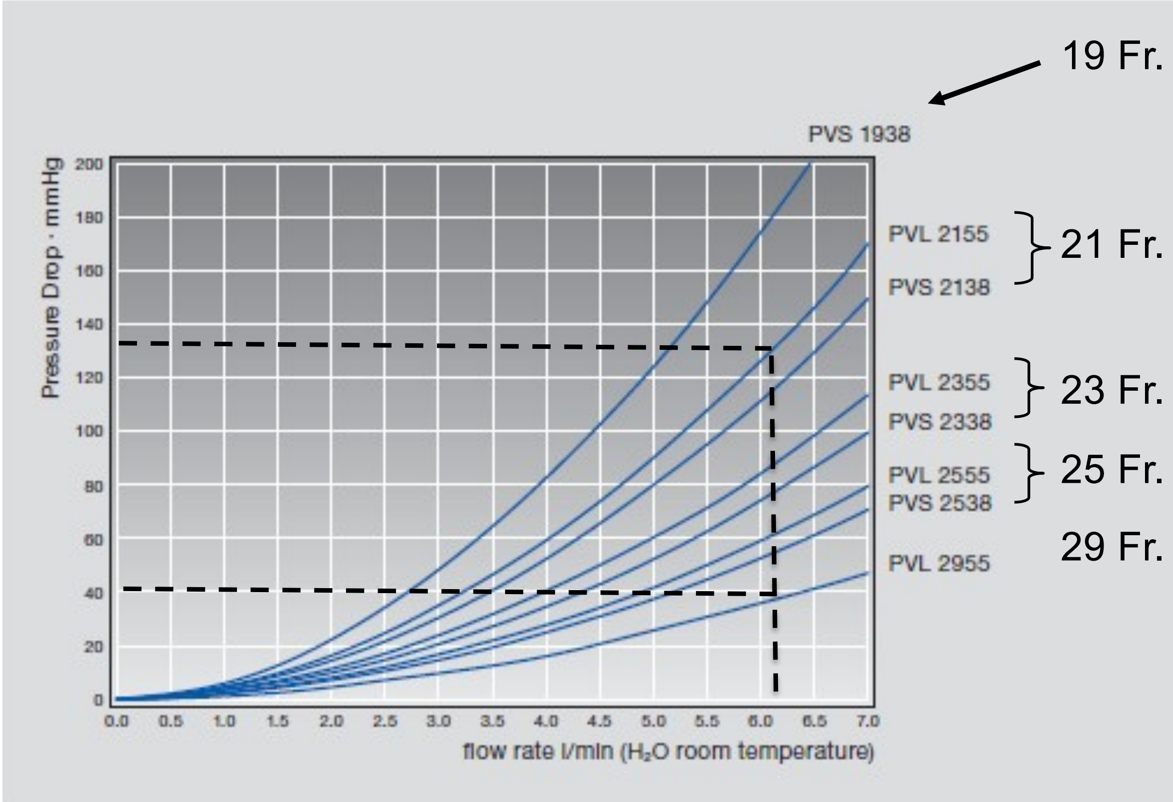


Objectives of ECMO = Oxygenating the body and resting the lungs

- What should be the objectives of MV for patients ventilated on VV ECMO ?
  - Low pressure
  - Low volume
  - Preserve diaphragm activity

Depends on the amount of ventilation and oxygenation achieved via the extracorporeal circuit….



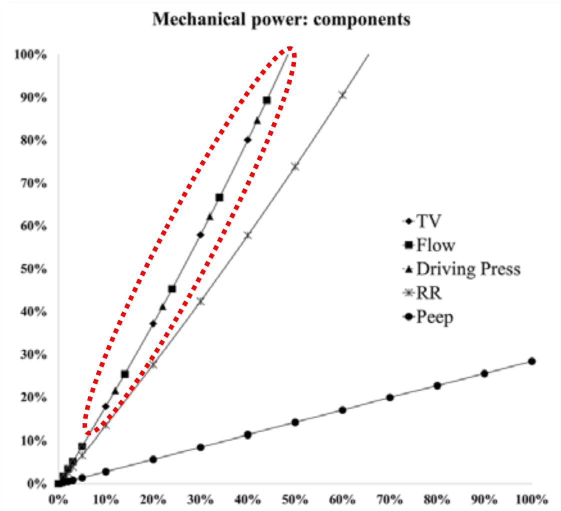


Ventilator-related causes of lung injury: the mechanical power

L. Gattinoni[1*], T. Tonetti[1], M. Cressoni[2], P. Cadringher[3], P. Herrmann[1], O. Moerer[1], A. Protti[3], M. Gotti[2], C. Chiurazzi[2], E. Carlesso[2], D. Chiumello[4] and M. Quintel[1]

Intensive Care Med (2016)

$$\text{Power}_{rs} = \text{RR} \cdot \left\{ \Delta V^2 \cdot \left[\frac{1}{2} \cdot \text{EL}_{rs} + \text{RR} \cdot \frac{(1 + I:E)}{60 \cdot I:E} \cdot R_{aw} \right] + \Delta V \cdot \text{PEEP} \right\}$$



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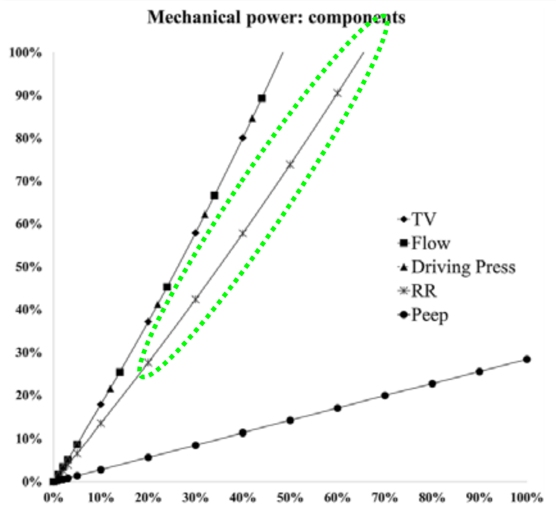

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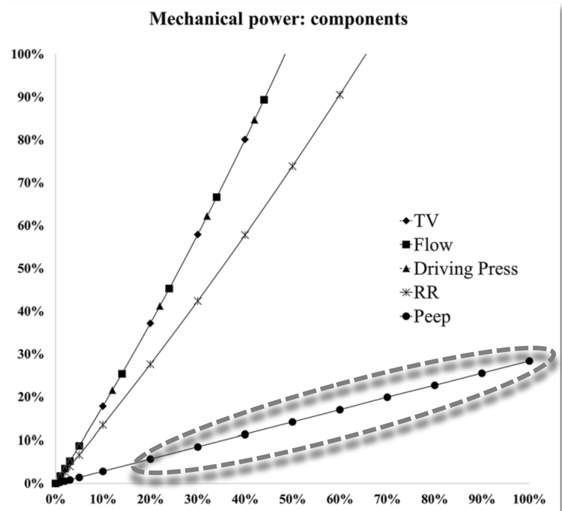


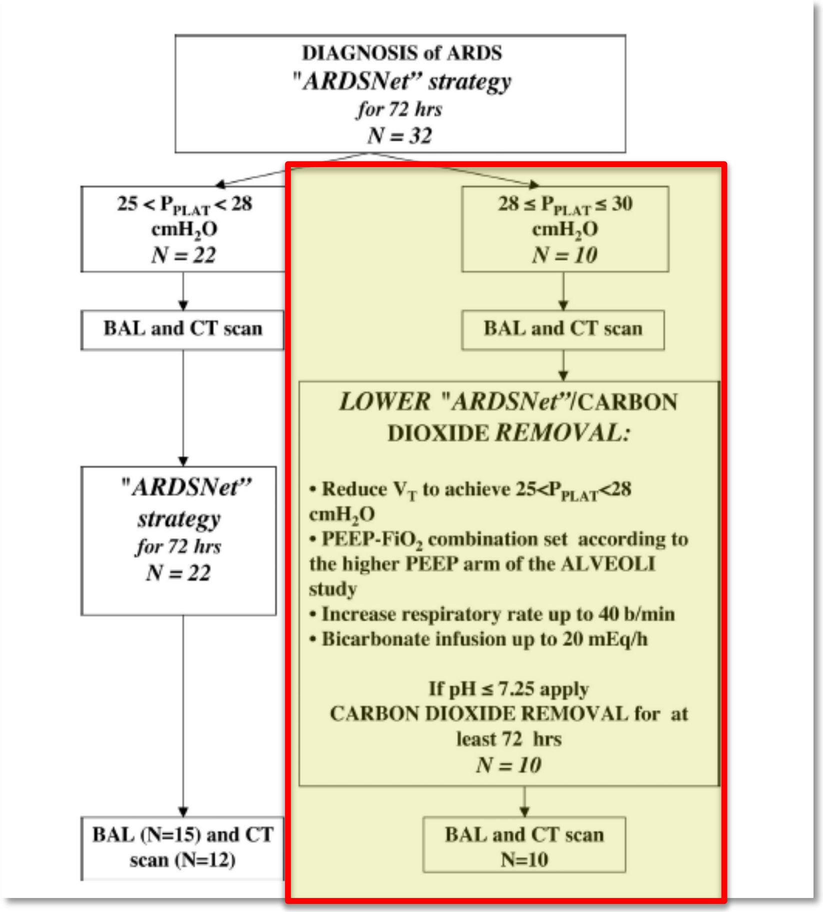
Reduce the plateau pressure on ECMO

Tidal Volume Lower than 6 ml/kg Enhances Lung Protection

Role of Extracorporeal Carbon Dioxide Removal

Pier Paolo Terragni, M.D.,* Lorenzo Del Sorbo, M.D.,* Luciana Mascia, M.D., Ph.D.,* Rosario Urbino, M.D.,*
Erica L. Martin, Ph.D.,* Alberto Birocco, M.D.,† Chiara Faggiano, M.D.,† Michael Quintel, M.D.,‡ Luciano Gattinoni, M.D.,§
V. Marco Ranieri, M.D.||

Anesthesiology 2009; 111:826-35



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V. Marco Ranieri, M.D.||

Anesthesiology 2009; 111:826–35

"ARDSNet" strategy: $25<P_{PLAT}<28$

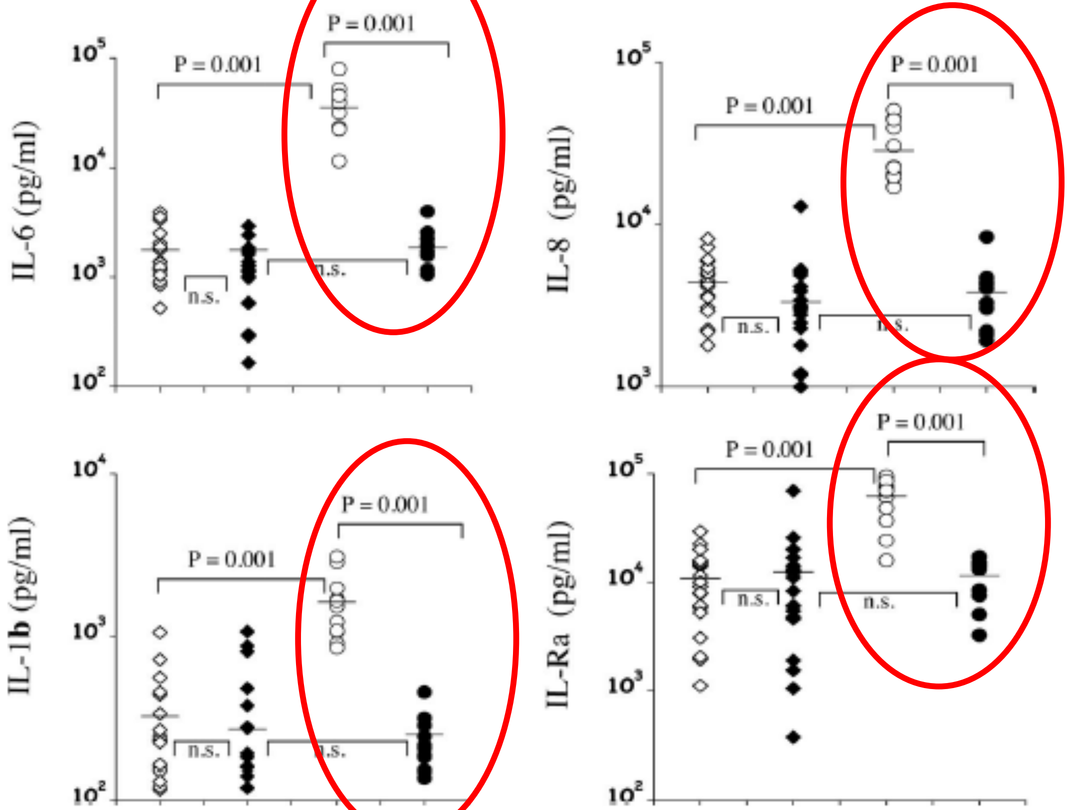
◇ *Entry (N = 22)*

◆ *after 72 hrs (N = 15)*

"ARDSNet" strategy: $28 \le P_{PLAT} \le 30$

○ *Entry (N = 10)*

● *after 72 hrs of LOWER* "ARDSNet"/CARBON DIOXIDE REMOVA



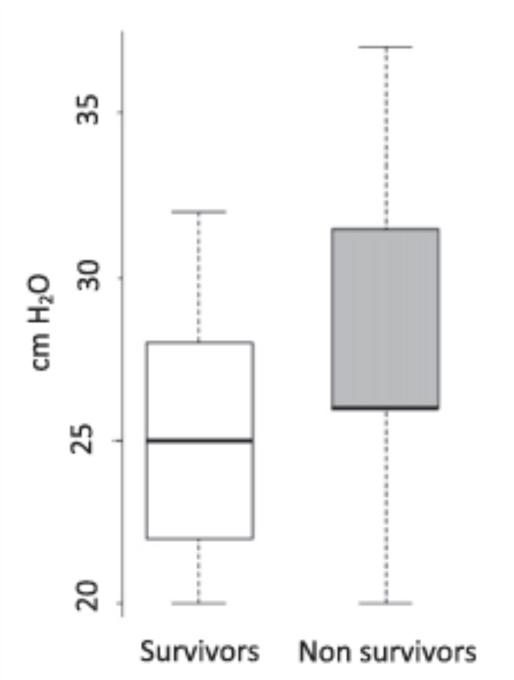
Extracorporeal Membrane Oxygenation for Pandemic Influenza A(H1N1)–induced Acute Respiratory Distress Syndrome

A Cohort Study and Propensity-matched Analysis

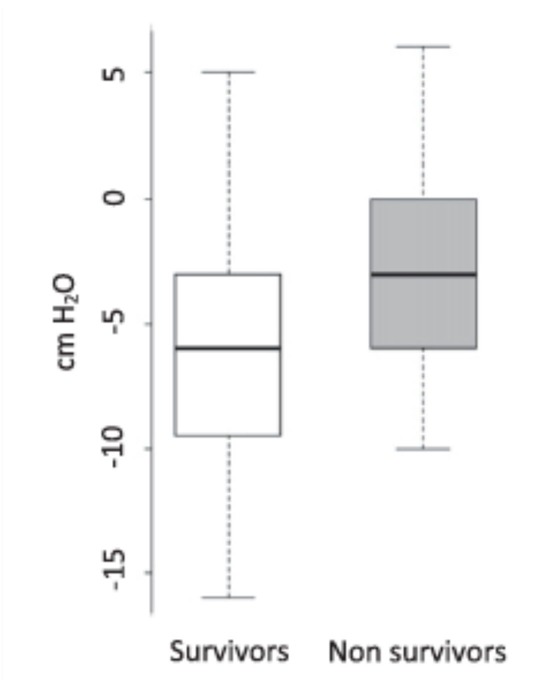
Tài Pham[1,2], Alain Combes[3,4], Hadrien Rozé[5], Sylvie Chevret[2,6], Alain Mercat[7,8], Antoine Roch[9,10], Bruno Mourvillier[11,12], Claire Ara-Somohano[13,14], Olivier Bastien[15,16], Elie Zogheib[17], Marc Clavel[18,19], Adrien Constan[1], Jean-Christophe Marie Richard[20,21,22], Christian Brun-Buisson[1,23,24], and Laurent Brochard[20,21,24]; for the REVA Research Network*

Am J Respir Crit Care Med 2013

N=123



Pplat on the first day of ECMO



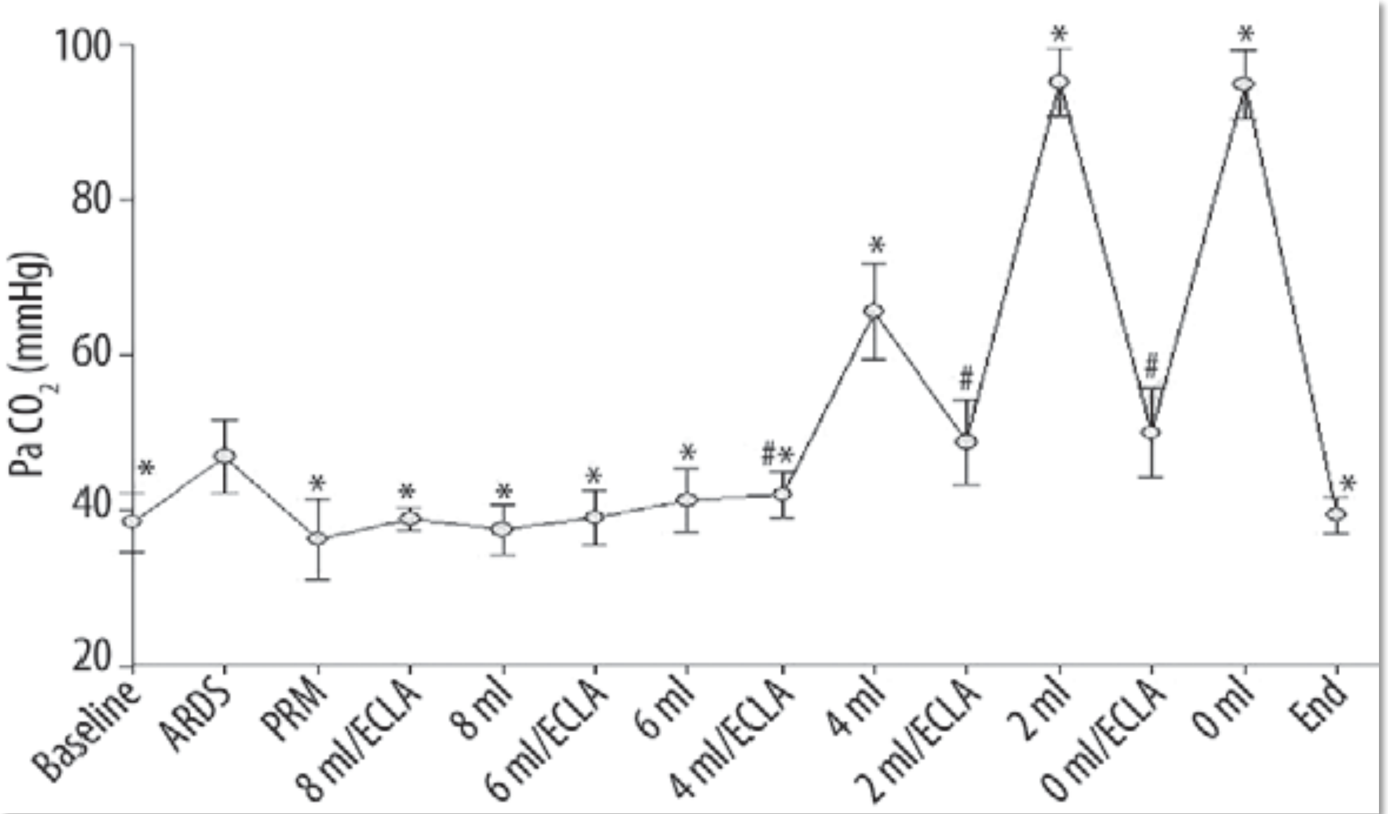
Pplat before – after

Use very low tidal volume…

Combining "open-lung" ventilation and arteriovenous extracorporeal lung assist: Influence of different tidal volumes on gas exchange in experimental lung failure

Ralf M. Muellenbach[ABCDEF], Markus Kredel[BC], Julian Kuestermann[BC], Michael Klingelhoefer[BC], Frank Schuster[BF], Christian Wunder[BF], Peter Kranke[DF], Norbert Roewer[ADG], Jörg Brederlau[ACD]

Med Sci Monit, 2009; 15(8): BR213-220

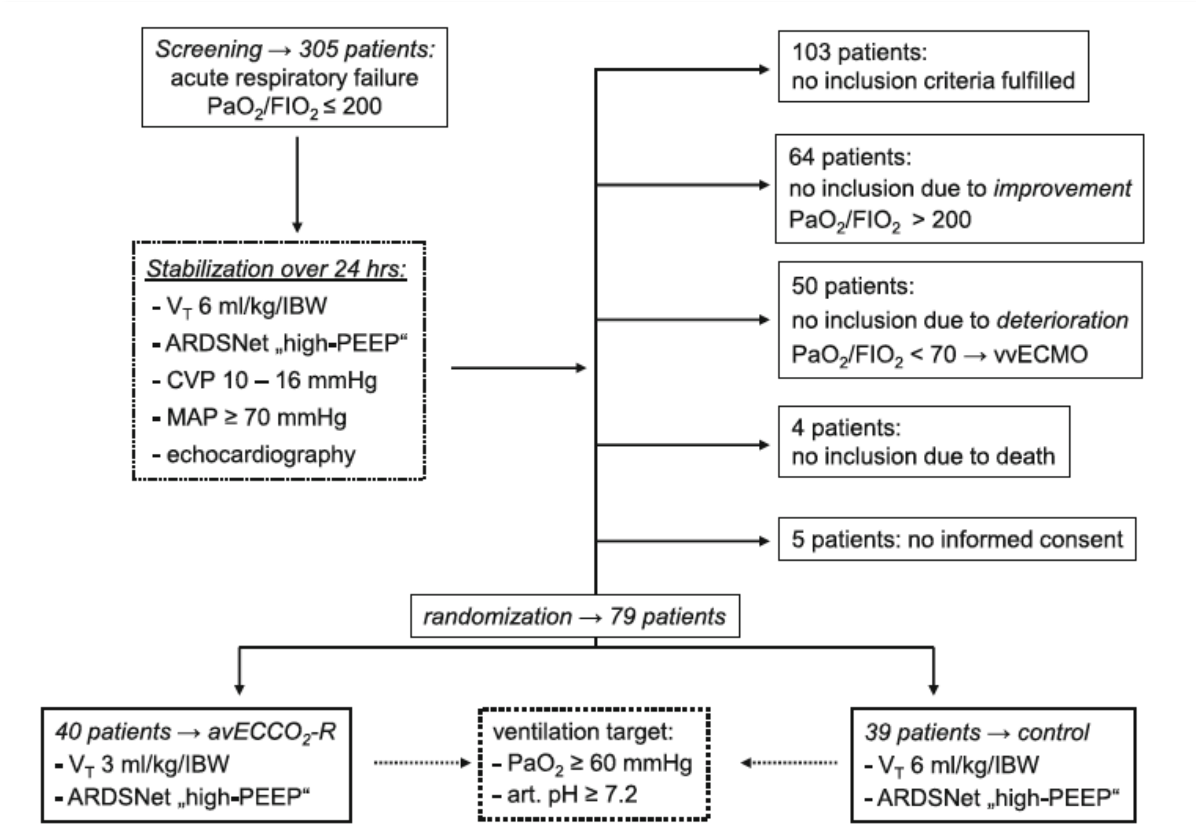


Thomas Bein
Steffen Weber-Carstens
Anton Goldmann
Thomas Müller
Thomas Staudinger
Jörg Brederlau
Ralf Muellenbach
Rolf Dembinski
Bernhard M. Graf

Lower tidal volume strategy (≈3 ml/kg) combined with extracorporeal CO_2 removal versus 'conventional' protective ventilation (6 ml/kg) in severe ARDS

The prospective randomized Xtravent-study

Intensive Care Med



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The prospective randomized Xtravent-study

Intensive Care Med

	All patients		
	avECCO$_2$-R	Control	*p*
Ventilator-free-days-28	10.0 ± 8	9.3 ± 9	0.779
Ventilator-free-days-60	33.2 ± 20	29.2 ± 21	0.469
Non-pulmonary organ failure free days-60	21.0 ± 14	23.9 ± 15	0.447
Lung injury score on day 10	2.2 ± 0.6	2.1 ± 0.5	0.854
Length of stay in hospital (days)	46.7 ± 33	35.1 ± 17	0.113
Length of stay in ICU (days)	31.3 ± 23	22.9 ± 11	0.144
In-hospital mortality	7/40 (17.5 %)	6/39 (15.4 %)	1.000

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The prospective randomized Xtravent-study

Intensive Care Med

	All patients			Subgroup: PaO_2/FIO_2 <150		
	avECCO₂-R	Control	*p*	avECCO₂-R	Control	*p*
Ventilator-free-days-28	10.0 ± 8	9.5 ± 9	0.779	11.3 ± 7.5	5.0 ± 6.3	0.033
Ventilator-free-days-60	33.2 ± 20	29.2 ± 21	0.469	40.9 ± 12.8	28.2 ± 16.4	0.033
Non-pulmonary organ failure free days-60	21.0 ± 14	23.9 ± 15	0.447	24.1 ± 7.5	29.0 ± 17.7	0.428
Lung injury score on day 10	2.2 ± 0.6	2.1 ± 0.5	0.854	2.3 ± 0.8	2.2 ± 0.5	0.601
Length of stay in hospital (days)	46.7 ± 33	35.1 ± 17	0.113	42.0 ± 16.6	40.3 ± 15.7	0.815
Length of stay in ICU (days)	31.3 ± 23	22.9 ± 11	0.144	25.9 ± 13.1	31.0 ± 12.7	0.258
In-hospital mortality	7/40 (17.5 %)	6/39 (15.4 %)	1.000	1/21 (4.8 %)	1/10 (10 %)	0.563

Use high PEEP level ?

Pumpless extracorporeal lung assist for protective mechanical ventilation in experimental lung injury*

Rolf Dembinski, MD, PhD; Nadine Hochhausen, MD; Sandra Terbeck, MD; Stefan Uhlig, MD, PhD; Constanze Dassow; Monika Schneider; Alexander Schachtrupp, MD, PhD; Dietrich Henzler, MD, PhD; Rolf Rossaint, MD, PhD; Ralf Kuhlen, MD, PhD

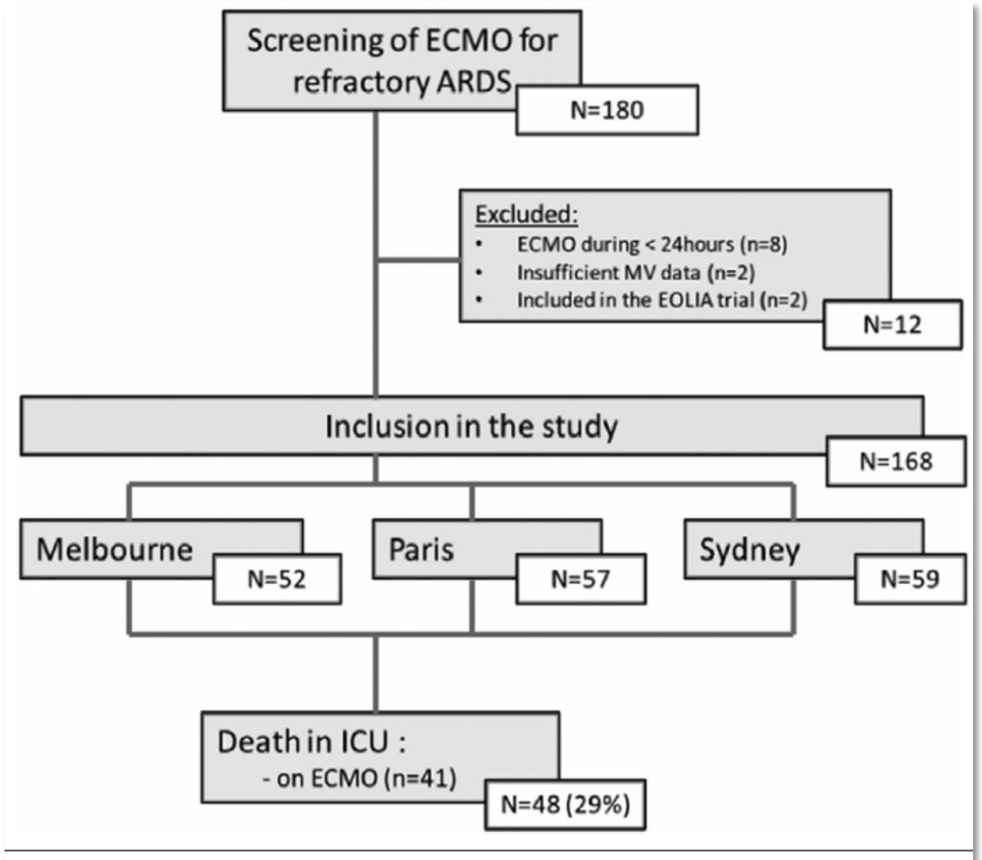
Crit Care Med 2007 Vol. 35, No. 10

Conclusions: Combined ventilation with lower tidal volumes and extracorporeal CO_2 removal as compared with traditional low tidal volumes without extracorporeal CO_2 removal is not associated with differences in organ injury. Obviously, ventilation with tidal volumes of <6 mL/kg may cause pulmonary de-recruitment when positive end-expiratory pressure is not adequately increased. (Crit Care Med 2007; 35:2359–2366)

Mechanical Ventilation Management During Extracorporeal Membrane Oxygenation for Acute Respiratory Distress Syndrome: A Retrospective International Multicenter Study

Matthieu Schmidt, MD[1,2]; Claire Stewart, MBBS (Hons), BSc (Adv)[3,4]; Michael Bailey, PhD, MSc (Statistics), BSc (Hons)[1,5]; Ania Nieszkowska, MD[2]; Joshua Kelly, BBiomedSc/BE[1]; Lorna Murphy, MBBS[3,4]; David Pilcher, MRCP, FRACP, FCICM;[1,5] D. James Cooper, BMBS, MD[1,5]; Carlos Scheinkestel, MBBS[5]; Vincent Pellegrino, MBBS[1,5]; Paul Forrest, MBChB, FANZCA[3,4]; Alain Combes, MD, PhD[2]; Carol Hodgson, PhD, FACP[1,5]

Crit Care Med *2015*



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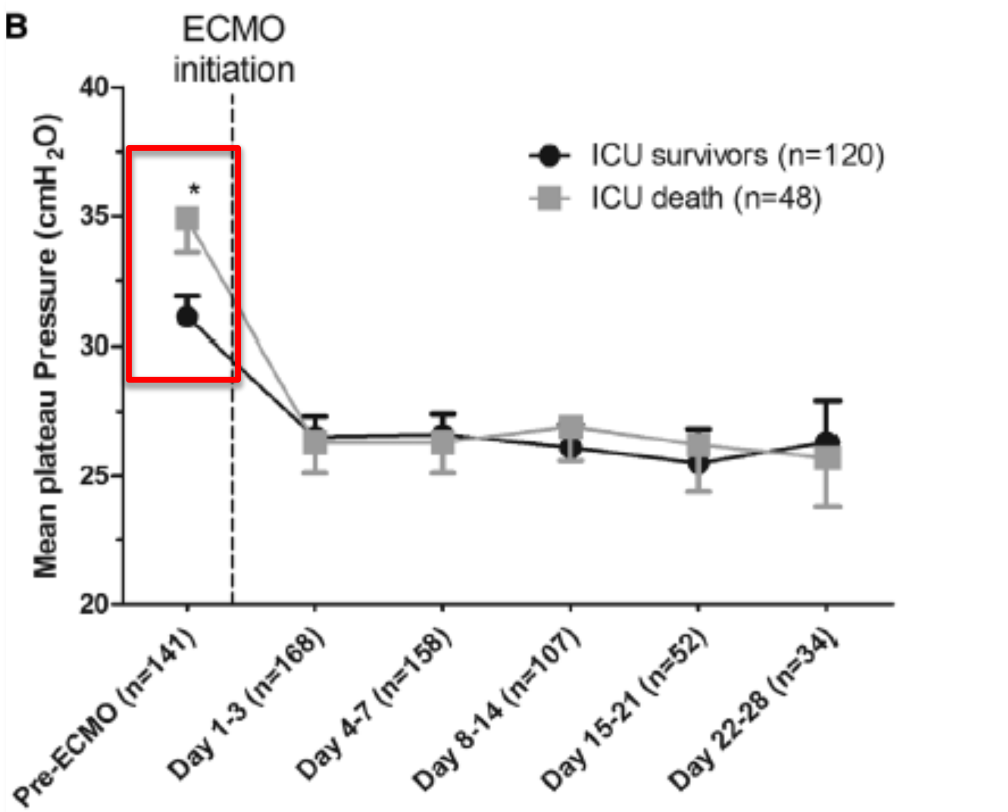
Crit Care Med *2015*



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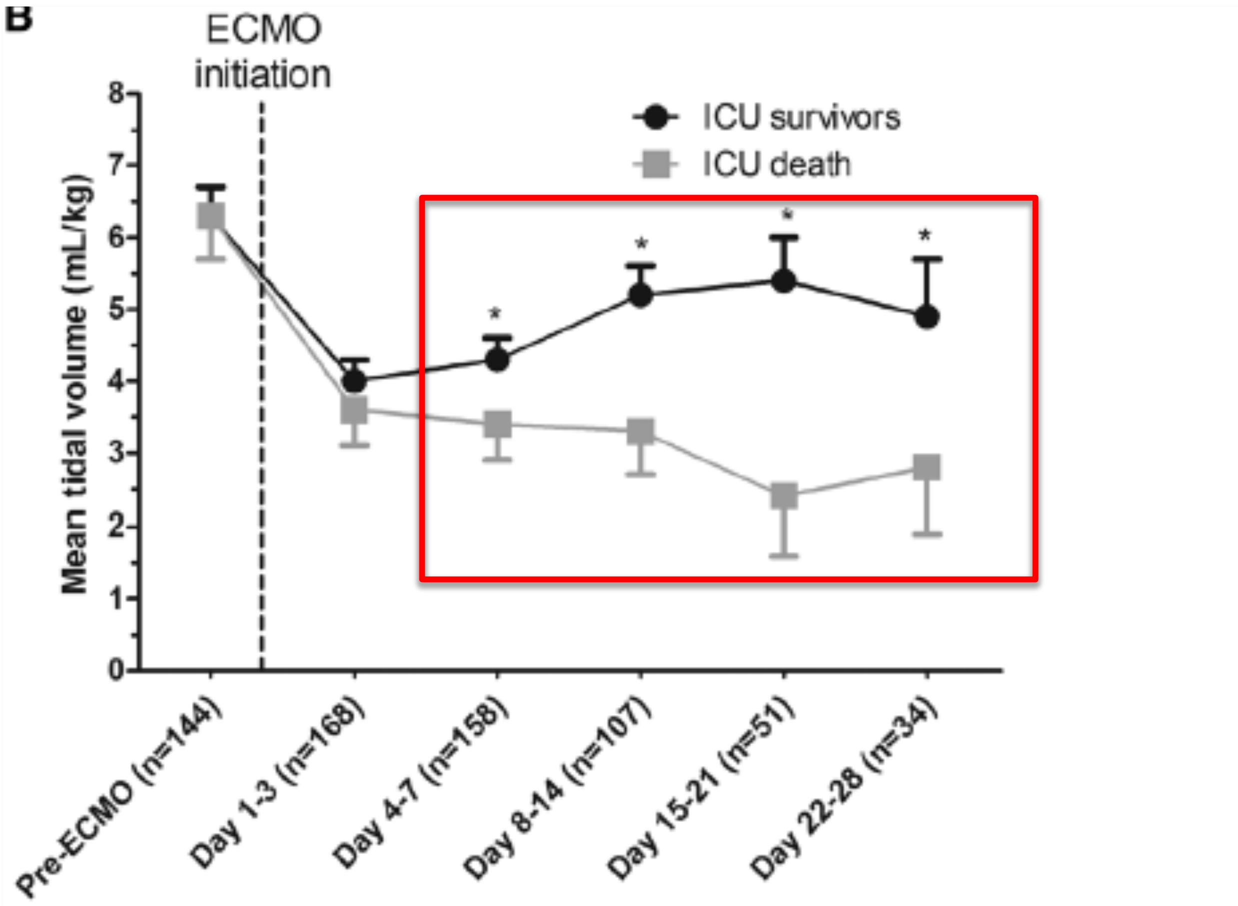

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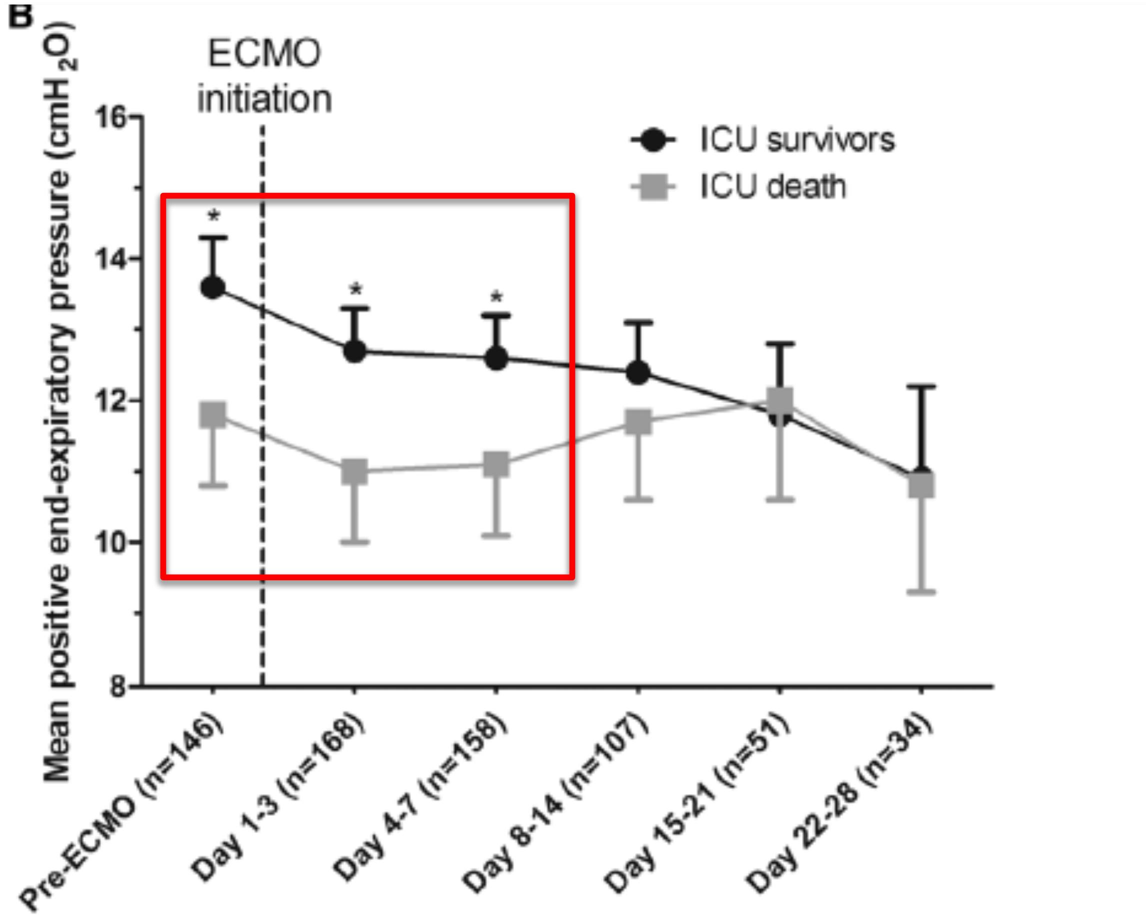


Mechanical Ventilation Management During Extracorporeal Membrane Oxygenation for Acute Respiratory Distress Syndrome: A Retrospective International Multicenter Study

Crit Care Med *2015*

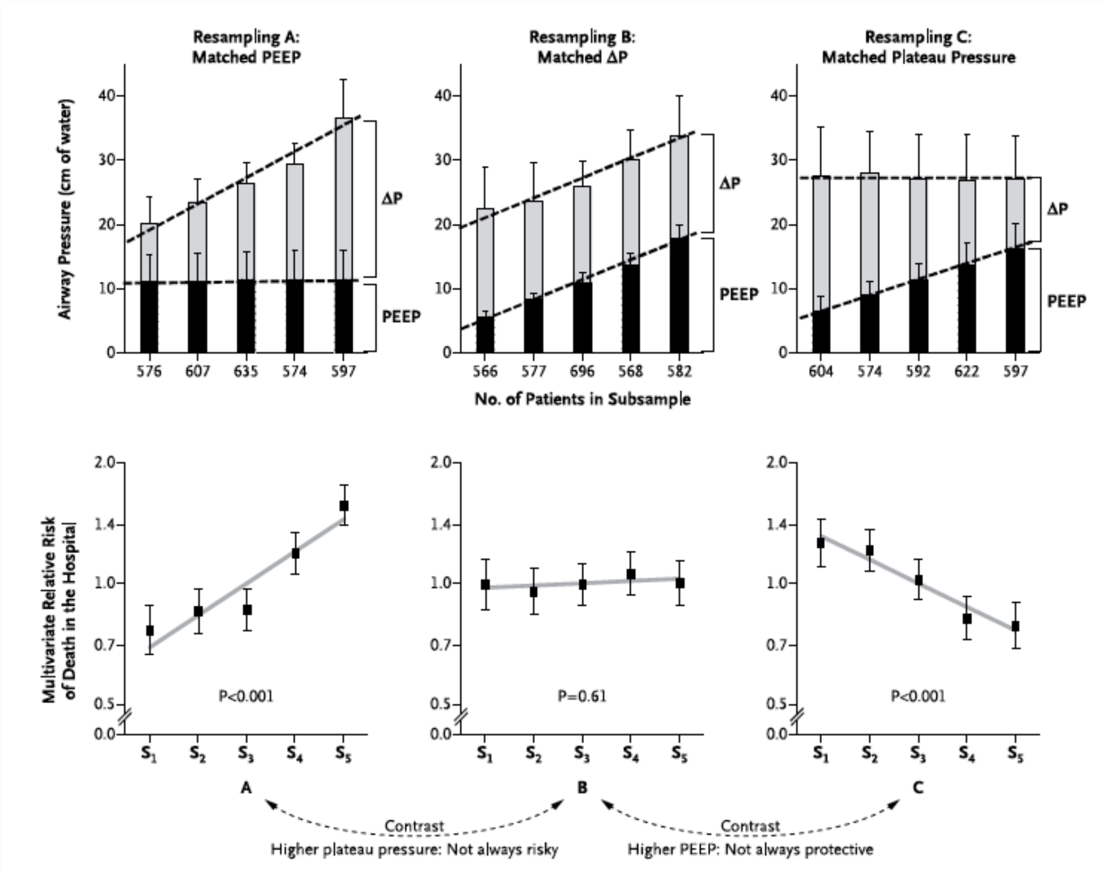
Variables	ICU Death		Time to ICU Death	
	OR (95% CI)	*p*	Hazard Ratio (95% CI)	*p*
Country (France vs Australia)	0.56 (0.22–1.42)	0.56	0.39 (0.19–0.81)	0.01
Duration between ICU admission and ECMO initiation (d)	1.15 (1.06–1.26)	0.001	1.02 (0.97–1.07)	0.56
Plateau pressure before ECMO > 30 cmH_2O	5.18 (1.88–14.31)	0.02	3.31 (1.53–7.15)	0.002
Mean positive end-expiratory pressure from day 1 to 3 on ECMO	0.75 (0.64–0.88)	0.0006	0.78 (0.69–0.88)	< 0.0001
Lactate at day 3 (log transformed)	4.77 (2.12–10.73)	0.0002	3.64 (2.24–5.92)	< 0.0001

Reduce the driving pressure…

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., Laurent Brochard, M.D., Eduardo L.V. Costa, M.D., David A. Schoenfeld, Ph.D., Thomas E. Stewart, M.D., Matthias Briel, M.D., Daniel Talmor, M.D., M.P.H., Alain Mercat, M.D., Jean-Christophe M. Richard, M.D., Carlos R.R. Carvalho, M.D., and Roy G. Brower, M.D.

N Engl J Med 2015;372:747-55.



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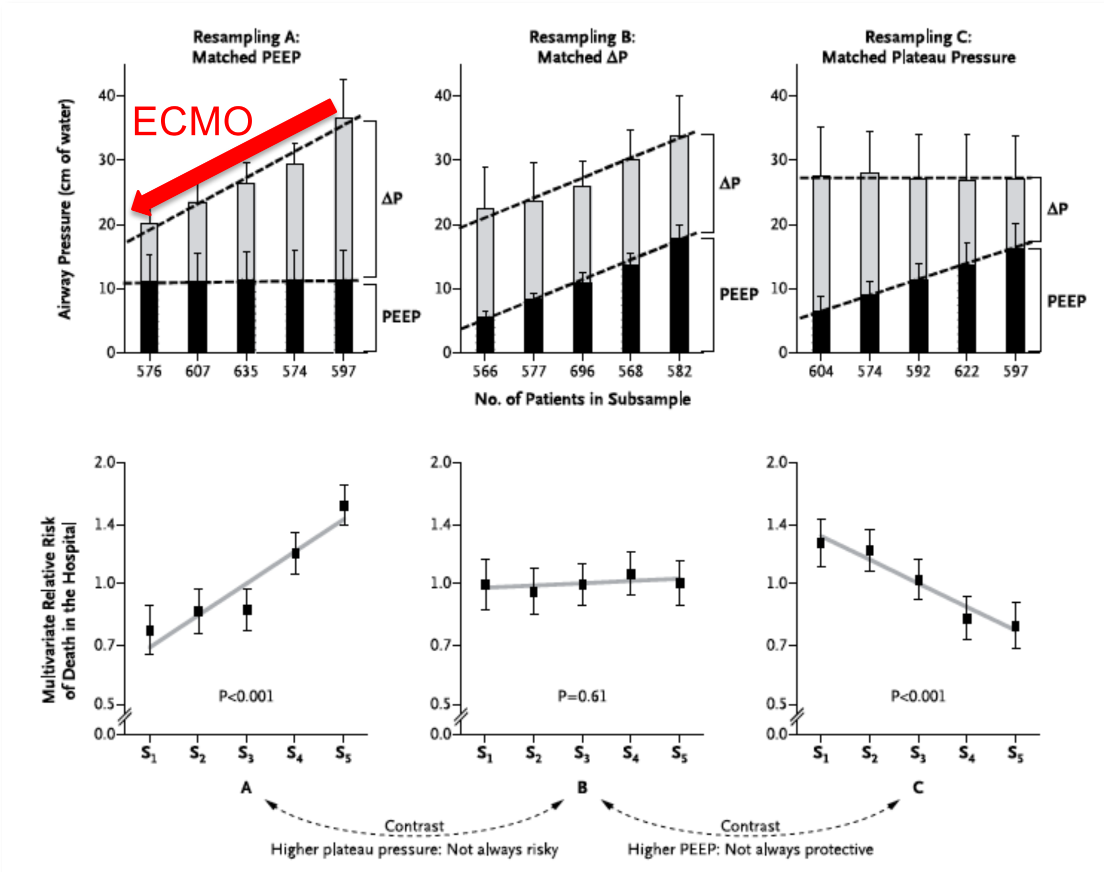

Associations between ventilator settings during extracorporeal membrane oxygenation for refractory hypoxemia and outcome in patients with acute respiratory distress syndrome: a pooled individual patient data analysis

Ary Serpa Neto[1,2,3*], Matthieu Schmidt[4,5], Luciano C. P. Azevedo[6,7], Thomas Bein[8], Laurent Brochard[9,10,11], Gernot Beutel[12], Alain Combes[5,13], Eduardo L. V. Costa[6,7], Carol Hodgson[4,14], Christian Lindskov[15], Matthias Lubnow[16], Catherina Lueck[12], Andrew J. Michaels[17], Jose-Artur Paiva[18], Marcelo Park[6,7], Antonio Pesenti[19,20], Tài Pham[21,22,23], Michael Quintel[24], V. Marco Ranieri[25], Michael Ried[26], Roberto Roncon-Albuquerque Jr[18], Arthur S. Slutsky[27], Shinhiro Takeda[28], Pier Paolo Terragni[29], Marie Vejen[15], Steffen Weber-Carstens[30], Tobias Welte[31], Marcelo Gama de Abreu[32], Paolo Pelosi[33], Marcus J. Schultz[1,34] and The ReVA Research Network and the PROVE Network Investigators

Intensive Care Med 2017

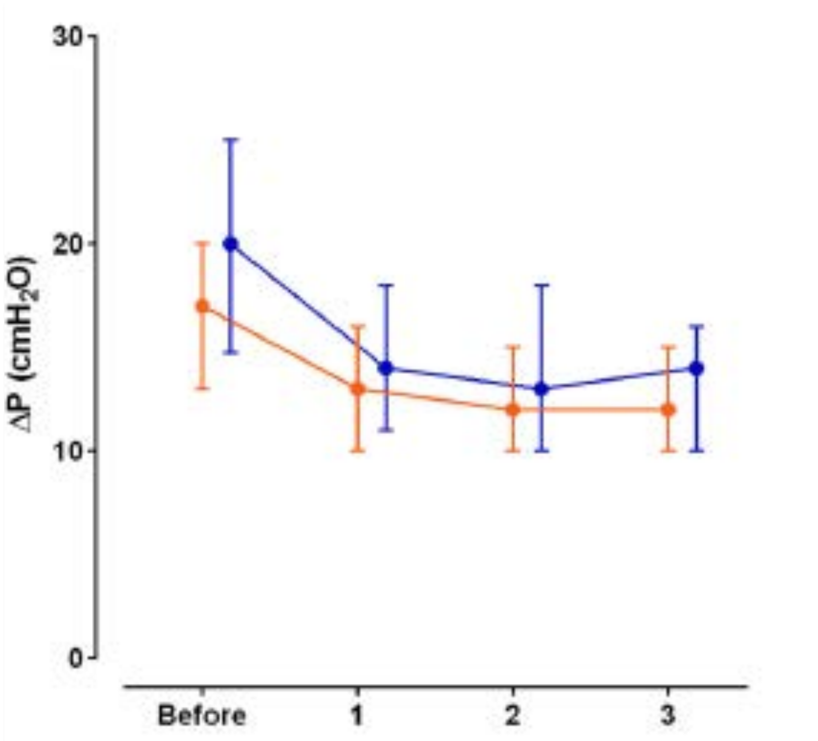

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Table 3 Multivariable time-dependent frailty model with in-hospital mortality as the primary outcome

Ventilatory parameters	
PEEP, cmH_2O	–
FiO_2, %	0.96 (0.40–2.30), 0.924
Driving pressure, cmH_2O	1.06 (1.03–1.10), <0.001
Respiratory rate, bpm	–

Extracorporeal Membrane Oxygenation for Pandemic Influenza A(H1N1)–induced Acute Respiratory Distress Syndrome

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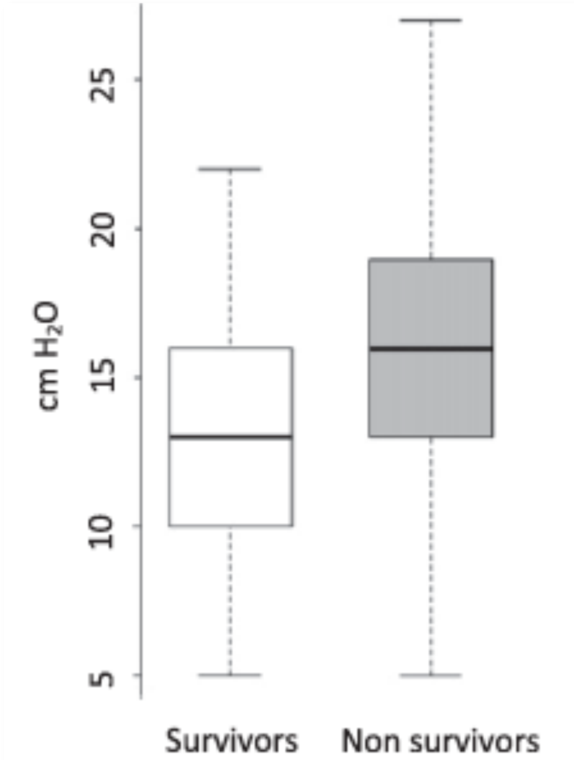
Tài Pham[1,2], Alain Combes[3,4], Hadrien Rozé[5], Sylvie Chevret[2,6], Alain Mercat[7,8], Antoine Roch[9,10], Bruno Mourvillier[11,12], Claire Ara-Somohano[13,14], Olivier Bastien[15,16], Elie Zogheib[17], Marc Clavel[18,19], Adrien Constan[1], Jean-Christophe Marie Richard[20,21,22], Christian Brun-Buisson[1,23,24], and Laurent Brochard[20,21,24]; for the REVA Research Network*

Am J Respir Crit Care Med 2013

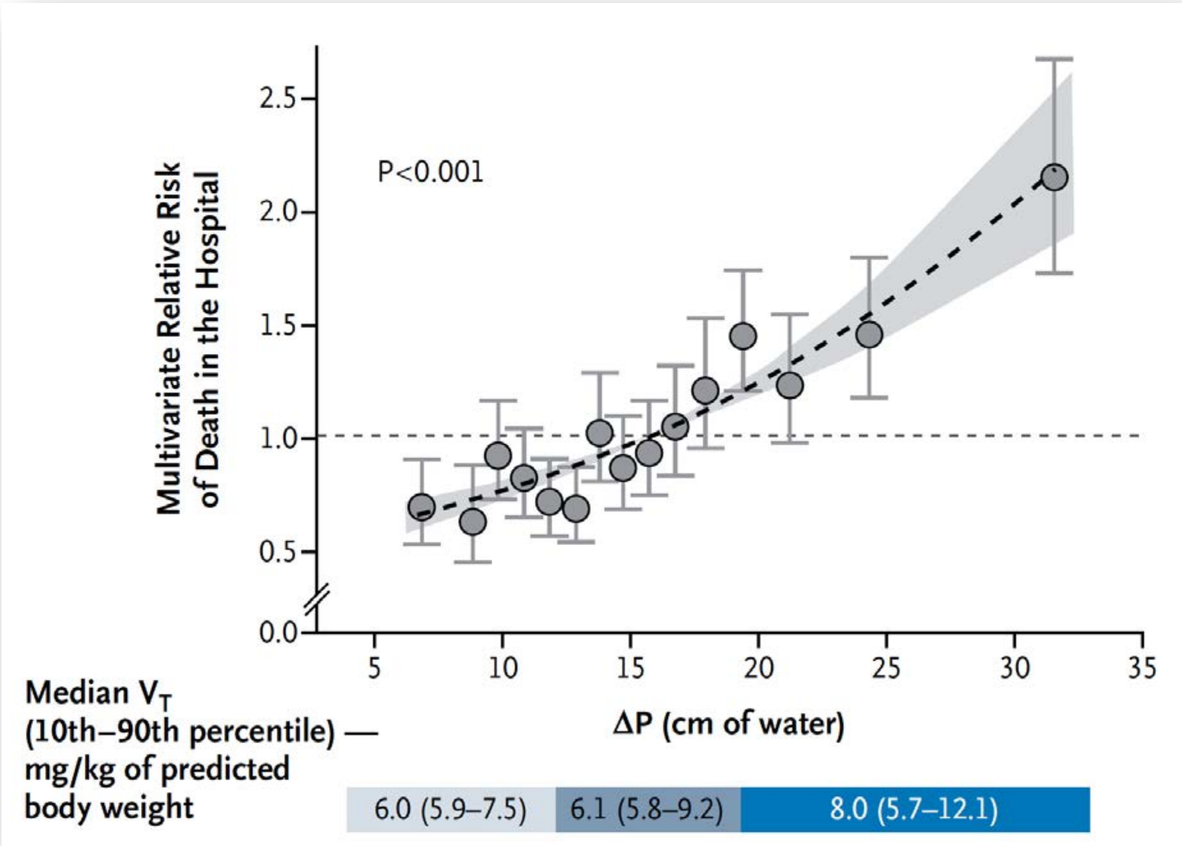


Driving pressure at ECMO Day 1

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., Laurent Brochard, M.D., Eduardo L.V. Costa, M.D., David A. Schoenfeld, Ph.D., Thomas E. Stewart, M.D., Matthias Briel, M.D., Daniel Talmor, M.D., M.P.H., Alain Mercat, M.D., Jean-Christophe M. Richard, M.D., Carlos R.R. Carvalho, M.D., and Roy G. Brower, M.D.

N Engl J Med 2015;372:747-55.



Driving Pressure and Survival in the Acute Respiratory Distress Syndrome

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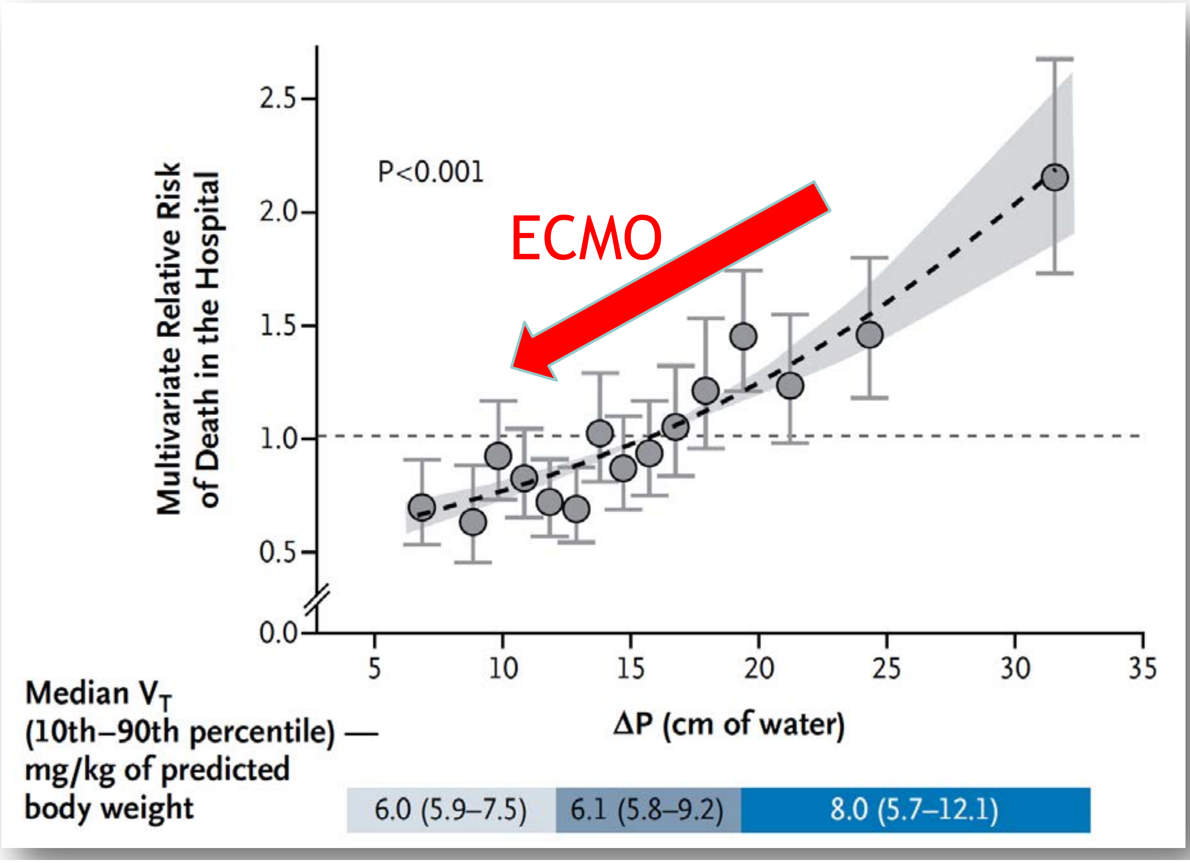

Driving Pressure and Survival in the Acute Respiratory Distress Syndrome

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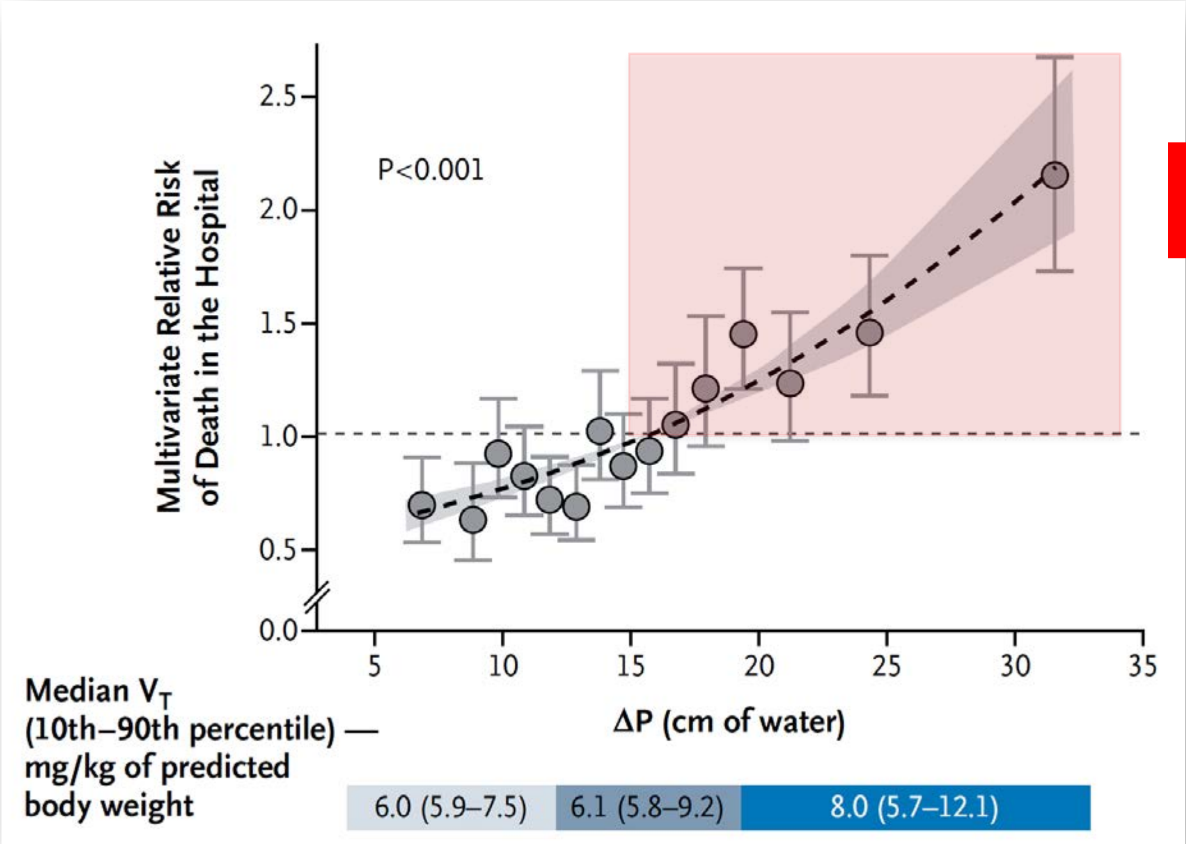
N Engl J Med 2015;372:747-55.

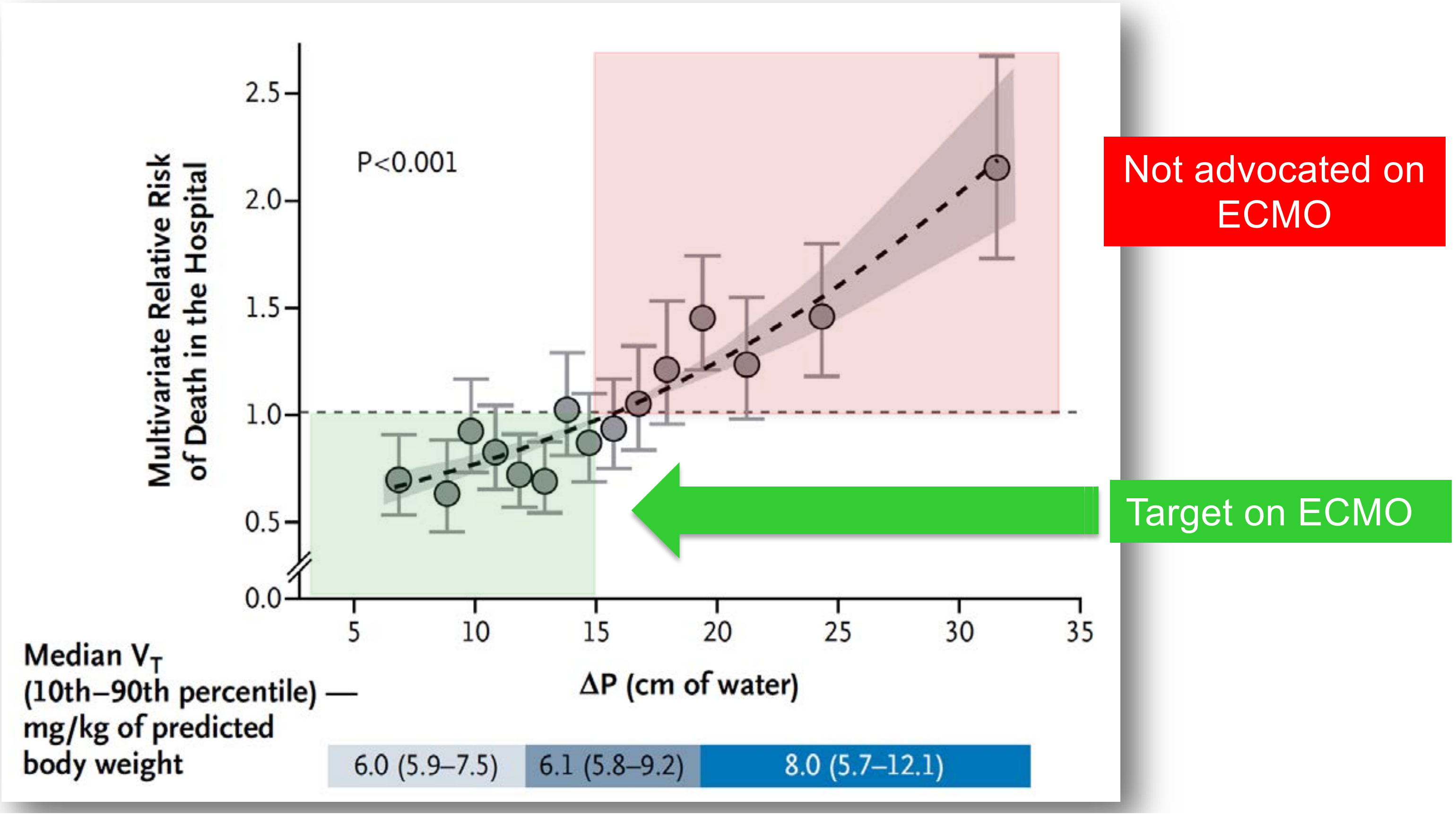


Not advocated on ECMO

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., Laurent Brochard, M.D., Eduardo L.V. Costa, M.D., David A. Schoenfeld, Ph.D., Thomas E. Stewart, M.D., Matthias Briel, M.D., Daniel Talmor, M.D., M.P.H., Alain Mercat, M.D., Jean-Christophe M. Richard, M.D., Carlos R.R. Carvalho, M.D., and Roy G. Brower, M.D.

N Engl J Med 2015;372:747-55.



Reduce respiratory rate

$$\text{Power}_{rs} = \text{RR} \cdot \left\{ \Delta V^2 \cdot \left[\frac{1}{2} \cdot \text{EL}_{rs} + \text{RR} \cdot \frac{(1 + I : E)}{60 \cdot I : E} \cdot R_{aw} \right] + \Delta V \cdot \text{PEEP} \right\}$$

Potentially modifiable factors contributing to outcome from acute respiratory distress syndrome: the LUNG SAFE study

John G. Laffey[1,2*], Giacomo Bellani[3,4], Tài Pham[5,6,7], Eddy Fan[8,9], Fabiana Madotto[10], Ednan K. Bajwa[11], Laurent Brochard[12,13], Kevin Clarkson[14], Andres Esteban[15], Luciano Gattinoni[16], Frank van Haren[17], Leo M. Heunks[18], Kiyoyasu Kurahashi[19], Jon Henrik Laake[20], Anders Larsson[21], Daniel F. McAuley[22], Lia McNamee[22], Nicolas Nin[15], Haibo Qiu[23], Marco Ranieri[24], Gordon D. Rubenfeld[25], B. Taylor Thompson[11], Hermann Wrigge[26], Arthur S. Slutsky[12,13,27], Antonio Pesenti[28,29] and The LUNG SAFE Investigators and the ESICM Trials Group

ICM 2016

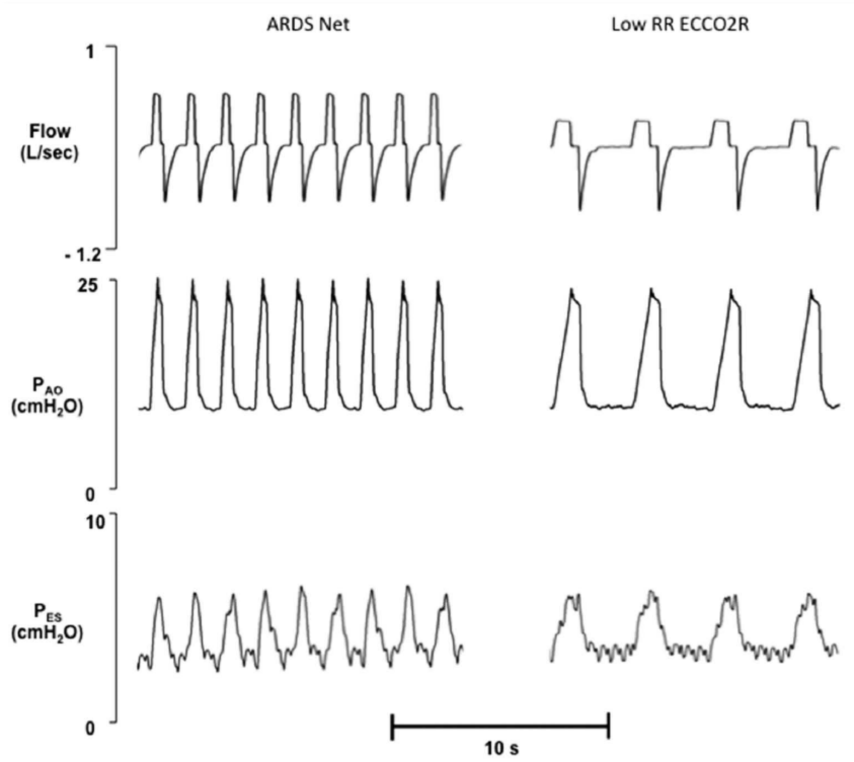
Table 2 Factors associated with hospital mortality in invasively ventilated patients ($n = 2377$)

Parameter	Multivariate model ($n = 2091$)	
	OR (95 % CI)	*p*-value
Illness severity factors		
pH	0.12 (0.05–0.29)	<0.001
PaO_2/FiO_2 ratio (mmHg)	0.998 (0.997–1.000)	0.025
Non-pulmonary SOFA score adjusted	1.12 (1.09–1.15)	<0.001
Management factors		
RR total (breaths/min)	1.03 (1.01–1.04)	0.003
PEEP (cmH_2O)	0.95 (0.92–0.98)	0.001
Peak inspiratory pressure (cmH_2O)	1.02 (1.01–1.04)	0.002
ICU organizational factors		
Number of beds	0.99 (0.99–1.00)	0.035

Low Respiratory Rate Plus Minimally Invasive Extracorporeal Co_2 Removal Decreases Systemic and Pulmonary Inflammatory Mediators in Experimental Acute Respiratory Distress Syndrome*

Salvatore Grasso, MD[1]; Tania Stripoli, MD, PhD[2]; Palma Mazzone, MD[3]; Marco Pezzuto, MD[3];
Luca Lacitignola, VD, PhD[3]; Paola Centonze, VD, PhD[4]; Alessandro Guarracino, VD[4];
Cosimo Esposito, VD[4]; Peter Herrmann, ScD[5]; Michael Quintel, MD, PhD[5]; Paolo Trerotoli, MD[6];
Francesco Bruno, MD[1]; Antonio Crovace, VD, PhD[3]; Francesco Staffieri, VD, PhD[3]

June 2014 • Volume 42 • Number 6



Variable	ARDS Net	Low RR $ECCO_2R$
Tidal volume (mL)	345 ± 79	342 ± 73
Respiratory rate (breaths/min)	30.5 ± 3.8	14.2 ± 3.5[a]
Minute volume (L/min)	10.4 ± 1.6	4.9 ± 1.7[a]
Inspiratory time (s)	0.68 ± 0.1	1.53 ± 0.5[a]
Inspiratory flow (mL/s)	509 ± 97	243 ± 83[a]
$P_{AO, PLAT}$ (cm H_2O)	23.3 ± 3.6	23.2 ± 3.2
$P_{AO, MEAN}$ (cm H_2O)	15.4 ± 3.3	14.8 ± 2.7
Total positive end-expiratory pressure (cm H_2O)	10.5 ± 2.9	10.4 ± 2.6
Stress index	1.034 ± 0.023	1.028 ± 0.026
Static respiratory system elastance (cm H_2O/L)	41.8 ± 10.6	38.9 ± 11.7
Static lung elastance (cm H_2O/L)	34.3 ± 10.9	31.9 ± 11.7
Static chest wall elastance (cm H_2O/L)	7.5 ± 2.1	6.9 ± 2.8
Pao_2/Fio_2	252 ± 75	231 ± 86
$Paco_2$ (mm Hg)	61.8 ± 11.6	61.9 ± 9.7
pH	7.381 ± 0.041	7.375 ± 0.054
Base excess	4.5 ± 1.5	4.8 ± 1.9

Low Respiratory Rate Plus Minimally Invasive Extracorporeal CO_2 Removal Decreases Systemic and Pulmonary Inflammatory Mediators in Experimental Acute Respiratory Distress Syndrome*

Salvatore Grasso, MD[1]; Tania Stripoli, MD, PhD[2]; Palma Mazzone, MD[1]; Marco Pezzuto, MD[1]; Luca Lacitignola, VD, PhD[3]; Paola Centonze, VD, PhD[4]; Alessandro Guarracino, VD[4]; Cosimo Esposito, VD[4]; Peter Herrmann, ScD[5]; Michael Quintel, MD, PhD[5]; Paolo Trerotoli, MD[6]; Francesco Bruno, MD[1]; Antonio Crovace, VD, PhD[3]; Francesco Staffieri, VD, PhD[3]

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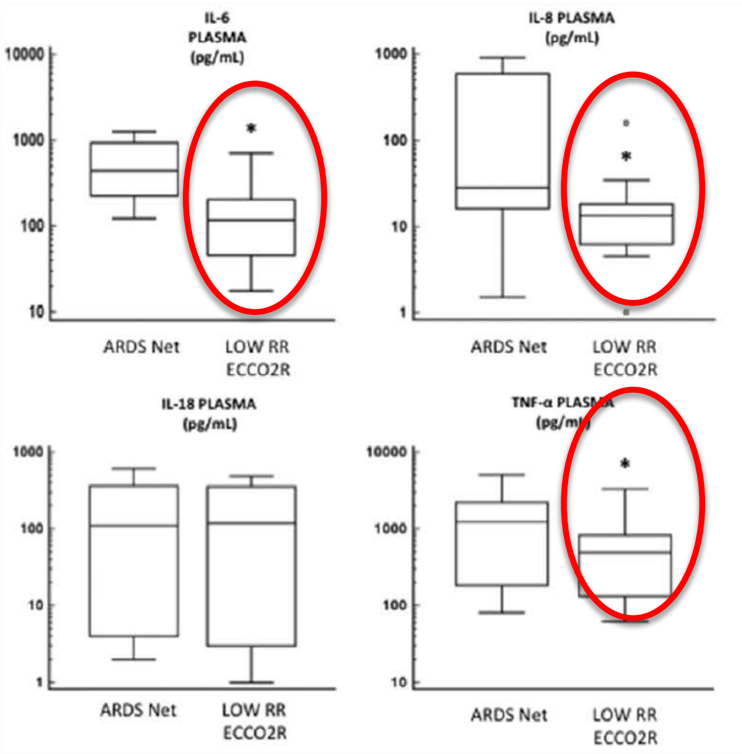
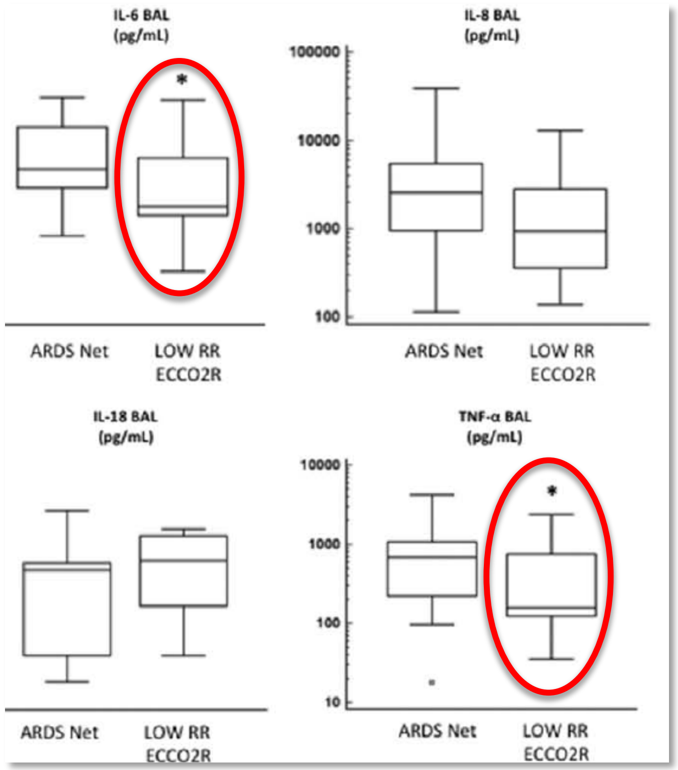
PLASMA



BAL



Reduce FiO_2

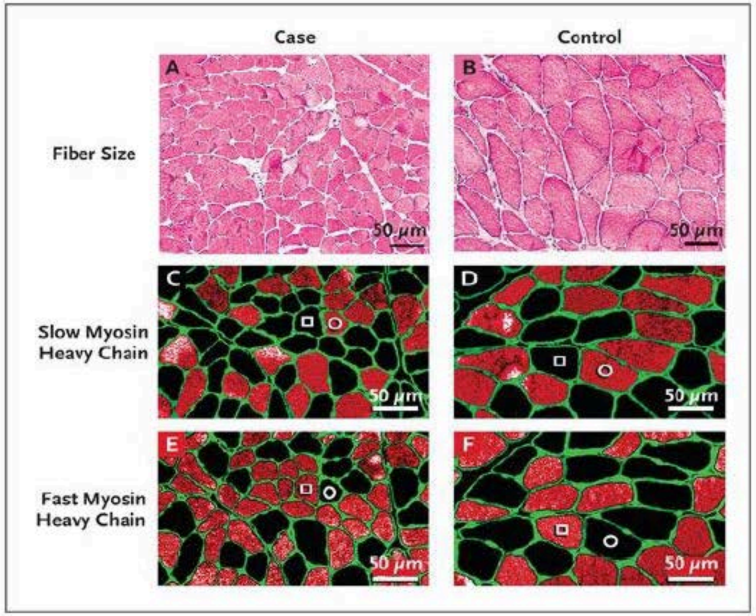
- *Oxygen toxicity*
- *Denitrogenation Atelectasis*

Why is spontaneous ventilation desirable ?

Rapid Disuse Atrophy of Diaphragm Fibers in Mechanically Ventilated Humans

Sanford Levine, M.D., Taitan Nguyen, B.S.E., Nyali Taylor, M.D., M.P.H., Michael E. Friscia, M.D., Murat T. Budak, M.D., Ph.D., Pamela Rothenberg, B.A., Jianliang Zhu, M.D., Rajeev Sachdeva, M.D., Seema Sonnad, Ph.D., Larry R. Kaiser, M.D., Neal A. Rubinstein, M.D., Ph.D., Scott K. Powers, Ph.D., Ed.D., and Joseph B. Shrager, M.D.

N Engl J Med 2008;358:1327-35.



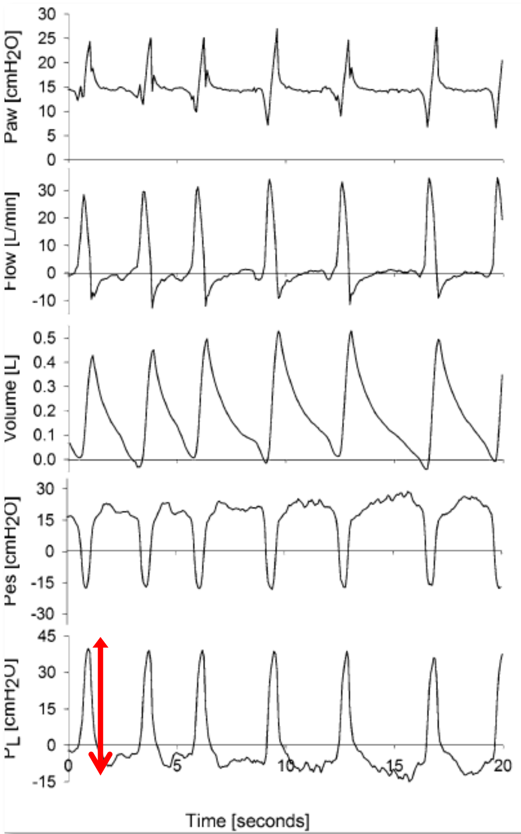
- Preserve Respiratory Muscle Function
- Avoid VIDD

- Improve VA/Q and Regional Ventilation

Extremely high transpulmonary pressure in a spontaneously breathing patient with early severe ARDS on ECMO

Tommaso Mauri[1], Thomas Langer[2], Alberto Zanella[1], Giacomo Grasselli[1] and Antonio Pesenti[1,2*]

Intensive Care Med (2016) 42:2101–2103



	Volume controlled	Pressure support
PEEP (cmH_2O)	15	15
Vt (ml/kg PBW)	4	6.5
RR (bpm)	10	21
Ppeak (cmH_2O)	37	24
ECMO GF (l/min)	6.5	11.0
VCO_2-NL (ml/min)	n.a.	74
VCO_2-ML (ml/min)	n.a.	253
VCO_2-ML/VCO_2-TOT (%)	n.a.	77
ΔPes (cmH_2O)	+2	-35
P_L (cmH_2O)	12	38
pH	7.42	7.47
PaO_2 (mmHg)	63	63
$PaCO_2$ (mmHg)	45	37

Patient Self-Inflicted Lung Injury (P-SILI)

APRV on ECMO

- Control of Plateau pressure and PEEP
- Spontaneous breathing permitted
  - Not synchronized with pressure cycle
- Driving pressure determines Vt
  - Allows monitoring of compliance improvement
  - Provides indices for ECMO weaning

Efficacy and economic assessment of conventional ventilatory support versus extracorporeal membrane oxygenation for severe adult respiratory failure (CESAR): a multicentre randomised controlled trial

Giles J Peek, Miranda Mugford, Ravindranath Tiruvoipati, Andrew Wilson, Elizabeth Allen, Mariamma M Thalanany, Clare L Hibbert, Ann Truesdale, Felicity Clemens, Nicola Cooper, Richard K Firmin, Diana Elbourne, for the CESAR trial collaboration

Lancet 2009; 374: 1351–63

published institutional protocols.[11,13] All ECMO was done in the venovenous mode with percutaneous cannulation. Servo-controlled roller pumps (Stockert, Freiburg, Germany) and poly-methyl pentene oxygenators (Medos Medizintechink, Stolberg, Germany) were used. Ventilation was in pressure control mode with Siemens Servo 300 ventilators (Solma, Sweden); lung rest settings were peak inspiratory pressure 20–25, positive end-expiratory pressure 10–15, rate 10, and FiO_2 0·3. ECMO was continued until lung recovery, or until apparently irreversible multiorgan failure.

Extracorporeal Membrane Oxygenation for Severe Acute Respiratory Distress Syndrome

A. Combes, D. Hajage, G. Capellier, A. Demoule, S. Lavoué, C. Guervilly, D. Da Silva, L. Zafrani, P. Tirot, B. Veber, E. Maury, B. Levy, Y. Cohen, C. Richard, P. Kalfon, L. Bouadma, H. Mehdaoui, G. Beduneau, G. Lebreton, L. Brochard, N.D. Ferguson, E. Fan, A.S. Slutsky, D. Brodie, and A. Mercat, for the EOLIA Trial Group, REVA, and ECMONet*

N ENGL J MED 378;21 NEJM.ORG MAY 24, 2018

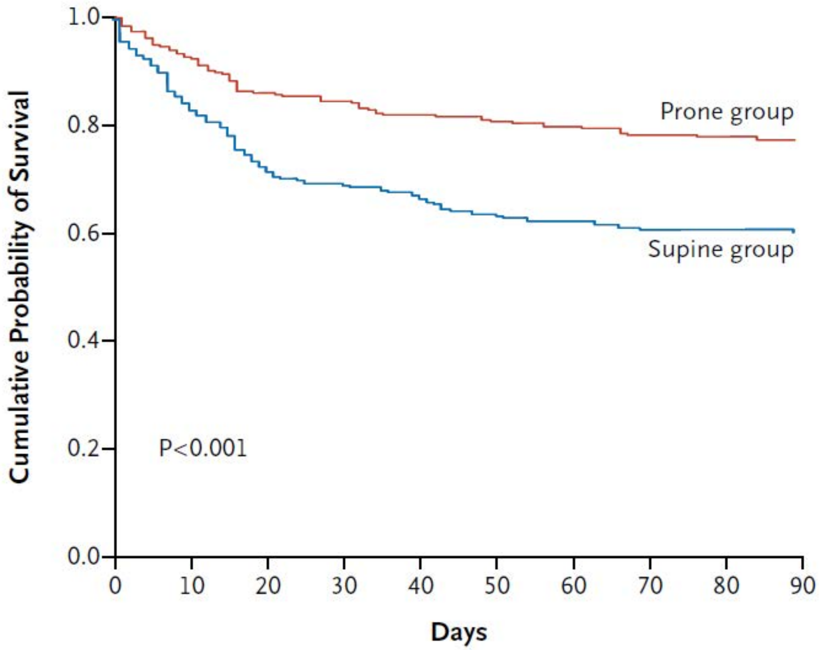
To minimize the trauma induced by mechanical ventilation, the following ventilator settings were used during extracorporeal membrane oxygenation (ECMO) support: volume-assist-control mode; fraction of inspired oxygen (FiO_2): 0.3-0.5; positive end-expiratory pressure (PEEP) above 10 cm of water; tidal volume (VT) lowered to obtain a plateau airway pressure (Pplat) of less than or equal to 24 cm of water; respiratory rate (RR): 10–30 breaths per min or bilevel positive airway pressure-release ventilation (APRV), with a high pressure level at most 24 cm of water, PEEP at least 10 cm of water, FiO_2: 0.3-0.5 and RR: 10–30 breaths per min. Early weaning off of analgesics and sedatives was encouraged.

What's the future ?

Prone Positioning in Severe Acute Respiratory Distress Syndrome

Claude Guérin, M.D., Ph.D., Jean Reignier, M.D., Ph.D., Jean-Christophe Richard, M.D., Ph.D., Pascal Beuret, M.D., Arnaud Gacouin, M.D., Thierry Boulain, M.D., Emmanuelle Mercier, M.D., Michel Badet, M.D., Alain Mercat, M.D., Ph.D., Olivier Baudin, M.D., Marc Clavel, M.D., Delphine Chatellier, M.D., Samir Jaber, M.D., Ph.D., Sylvène Rosselli, M.D., Jordi Mancebo, M.D., Ph.D., Michel Sirodot, M.D., Gilles Hilbert, M.D., Ph.D., Christian Bengler, M.D., Jack Richecoeur, M.D., Marc Gainnier, M.D., Ph.D., Frédérique Bayle, M.D., Gael Bourdin, M.D., Véronique Leray, M.D., Raphaele Girard, M.D., Loredana Baboi, Ph.D., and Louis Ayzac, M.D., for the PROSEVA Study Group*

NEJM, 2013



No. at Risk

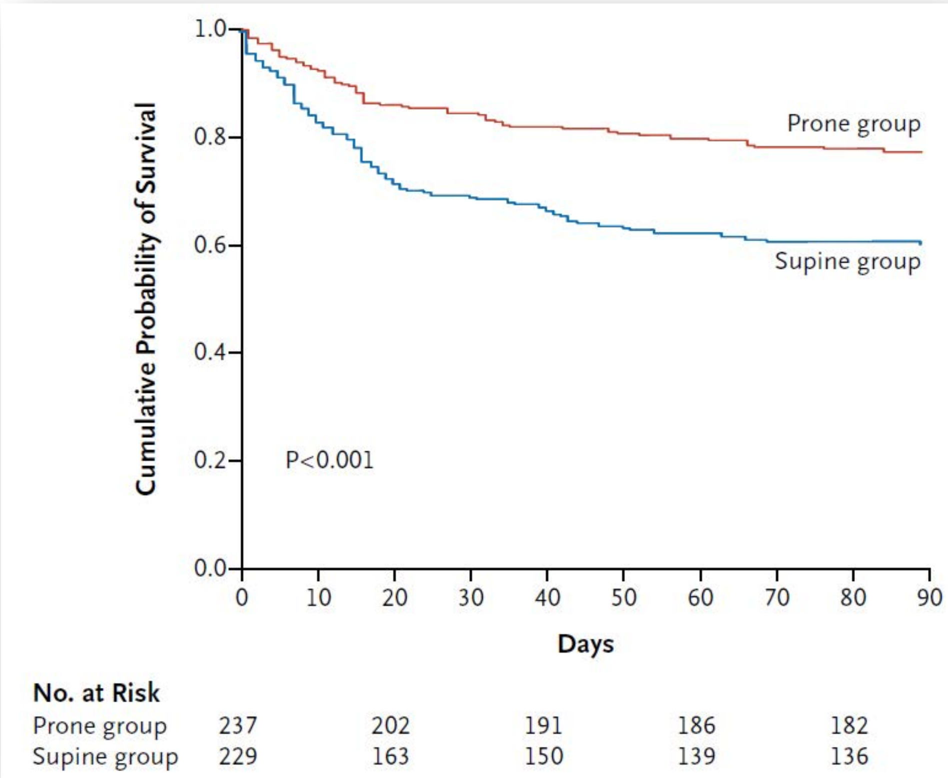
Prone group	237	202	191	186	182
Supine group	229	163	150	139	136

Prone Positioning in Severe Acute Respiratory Distress Syndrome

Claude Guérin, M.D., Ph.D., Jean Reignier, M.D., Ph.D., Jean-Christophe Richard, M.D., Ph.D., Pascal Beuret, M.D., Arnaud Gacouin, M.D., Thierry Boulain, M.D., Emmanuelle Mercier, M.D., Michel Badet, M.D., Alain Mercat, M.D., Ph.D., Olivier Baudin, M.D., Marc Clavel, M.D., Delphine Chatellier, M.D., Samir Jaber, M.D., Ph.D., Sylvène Rosselli, M.D., Jordi Mancebo, M.D., Ph.D., Michel Sirodot, M.D., Gilles Hilbert, M.D., Ph.D., Christian Bengler, M.D., Jack Richecoeur, M.D., Marc Gainnier, M.D., Ph.D., Frédérique Bayle, M.D., Gael Bourdin, M.D., Véronique Leray, M.D., Raphaele Girard, M.D., Loredana Baboi, Ph.D., and Louis Ayzac, M.D., for the PROSEVA Study Group*

NEJM, 2013

Proning ECMO patients to reduce VILI ?

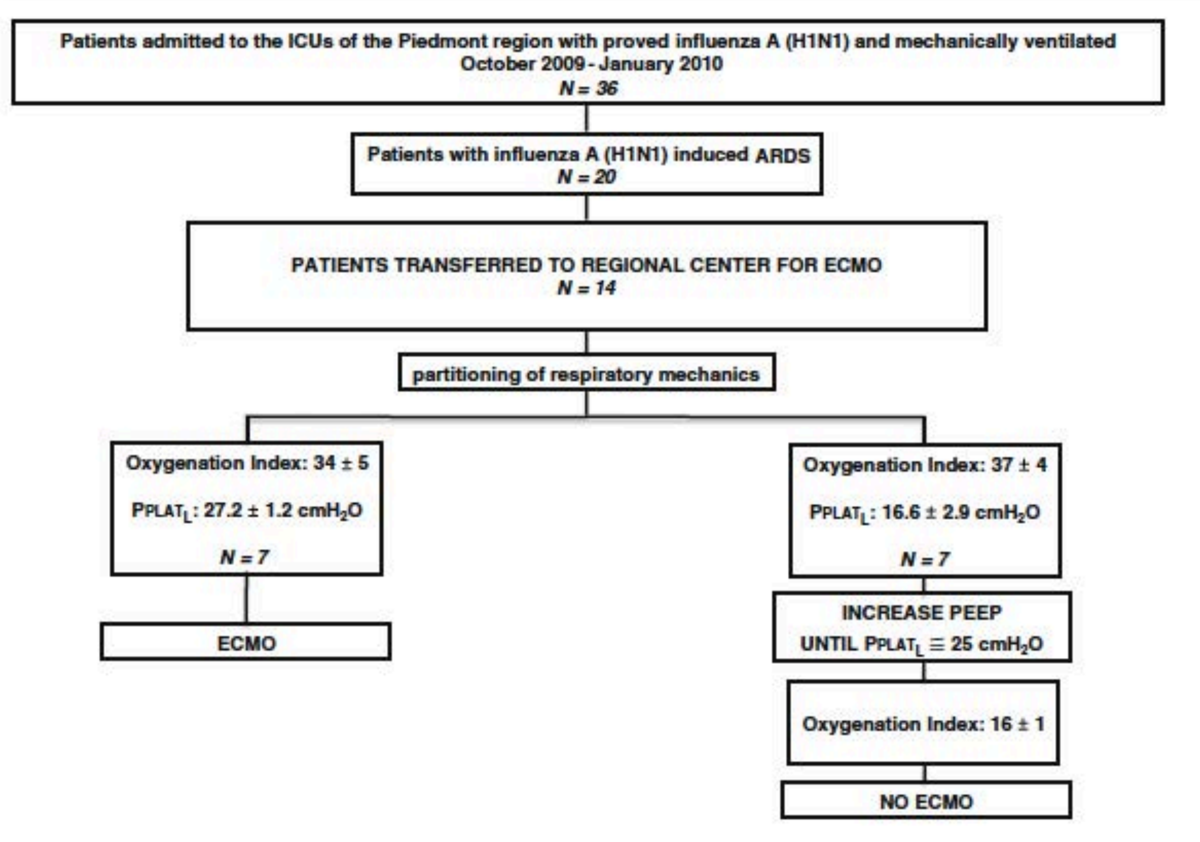


Individual titration of MV on ECMO ?

Salvatore Grasso
Pierpaolo Terragni
Alberto Birocco
Rosario Urbino
Lorenzo Del Sorbo
Claudia Filippini
Luciana Mascia
Antonio Pesenti
Alberto Zangrillo
Luciano Gattinoni
V. Marco Ranieri

ECMO criteria for influenza A (H1N1)-associated ARDS: role of transpulmonary pressure

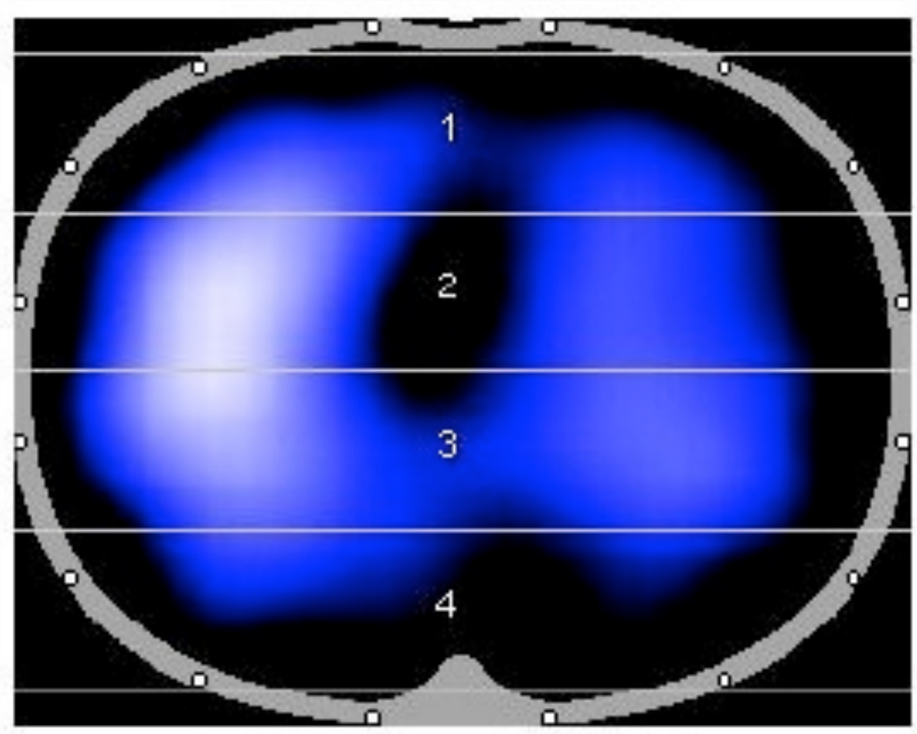
Intensive Care Med (2012)



Bedside Contribution of Electrical Impedance Tomography to Setting Positive End-Expiratory Pressure for Extracorporeal Membrane Oxygenation–treated Patients with Severe Acute Respiratory Distress Syndrome

Guillaume Franchineau[1,2], Nicolas Bréchot[1,2], Guillaume Lebreton[1,3], Guillaume Hekimian[1,2], Ania Nieszkowska[1,2], Jean-Louis Trouillet[1,2], Pascal Leprince[1,3], Jean Chastre[1,2], Charles-Edouard Luyt[1,2], Alain Combes[1,2], and Matthieu Schmidt[1,2]

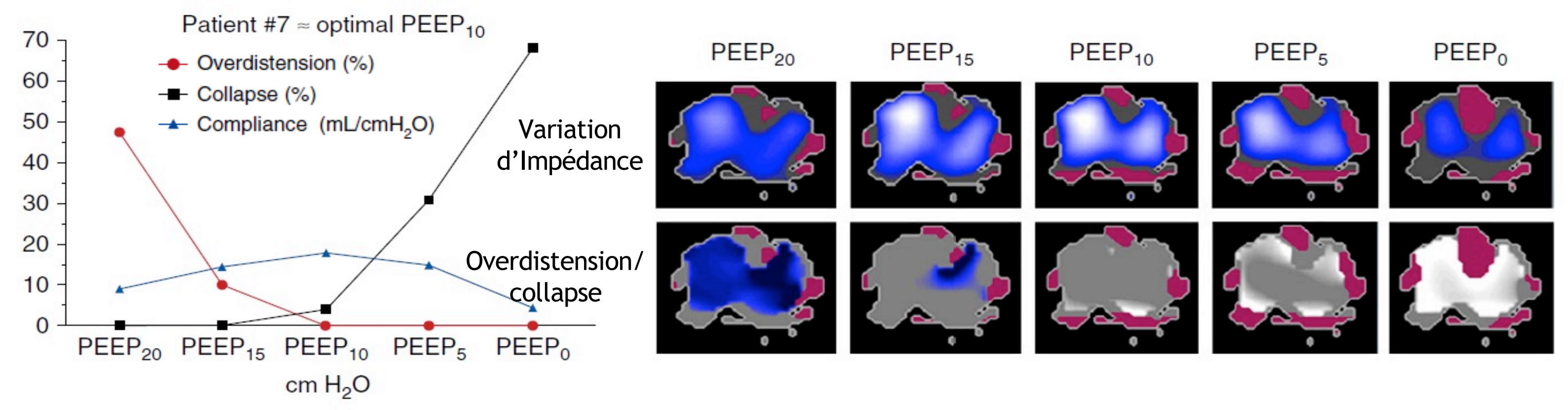
Am J Respir Crit Care Med Vol 196, Iss 4, pp 447–457, Aug 15, 2017

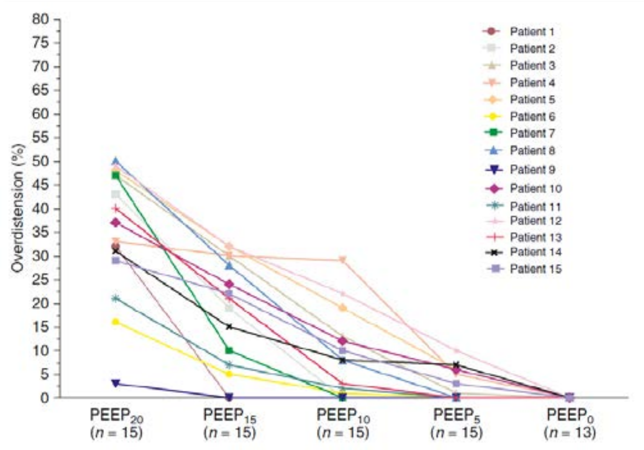


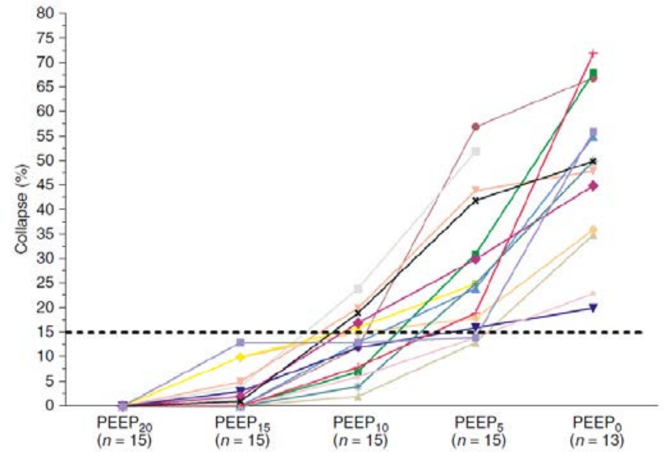
Bedside Contribution of Electrical Impedance Tomography to Setting Positive End-Expiratory Pressure for Extracorporeal Membrane Oxygenation–treated Patients with Severe Acute Respiratory Distress Syndrome

Guillaume Franchineau[1,2], Nicolas Bréchot[1,2], Guillaume Lebreton[1,3], Guillaume Hekimian[1,2], Ania Nieszkowska[1,2], Jean-Louis Trouillet[1,2], Pascal Leprince[1,3], Jean Chastre[1,2], Charles-Edouard Luyt[1,2], Alain Combes[1,2], and Matthieu Schmidt[1,2]

Am J Respir Crit Care Med Vol 196, Iss 4, pp 447–457, Aug 15, 2017







Conclusion

- ECMO enables to markedly reduce mechanical ventilation

- Evolving paradigm :
  - ❖Vt reduction < 4 ml/kg IBW
  - ❖To decrease Pplat <25 cm H_2O, respiratory rate, FiO_2
  - ❖To further reduce VILI
  - ❖With sufficient PEEP to prevent lung derecruitment

- Still many questions…studies are needed
  - ❖Clinical benefit ?
  - ❖PEEP role?
  - ❖Promote spontaneous breathing? Control of the central drive ?
  - ❖Which monitoring ?