AZIENDA OSPEDALIERO UNIVERSITARIA
Santa Maria della Misericordia di Udine

UNIVERSITY OF UDINE

BEYOND THE SLIDES 2015

1st UDINE ECMO WORKSHOP

DECEMBER 18-19, 2015

AUDITORIUM HYPO ALPE ADRIA

TAVAGNACCO (UD)

LUNG:
Working vs Resting Mode

G. Foti

Dipartimento DEA

SC Anestesia e Rianimazione

AO Provincia di Lecco

AZIENDA OSPEDALIERA della PROVINCIA DI LECCO

Perchè li mettiamo in ECMO ?

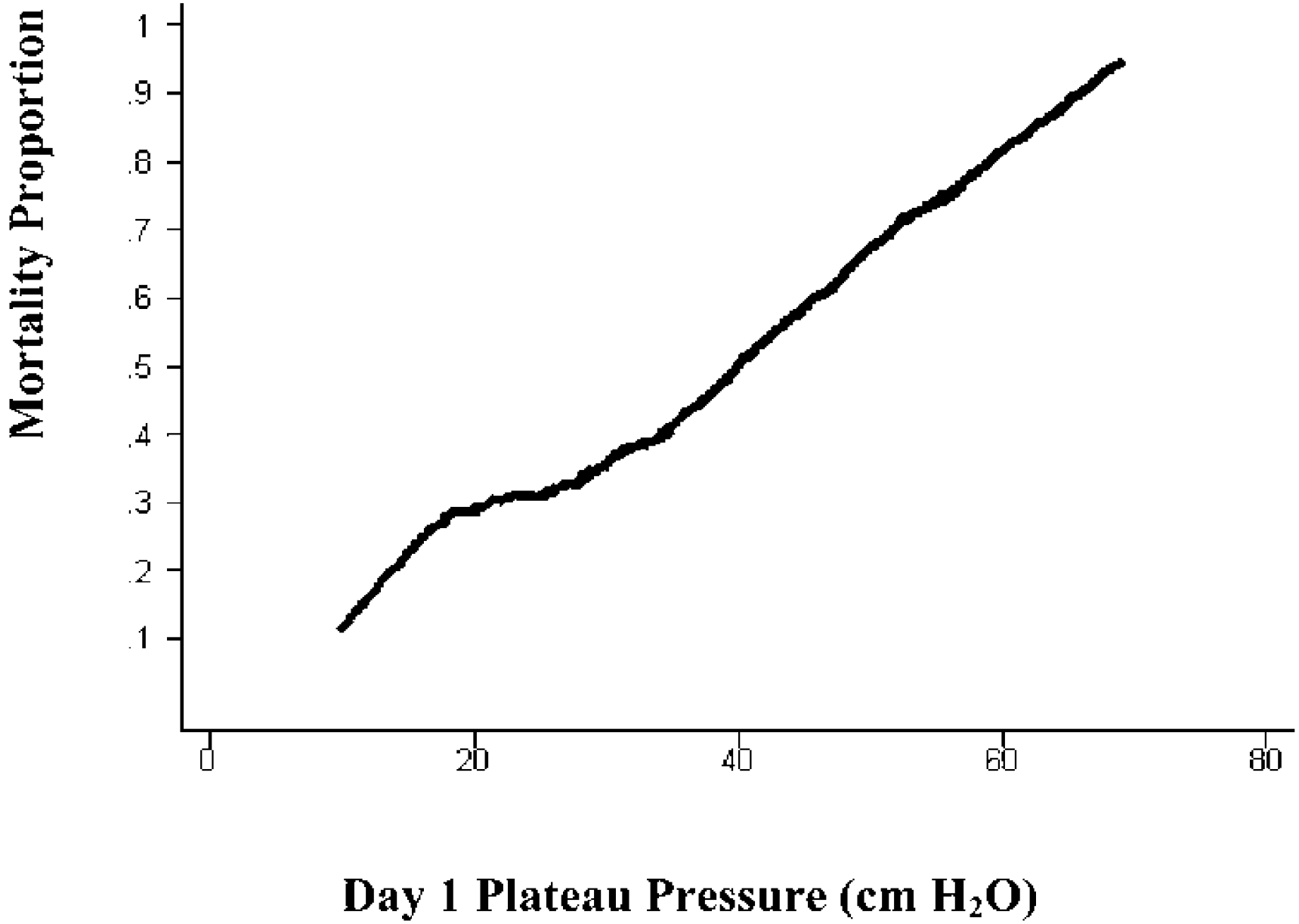
Controllo EGA

Riposo polmonare

VILI

Ventilator Induced Lung Injury

….in ECMO con la ventilazione faccio quello che voglio……


Mortality Proportion
1
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
20
40
60
80
Day 1 Plateau Pressure (cm H_2O)

Intensive Care Med (2013) 39:847–856
DOI 10.1007/s00134-012-2787-6

ORIGINAL

Thomas Bein
Steffen Weber-Carstens
Anton Goldmann
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Lower tidal volume strategy ($\approx$ 3 ml/kg) combined with extracorporeal CO_2 removal versus 'conventional' protective ventilation (6 ml/kg) in severe ARDS

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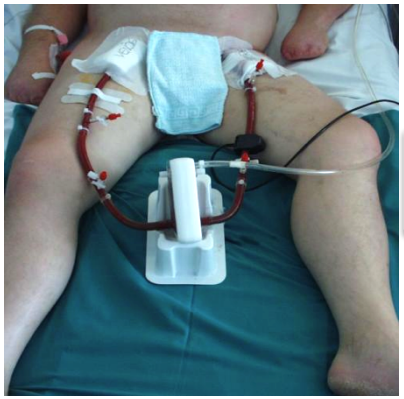
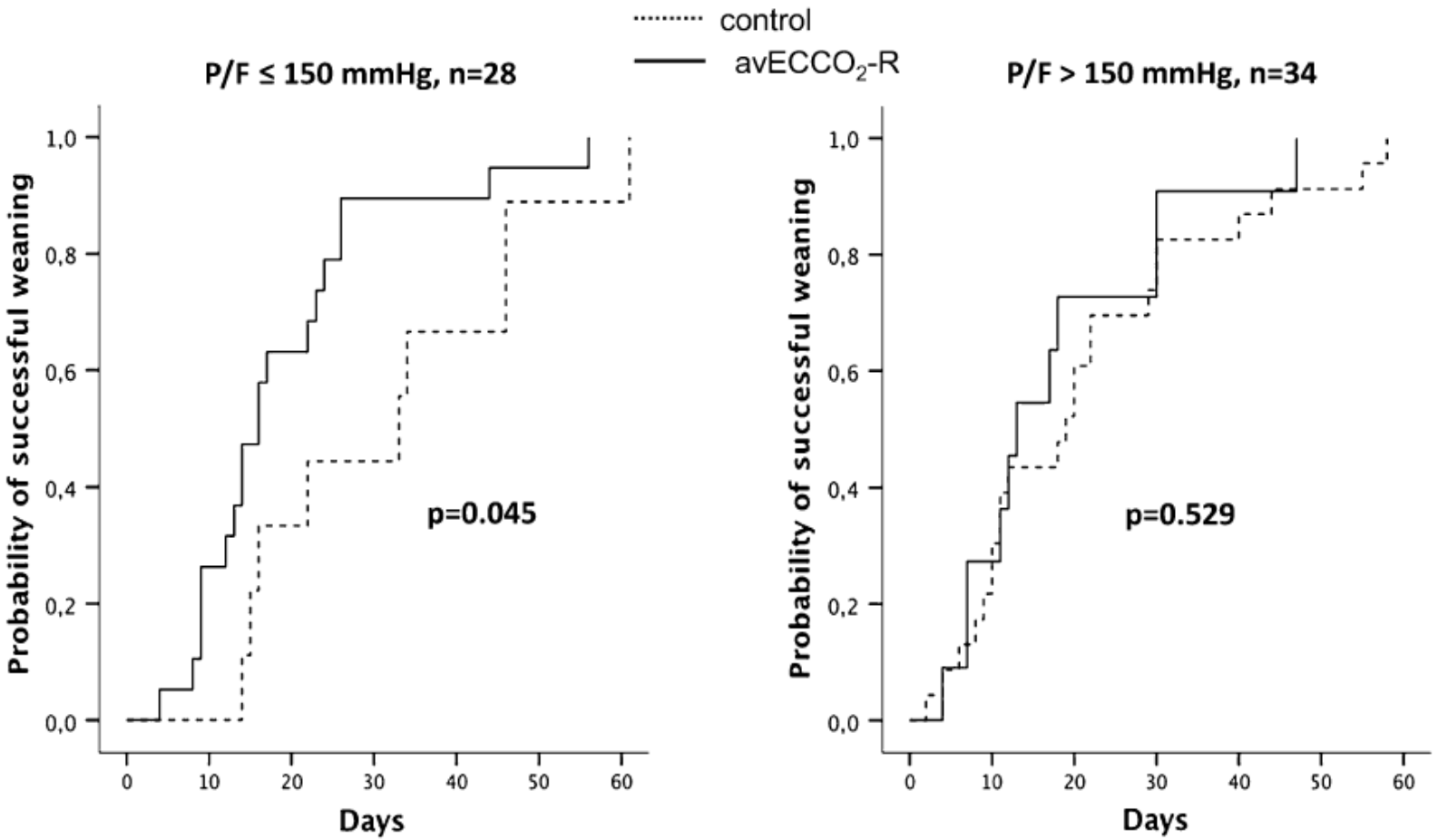
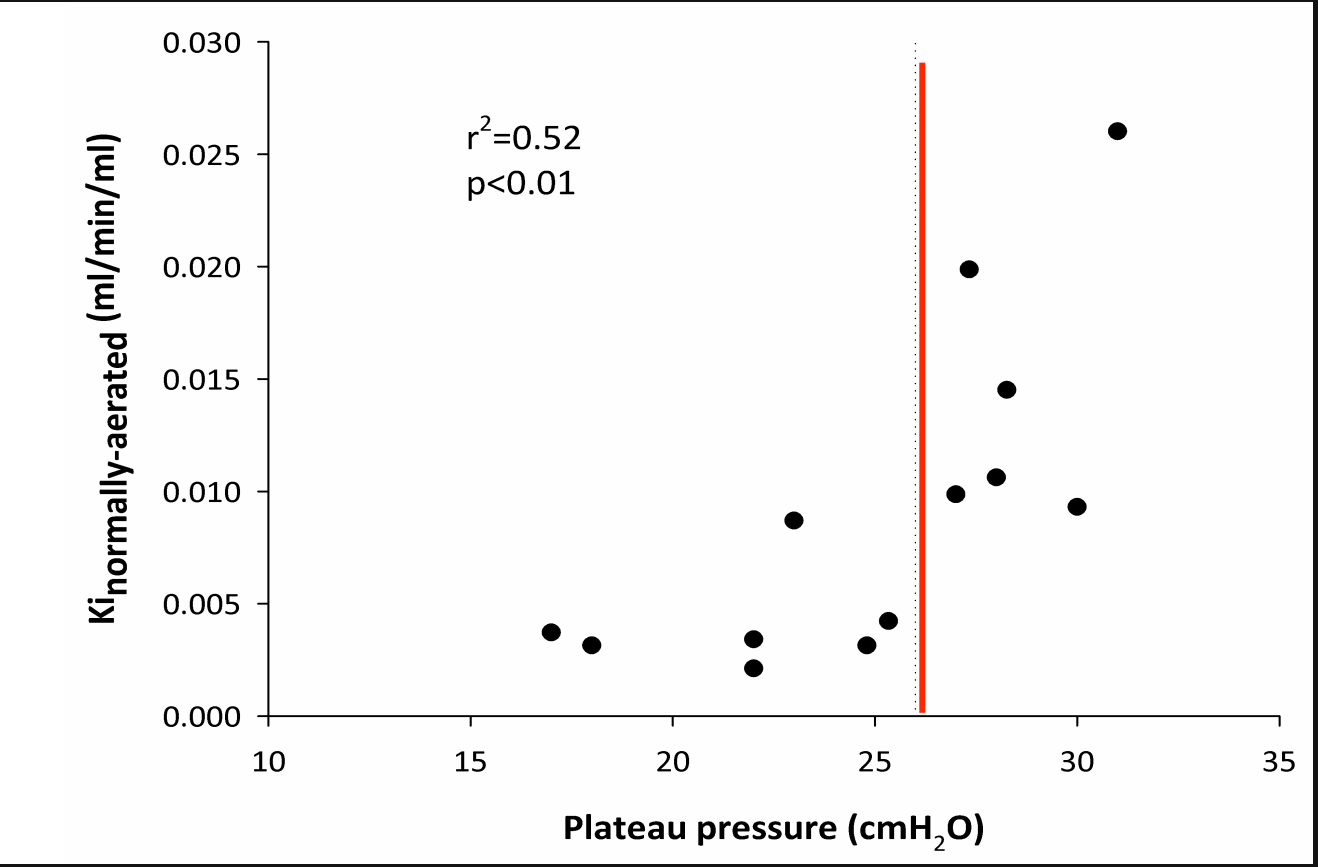


1.3± 0.2 L/min



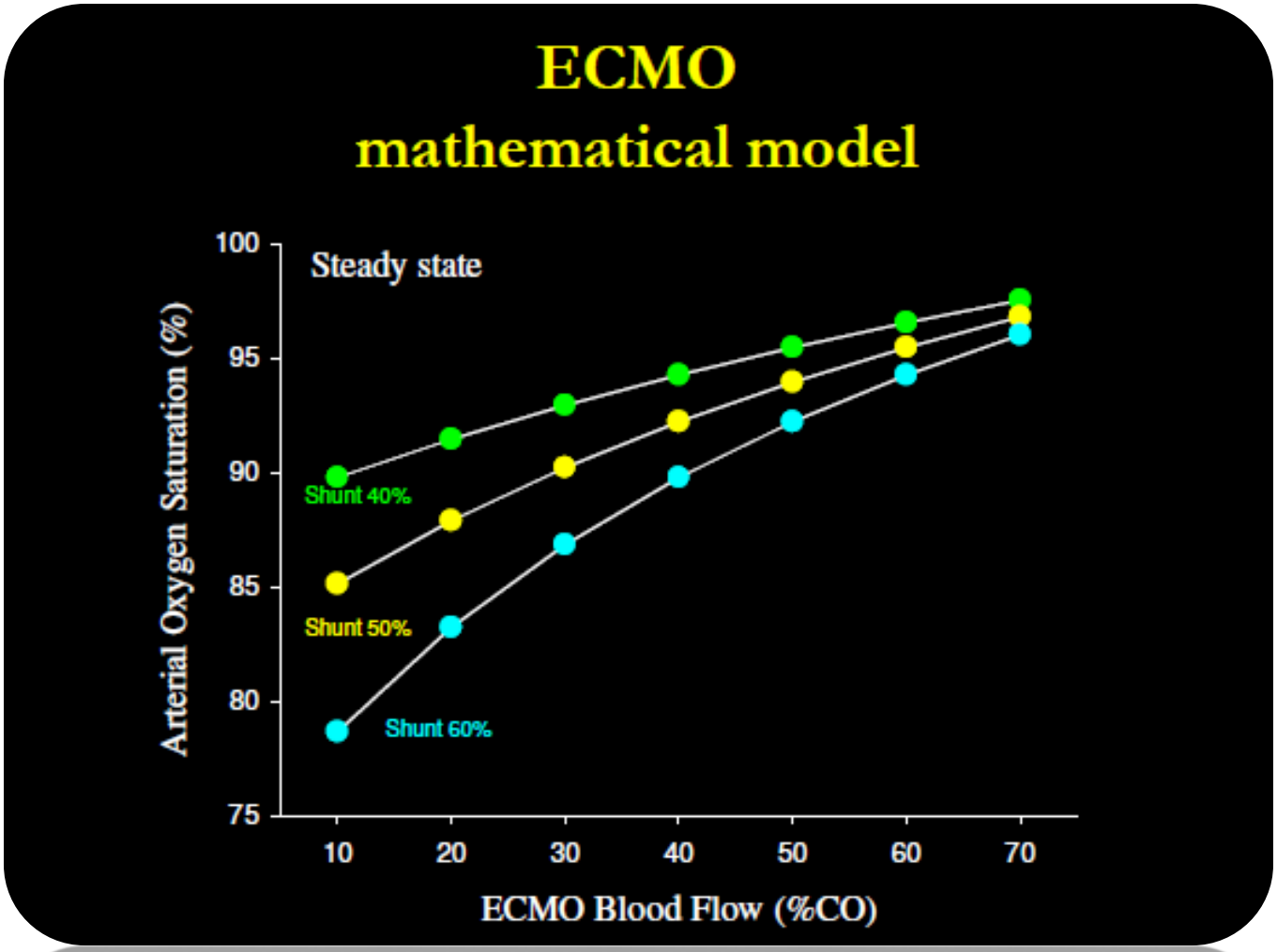
Plat < 30 is OK.....< 27 may be better



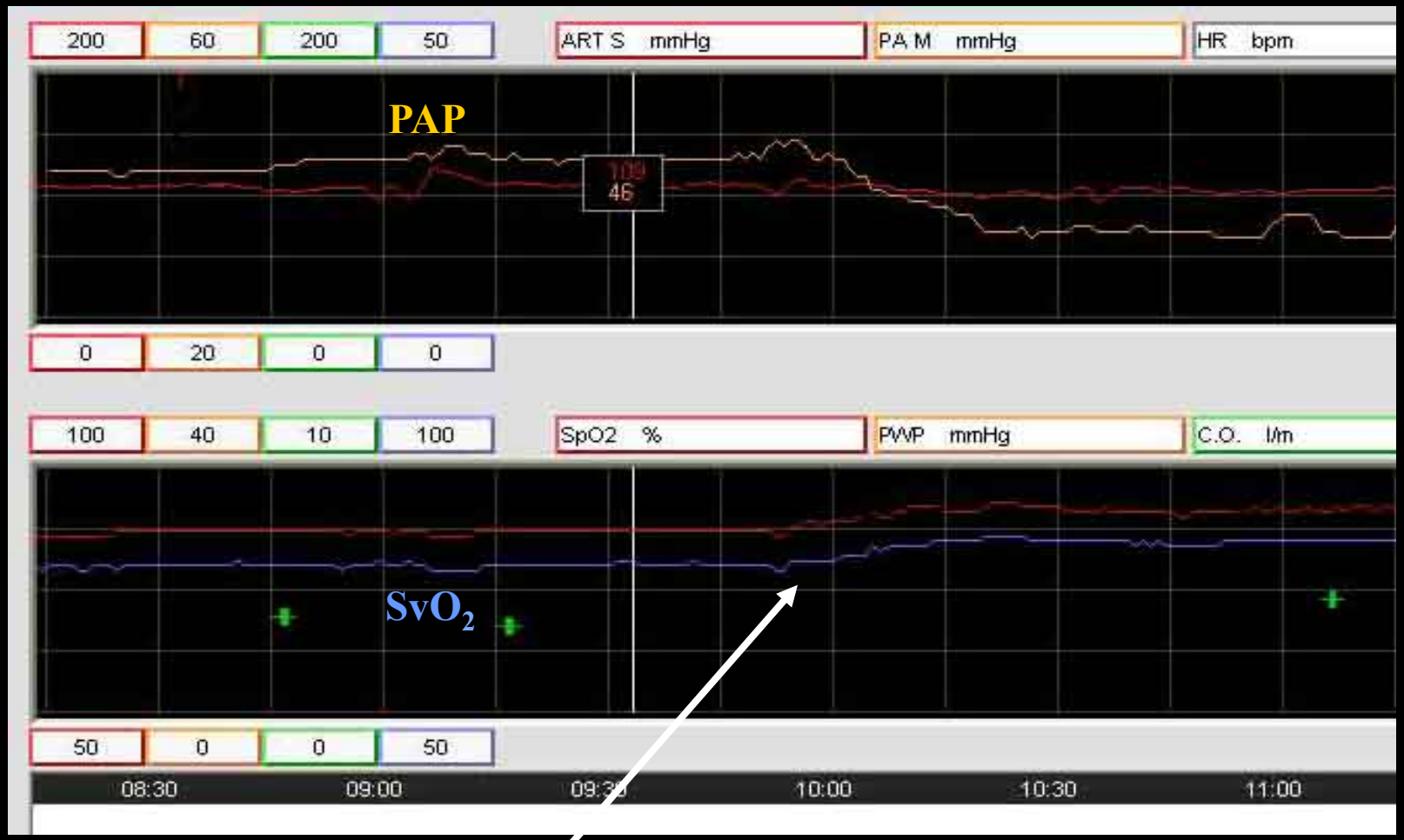
Bellani,Mauri, Pesenti AJRCCM 2011

….in ECMO con la ossigenazione faccio quello che voglio……

ECMO e SatO2


ECMO
mathematical model
Steady state
Shunt 40%
Shunt 50%
Shunt 60%
Arterial Oxygen Saturation (%)
100
95
90
85
80
75
10
20
30
40
50
60
70
ECMO Blood Flow (%CO)

PO2 e PAP



↑ Flusso CEC→ SvO_2

CASE REPORT

A case of ARDS associated with influenza A - H1N1 infection treated with extracorporeal respiratory support

G. GRASSELLI [1], G. FOTI [1], N. PATRONITI [1, 2], A. GIUFFRIDA [1], B. CORTINOVIS [1], A. ZANELLA [2], F. PAGNI [3], M. MERGONI [4], A. PESCI [5, 6], A. PESENTI [1, 2]

- FiO2 1, PEEP 18, TV 300, λ 35, Prone, NO 20 ppm
- Pplat 40
- PaO_2 42, $PaCO_2$ 75, pH 7.05
- **1° Controllo EGA**
- **2° Controllo VILI**

(VentilatorIndecedLung Injury)

CASE REPORT

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G. GRASSELLI [1], G. FOTI [1], N. PATRONITI [1, 2], A. GIUFFRIDA [1], B. CORTINOVIS [1], A. ZANELLA [2], F. PAGNI [3], M. MERGONI [4], A. PESCI [5, 6], A. PESENTI [1, 2]

- ECMO v-v:
  - Blood Flow 4 L/min
  - Gas Flow ; 4 L/min
- Ventilator:
  - FiO2 1, PEEP 18, TV 180, λ 12,
  - Pplat 28
- **EGA**
  - **PaO2 78**
  - **paCO2 45**
  - **pH 7.38**

Intensive Care Med
DOI 10.1007/s00134-009-1661-7

ORIGINAL

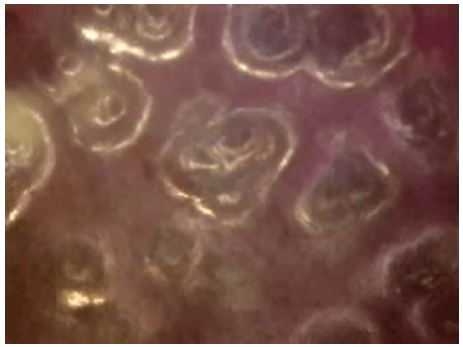
Thomas V. Brogan
Ravi R. Thiagarajan
Peter T. Rycus
Robert H. Bartlett
Susan L. Bratton

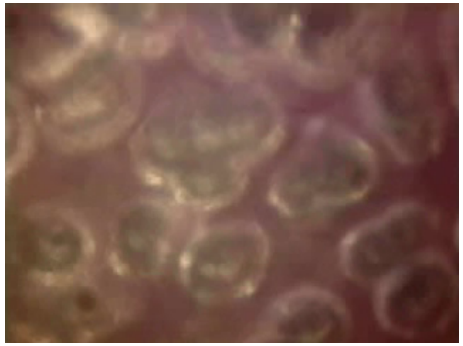
Extracorporeal membrane oxygenation in adults with severe respiratory failure: a multi-center database

Table 2 Pre-ECMO parameters and variables after institution of ECMO by survival group for adults with respiratory failure

Variable	All patients (1986–2006)			Most recent patients (2002–2006)		
	Survivors ($n = 741$)	Non-survivors ($n = 732$)	p value	Survivors ($n = 301$)	Non-survivors ($n = 299$)	p value
ECMO 24-h ventilator settings: median (IQR)						
Peak inspiratory pressure (cm H_2O)	28 (24, 32)	30 (25, 35)	<0.001	28 (24, 32)	28 (24, 34)	0.07
Mean airway pressure (cm H_2O)	16 (13, 22)	17 (14, 22)	0.53	16 (13, 21)	15 (13, 20)	0.97
Positive end expiratory pressure (cm H_2O)	10 (10, 12)	10 (9, 12)	0.68	10 (8, 14)	10 (8, 12)	0.68
Fraction inspired oxygen	0.4 (0.3, 0.5)	0.5 (0.4, 0.65)	<0.001	50 (40, 51)	50 (40, 71)	<0.001
Rate	10 (10, 14)	10 (8, 14)	0.85	10 (10, 15)	10 (8, 15)	0.68
Bridge to transplant n (%)	11 (1)	8 (1)	0.51	7 (2)	4 (1)	0.37

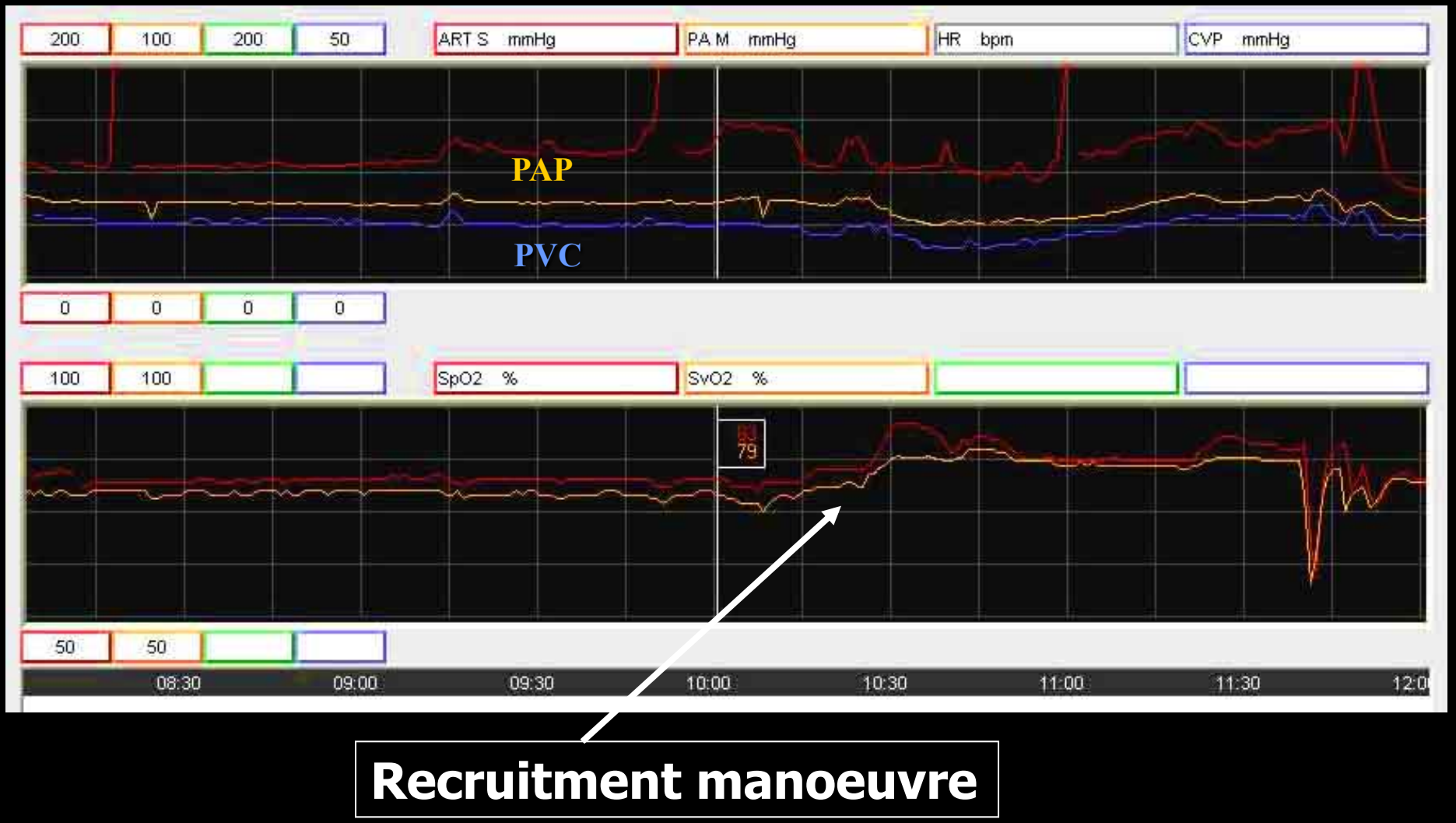
Non Recruiter strategy





- Low PEEP (5-10)
- Lung Protective Strategy
  - *What about Atelectrauma ?*
- High Blood Flow mandatory
  - *II° drainage cannula*
- Pulmonary Hypertension
  - V-A bypass to compensate Right Ventricular Failure?

Reclutamento e PAP



Recruiter strategy: to cure the lung (what I do..)

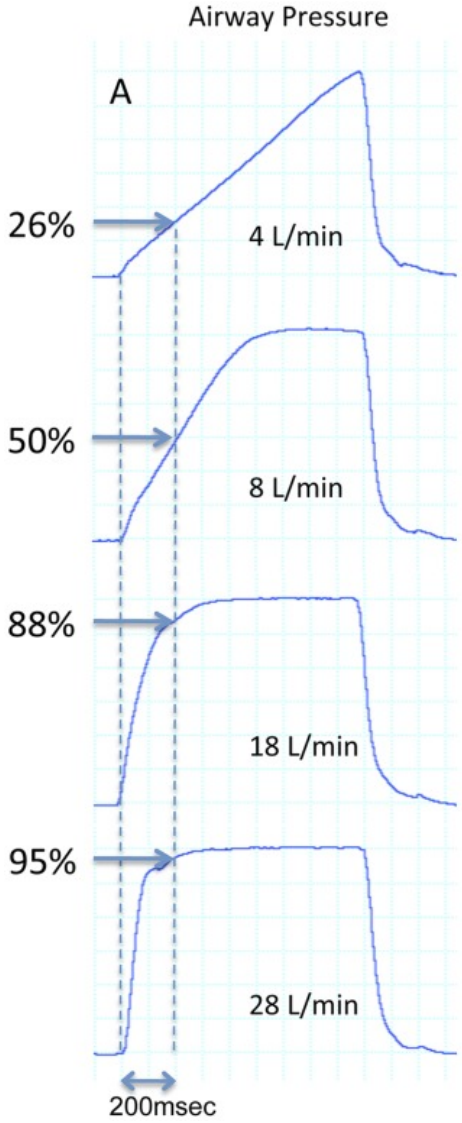
- **Avoid Baro-Volotrauma**
  - TV < 6 ml/kg best titrated on FRC
  - Pplat < 27
  - RR 10-12
  - RM & SIGH to promote recruitment at lower PEEP
  - Use slow inspiratory flow profile
- **Avoid Atelectrauma**
  - PEEP above Pflex
  - Stress Index
  - SpO2 stabilization following RMs

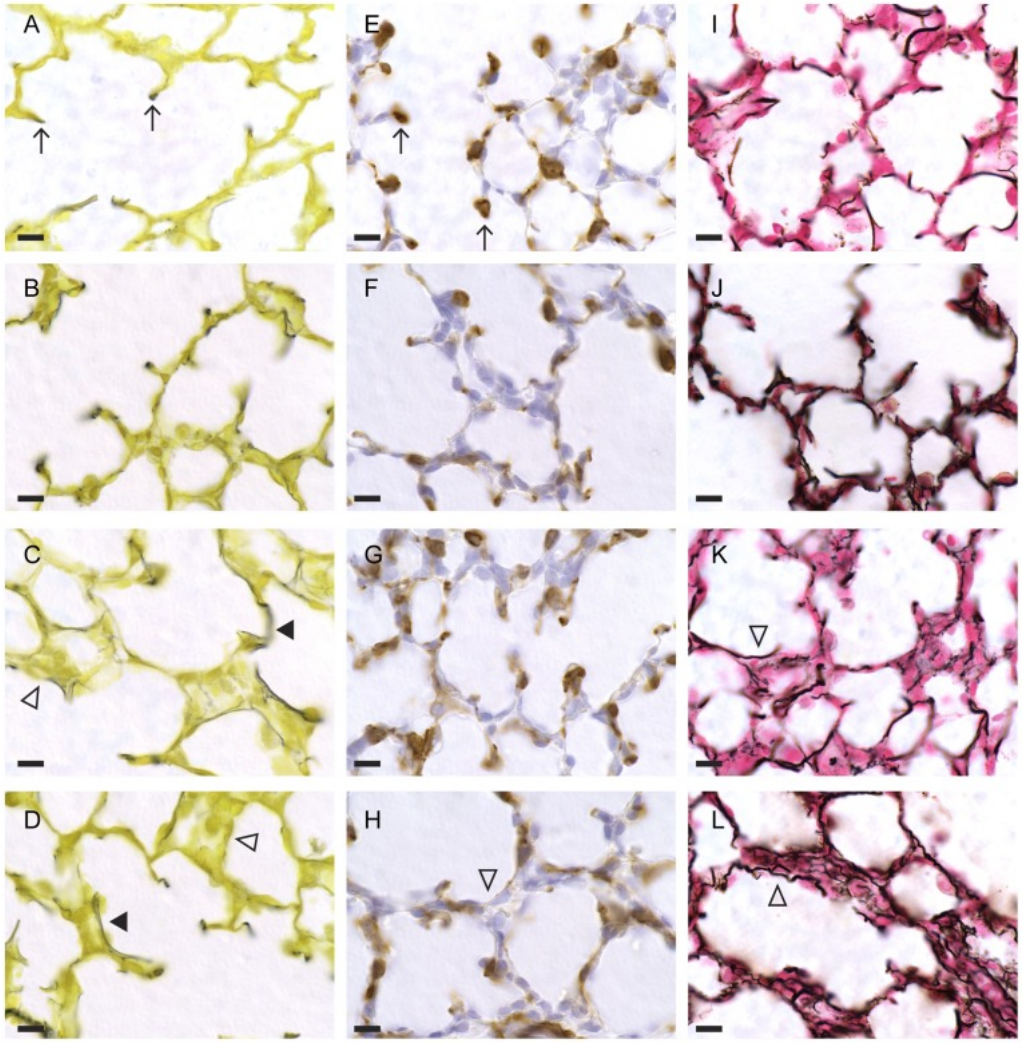
OPEN ACCESS Freely available online

PLOS ONE

High Bias Gas Flows Increase Lung Injury in the Ventilated Preterm Lamb

Katinka P. Bach[1,4*], Carl A. Kuschel[2], Stuart B. Hooper[3], Jean Bertram[4], Sue McKnight[4], Shirley E. Peachey[4], Valerie A. Zahra[3], Sharon J. Flecknoe[3], Mark H. Oliver[1,5], Megan J. Wallace[3], Frank H. Bloomfield[1,4,5,6]





ECMO per favorire il passaggio al respiro assistito

- Quando è terminata fase iperacuta
  - No capillary leak
- Per favorire reclutamento alveolare
- Per accelerare il weaning

Dottore..dottore..la frequenza respiratoria ↑

Aumenta PSV..mmm..no anzi

Sedalo un pochino…..mmm….,aspetta

Aumenta gas flow !

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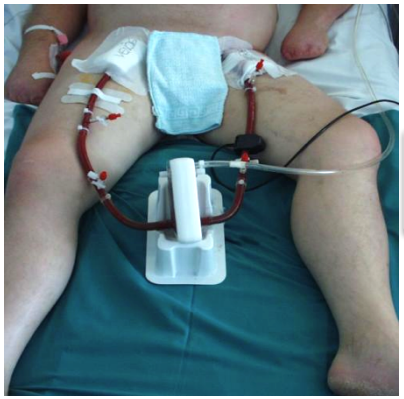
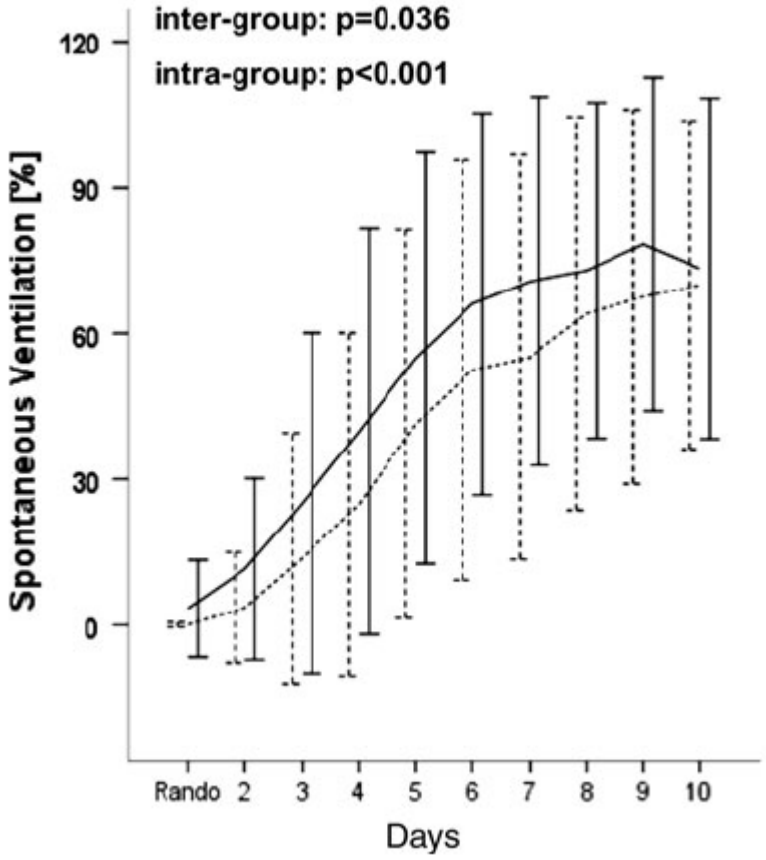
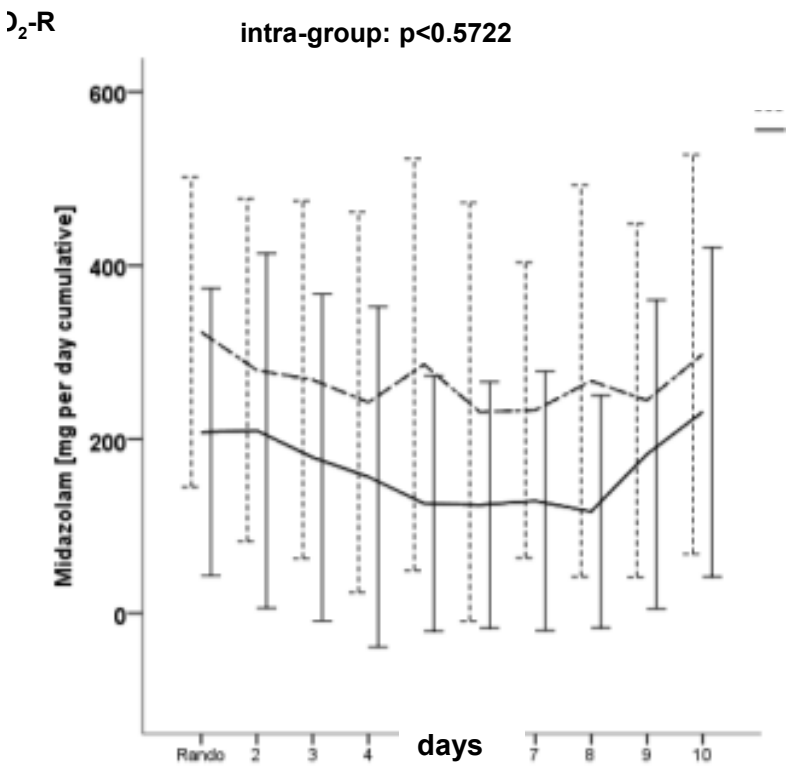


1.3± 0.2 L/min



5B



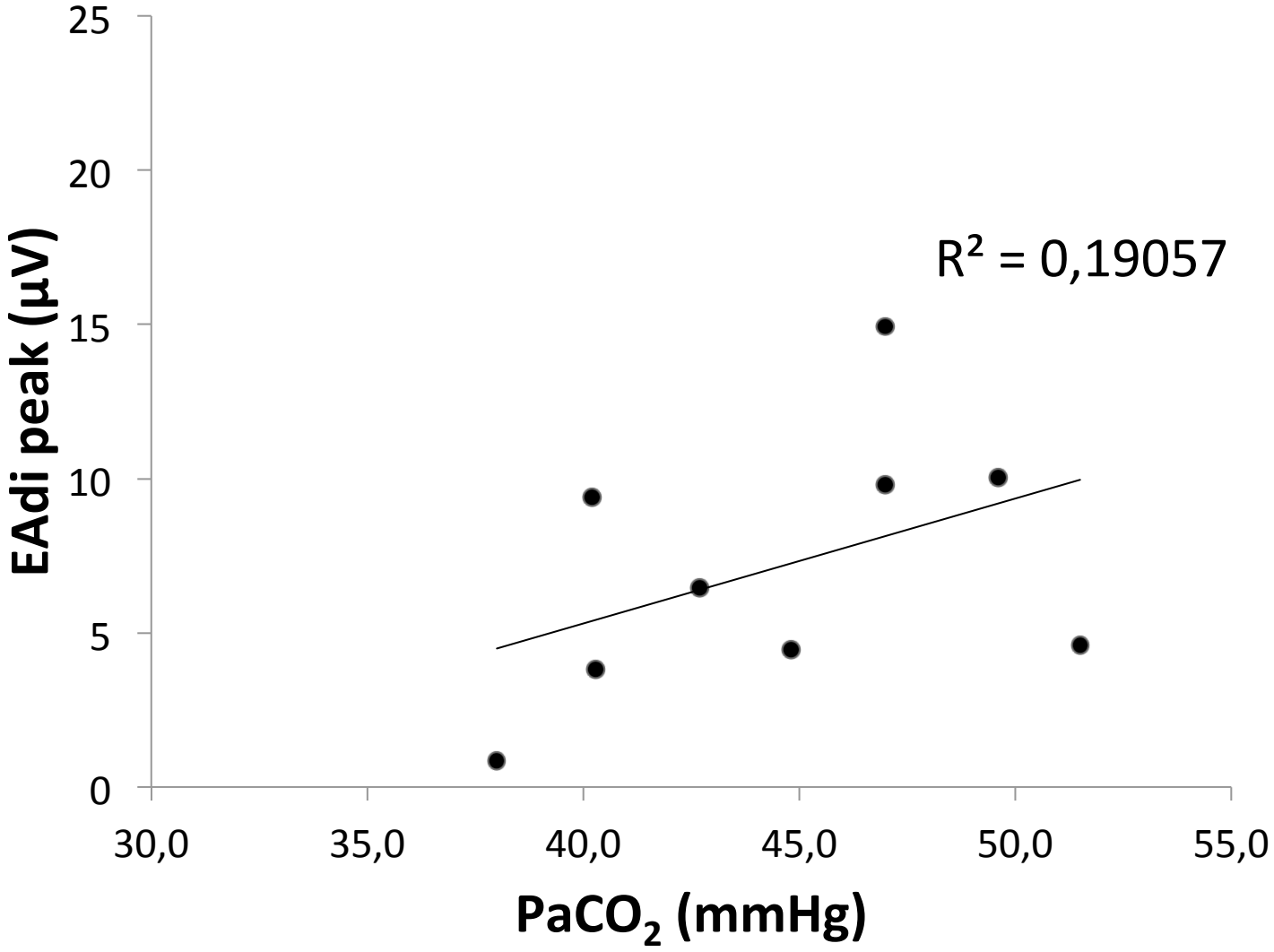
Condizioni x continuare Supporto Ventilatorio Parziale in ECMO

- TV < 8 ml/kg
- Controlled Respiratory effort
  - Po.1 < 2
  - PMI < 5
  - PTP/min < 100 cmH2O/sec./min
  - Pes < 5 cmH2O
  - RR < 20
- ↑ PaO2

Beyond The Slides : summary

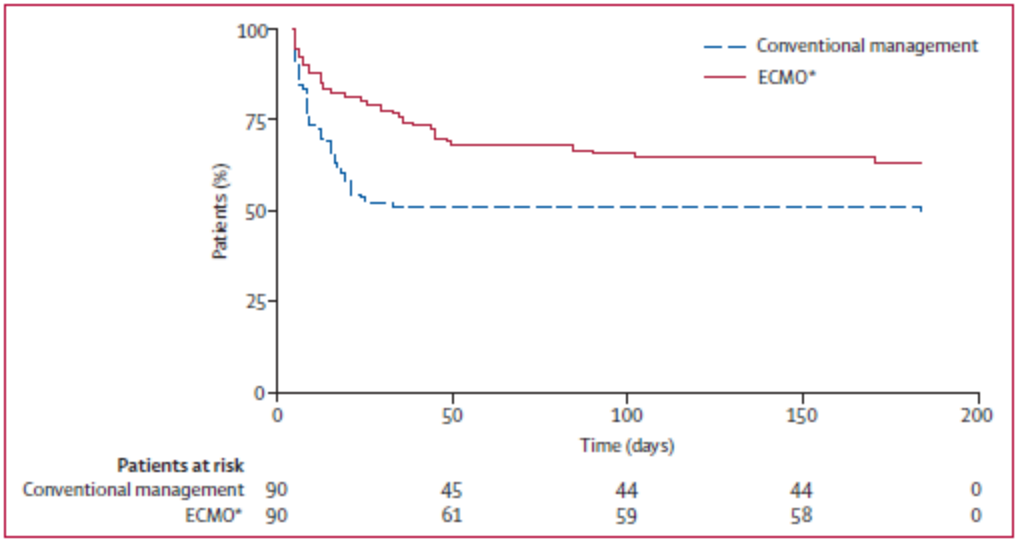
- **Safely keep recruited the lung to improve healing**
  - Avoid atelectrauma, baro-volutrauma
  - Normalize Respiratory Rate
- **Move to partial ventilatory support if:**
  - TV < 8 ml/kg
  - Normal Effort
    - Use ECMO Gas Flow to control effort

What influences the respiratory drive in ARDS pts increasing CO removal?



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

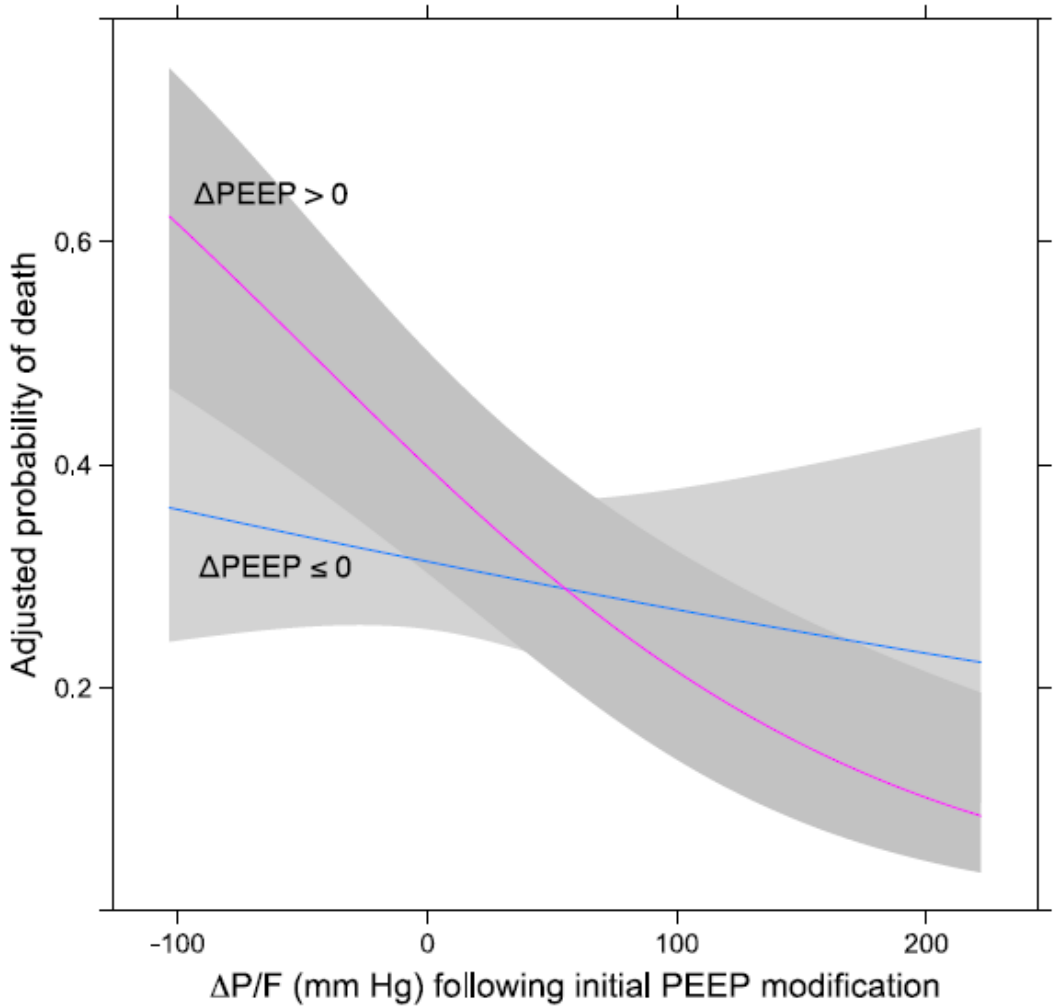
Giles J Peek, Miranda Mugford, Ravindranath Tiruvoipati, Andrew Wilson, Elizabeth Allen, Mariamma M Thalanany, Clare L Hibbert, Ann Truesdale, Felicity Clemens, Nicola Cooper, Richard K Firmin, Diana Elbourne, for the CESAR trial collaboration



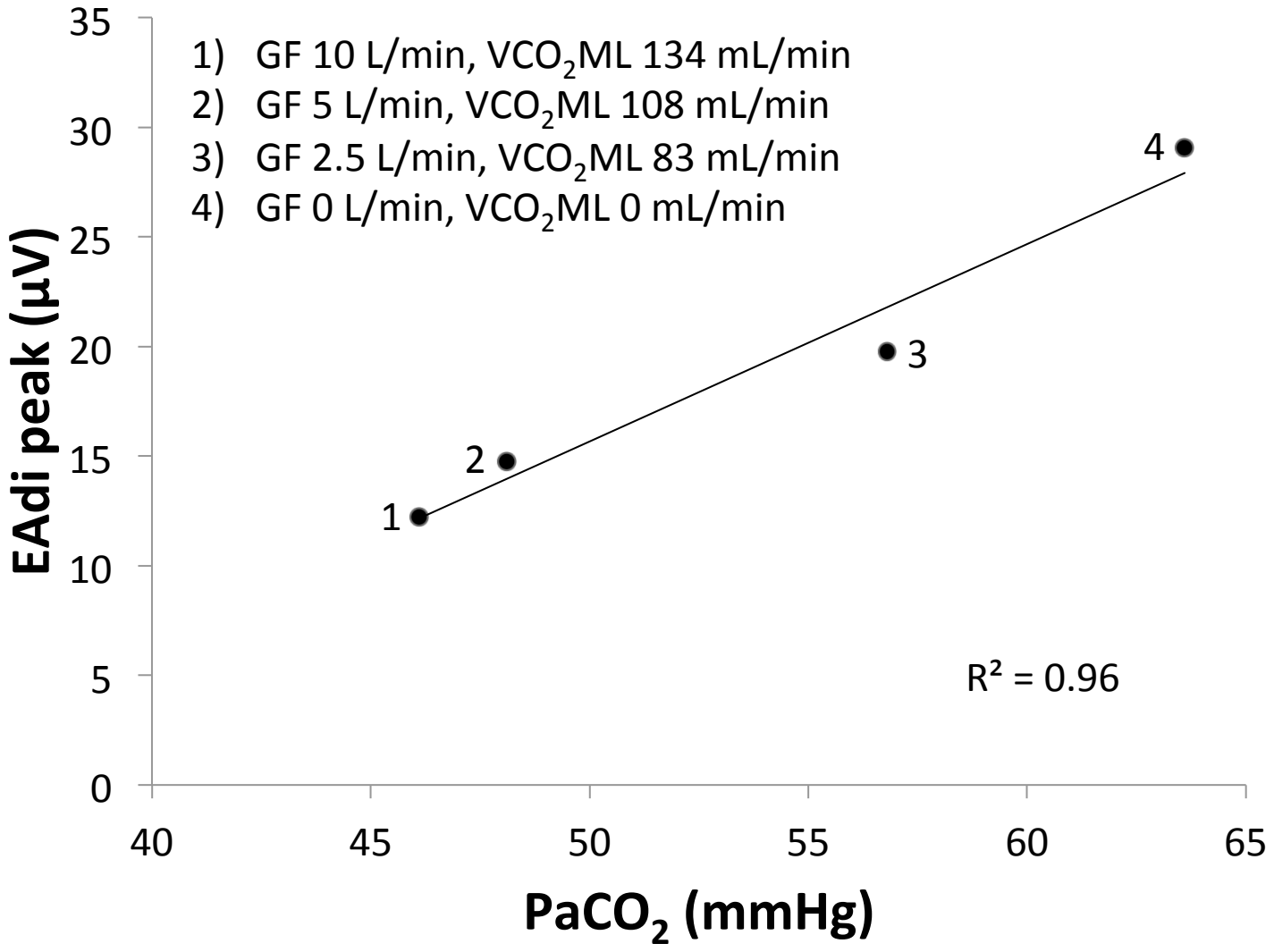
lung rest settings were :
- peak inspiratory pressure 20–25,
- positive endexpiratory pressure 10–15,
- rate 10,
- FiO2 0·3.

Oxygenation Response to Positive End-Expiratory Pressure Predicts Mortality in Acute Respiratory Distress Syndrome

A Secondary Analysis of the LOVS and ExPress Trials

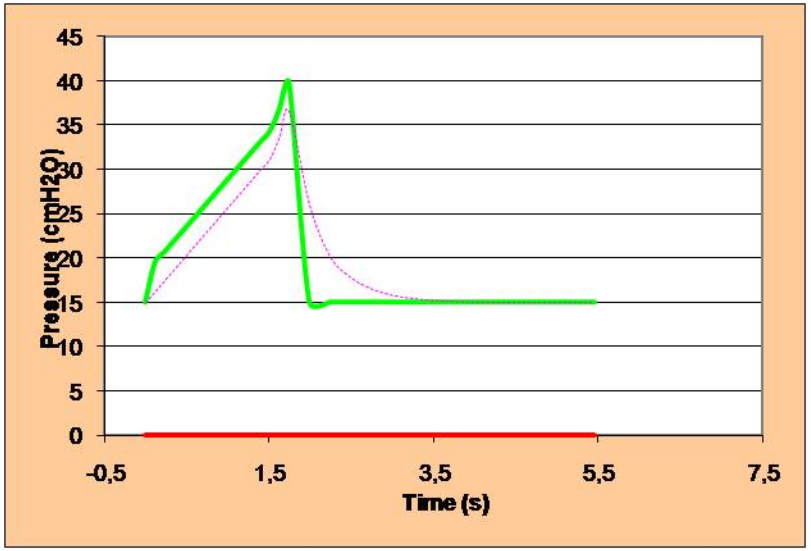


What influences the respiratory drive in **COPD** pts undergoing CO_2 removal

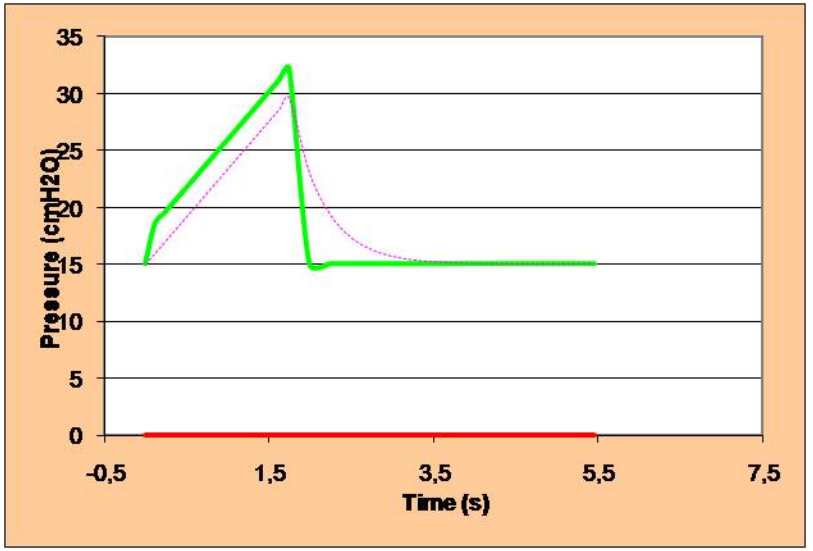


Attenzione ai cambi bruschi di Pmedia

- Evitare immediatamente la sovradistensione
- Ridurre Pplat < 30
- TV < 6 ml/Kg



NO GOOD



BETTER

Come contrastare i bruschi cambi Pmedia ?

- ↑ **PEEP**
- **Minimizzando cambi I/E**

Fate cambi acuti MAP ≤ 2-4 cmH2O

Strategie Ventilatorie in ECMO (una guerra di religione)

Recruiter

Non Recruiter

Non Recruiter strategy

Recruiter strategy

Strategie Ventilatorie in ECMO (pro e con)

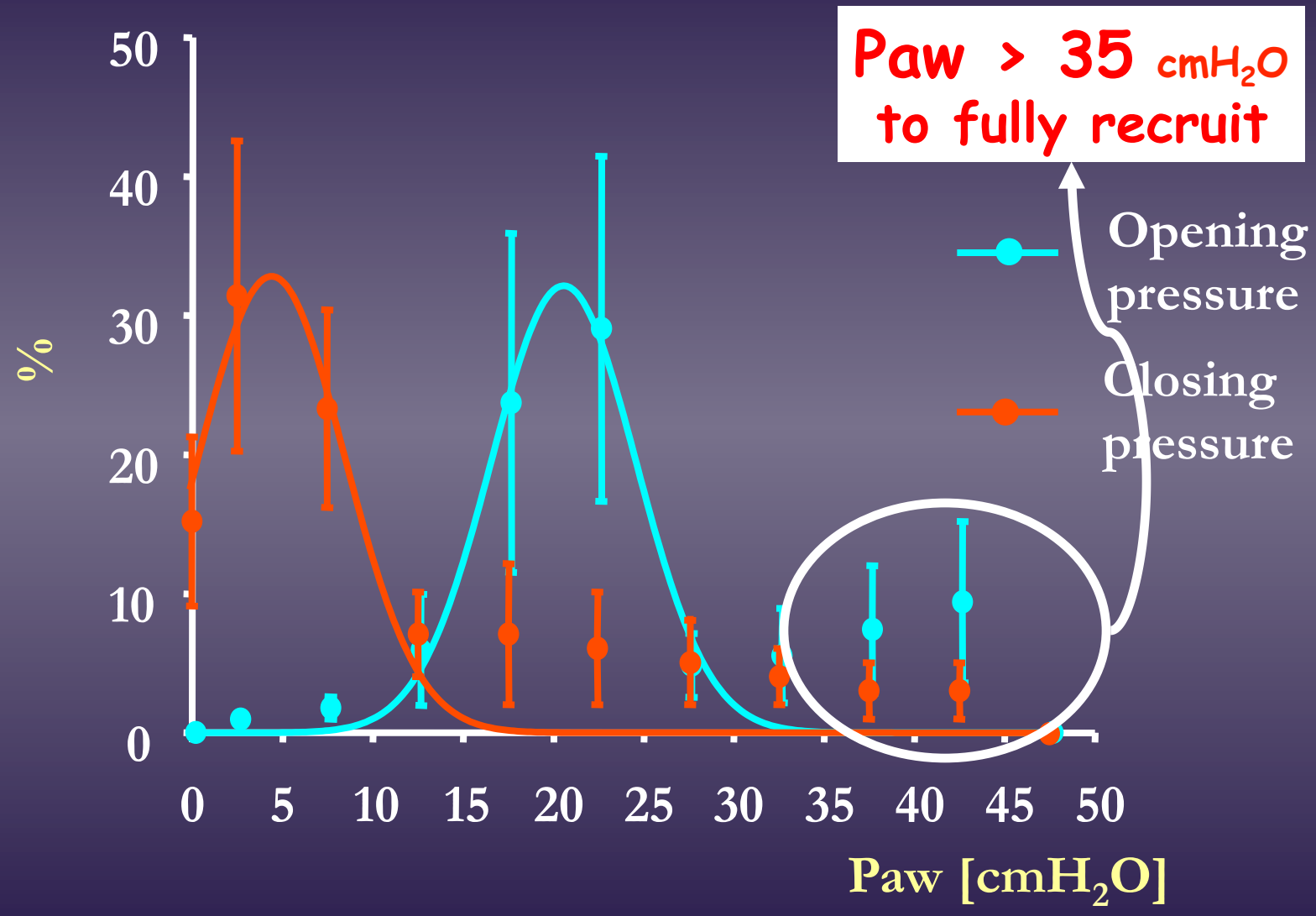
Recruiter

- ↑ PEEP, Sigh etc
  - Barotrauma ?
- ↓ Blood Flow
  - Femoro-femoro
  - No III° cannula
- ↓ PAP
  - ↑ VDx

Non Recruiter

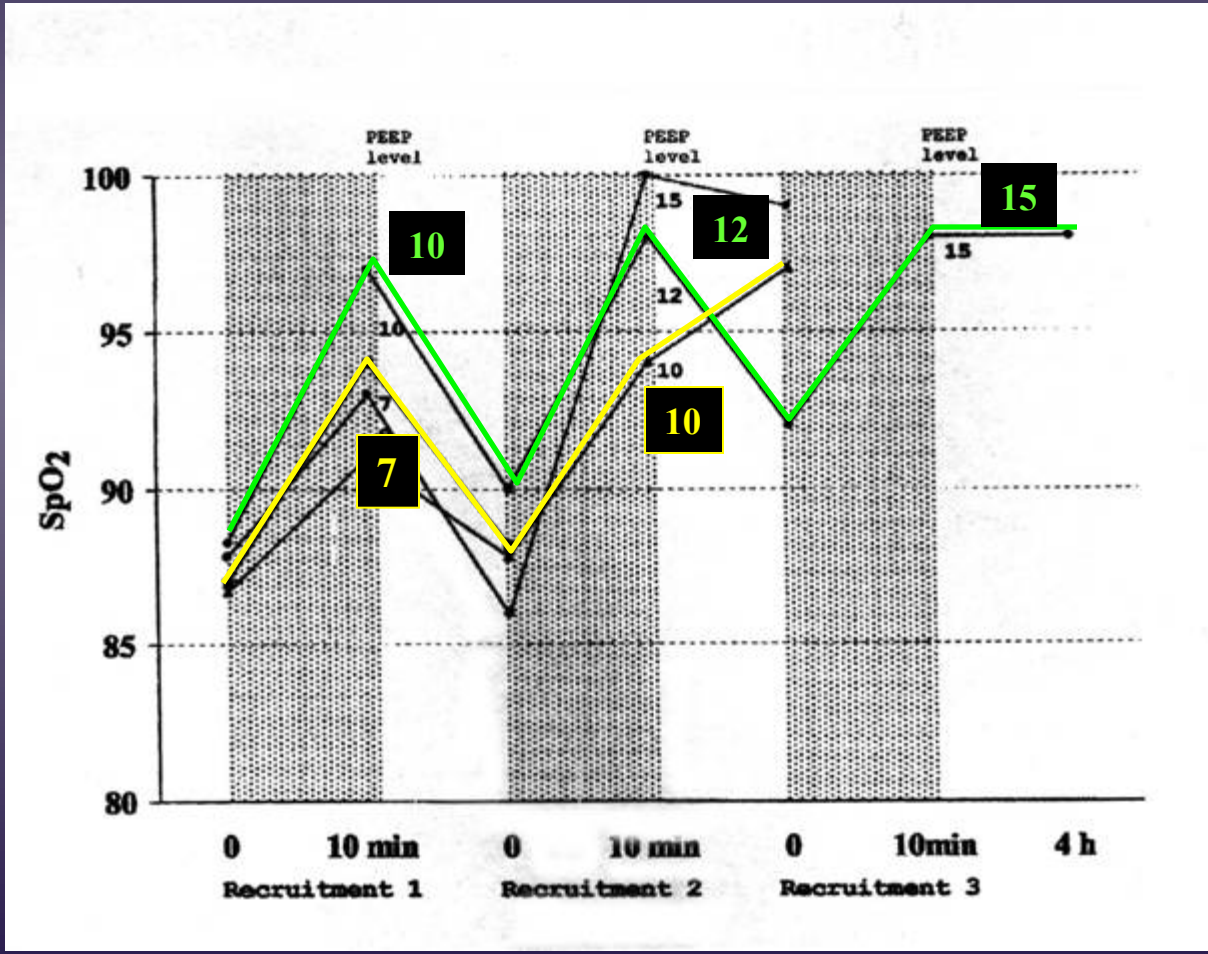
- ↓ PEEP, no Sigh etc
  - ↓ Barotrauma
- ↑ Blood Flow
  - Femoro-Giugulo
  - III° cannula
- ↑ PAP
  - Right Heart Failure
  - A-V

Opening and closing pressures



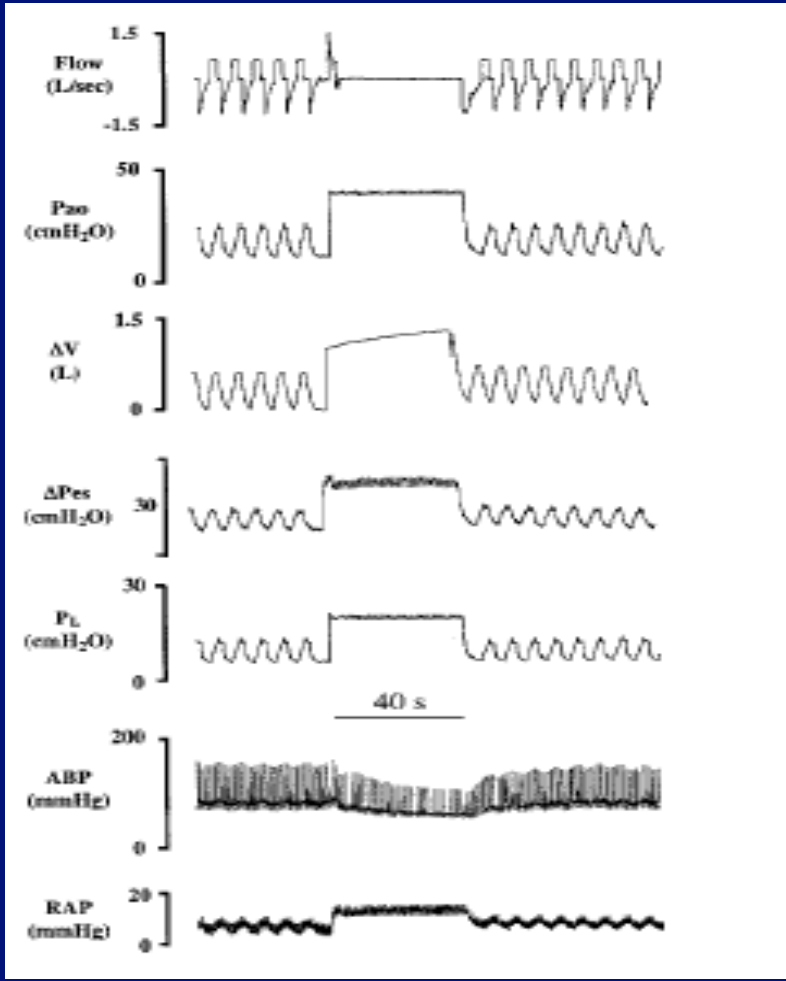
Crotti et al. *Am J Respir Crit Care Med* 2001

Modern PEEP Titration

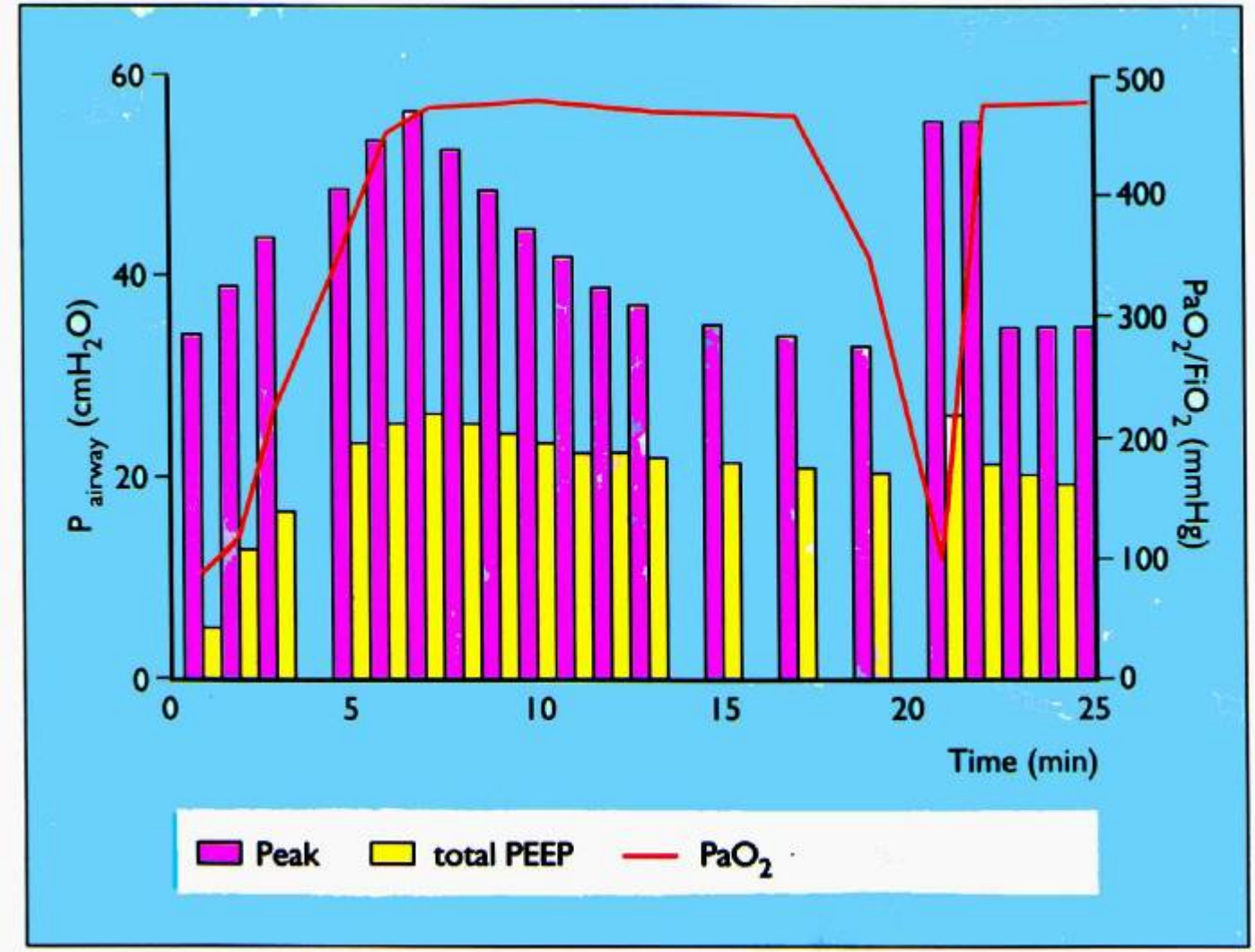


40 by 40”

(preferisco 20 by 20”)



Lachmann's style



Ricetta manovra di reclutamento

- **Il reclutamento prende tempo**
- **Assicuratevi che flusso inspiratorio = 0**
- **Pressometrica >>> Volumetrica**
- **Non usate le pause di fine inspirazione**
- **<u>NON USATE AMBU</u>**
  - **Controllo PAW**
  - **Controllo FiO2**
  - **Connessione / deconnessione**

Spo2 e RM's

- ↑ ➲ Problema risolto !
  Era un'atelettasia
- ↑ e poi ↓ ➲ Ripeto e ↑ PEEP
- ± ➲ ↑ Pressione Rm's oppure **aspetto**

Quante RM's ?

- Pochissime se uso SIGH
- In Controllata e Assistita
- Che pressione ? ➲ quella di reclutamento
- A chi ? ➲ A quelli che reclutano

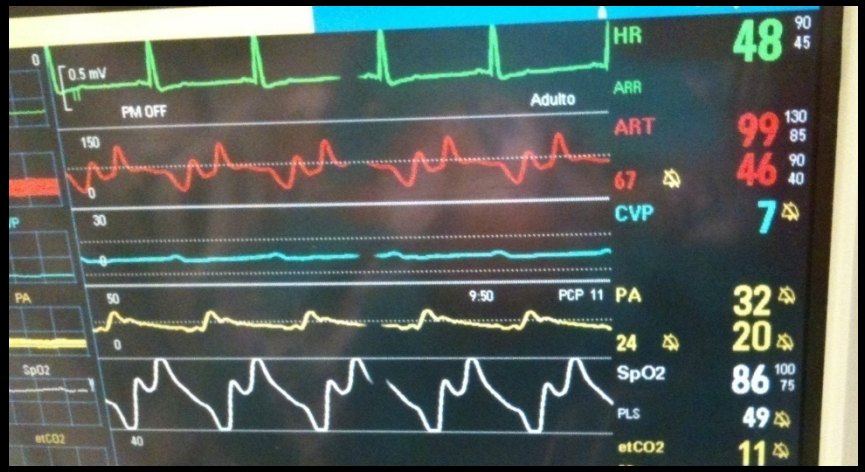
Monitoraggio reclutamento

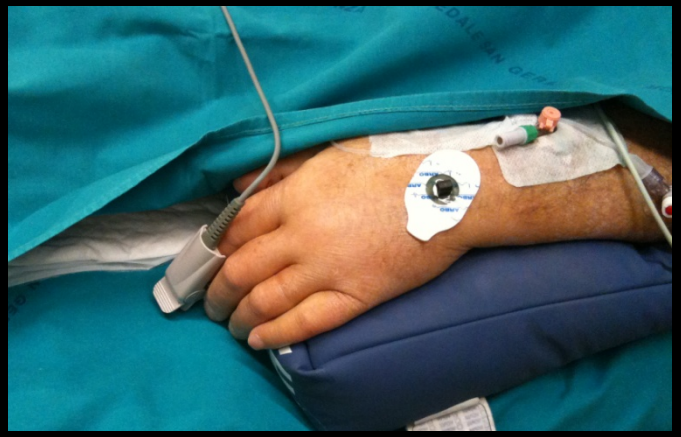
- **EGA**
  - P/F
  - PaO2 al 100%
  - **Shunt**
- **Meccanica respiratoria**
  - **Cpl**, FRC
- **Imaging**
  - Rx
  - TC

Monitoraggio reclutamento durante V-A bypass

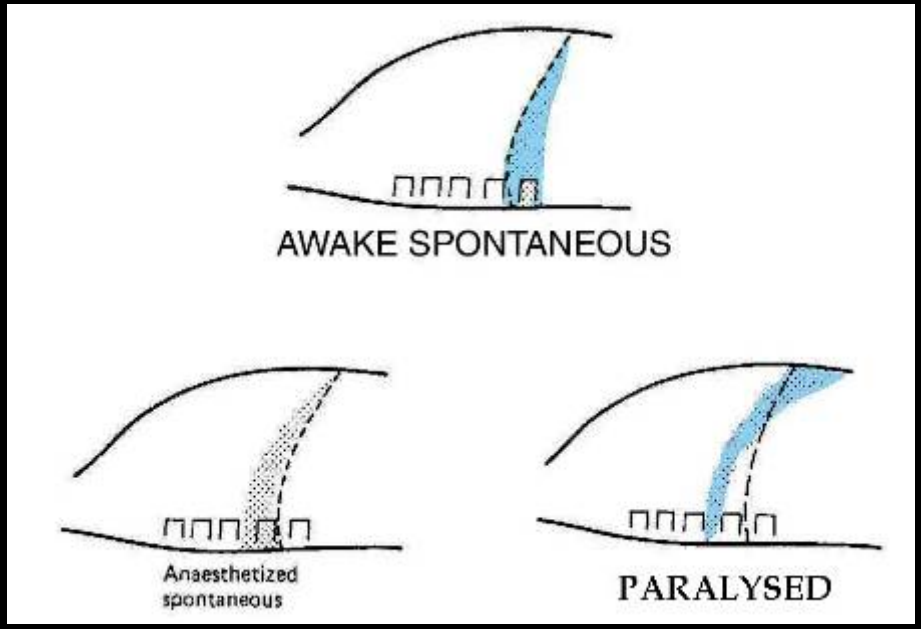
- **Quale sangue proviene dai polmoni ?**
- **Incannula la radiale dx**
  - **Se attività cardiaca**
  - **Sangue proveniente dal polmone naturale**

OCCHIO a dove mettete il saturimetro !

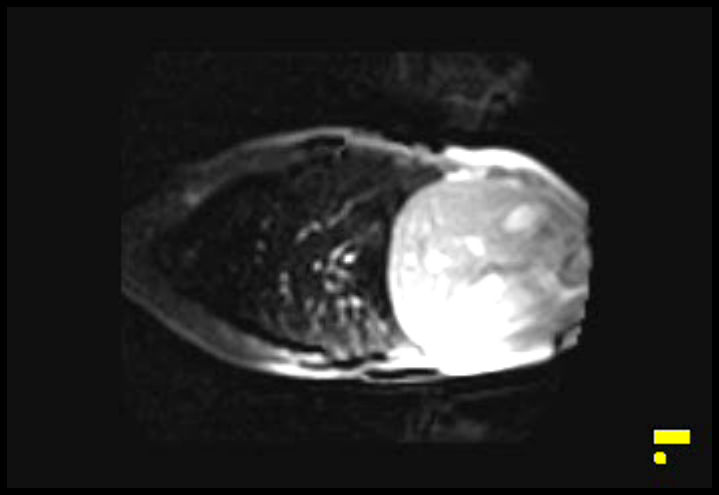


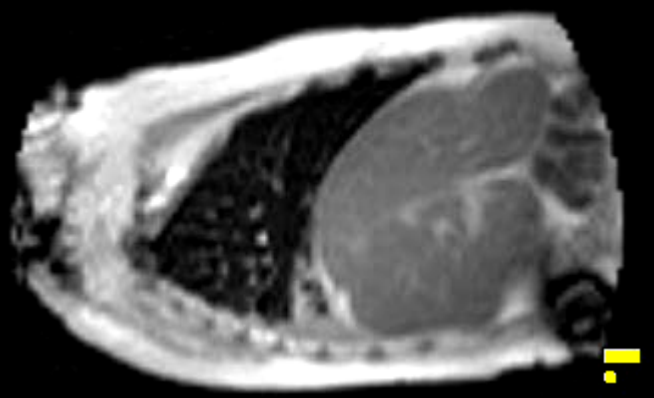


BENEFICI Respiro Spontaneo in ARDS



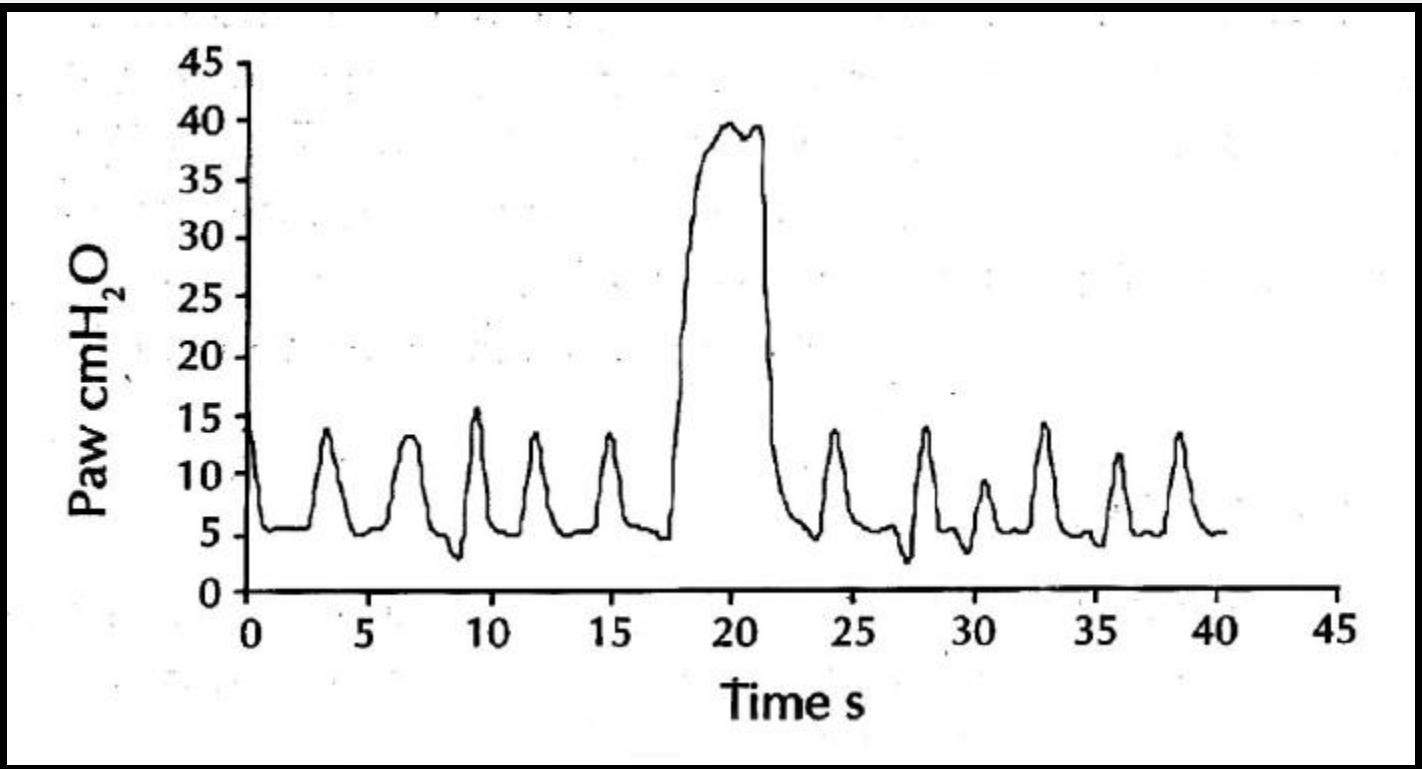
spontaneous breathing **controlled ventilation, NMBA**





Sigh Improves Gas Exchange and Lung Volume in Patients with Acute Respiratory Distress Syndrome Undergoing Pressure Support Ventilation

Nicolò Patroniti, M.D., Giuseppe Foti, M.D.,† Barbara Cortinovis, M.D.,‡ Elena Maggioni, M.D.,‡ Luca M. Bigatello, M.D.,§ Maurizio Cereda, M.D.,* Antonio Pesenti, M.D.||*



Set: BIPAP+PSV, Pmax = 35-40$_{cmH2O}$

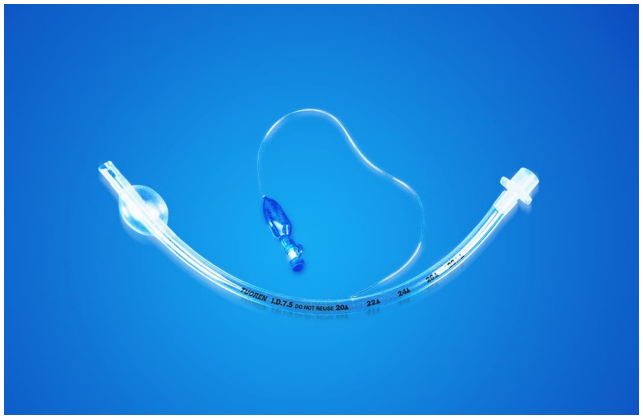
Ti = 3-5 s.

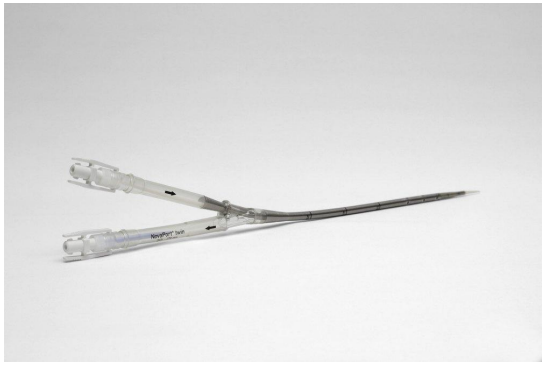
RR_{BIPAP} = 0.5-1 b.p.m.

Anesthesiology, V 96, No 4, Apr 2002

…e da cosa nasce cosa…..

VENTILAZIONE DIVERSAMENTE INVASIVA

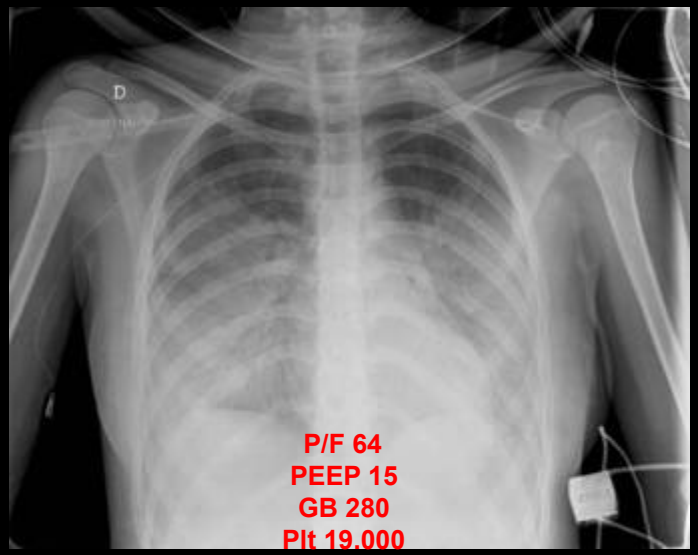




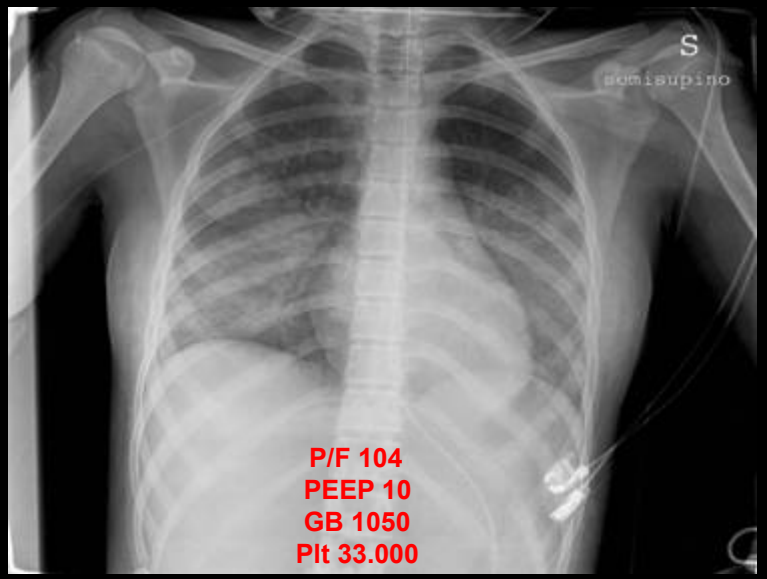
To avoid intubation

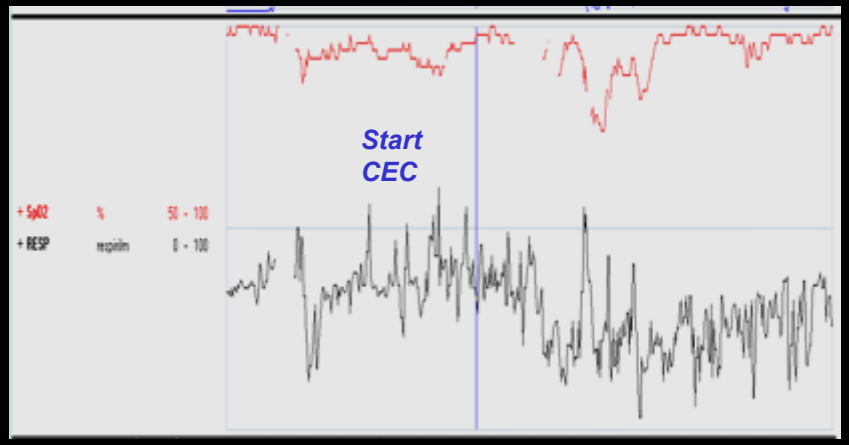
- *Bridge to lung transplantation*

IMMUNOCOMPROMESSI



1 Week
CEC





ICU Day	2	7	9	9
			Decapsmart® **BF 0.35L/min** **GF 10 L/min**	**$ECCO_2r$** **BF 1L/min** **GF 3l/min O_2**
FiO2	60%	70%	100%	90%
PEEP	10	10	10	10
Resp Rate	40	34-38	37	20
pO2	140	61	114	80
pCO2	44	41	48	41
pH	7,46	7,45	7,416	7,47
HR	90	110	64	80
PAs	130	110	130	135
WBC	120/mm^3	640/mm^3	830/mm^3	

Dynamics of re-expansion of atelectasis during general anesthesia

Rothen HU,Neuman p, Berglund J, Valtaysson J,Magnusson a and Hedenstierna G.
British J of Anesthesia (1999):82, 4, 551-6

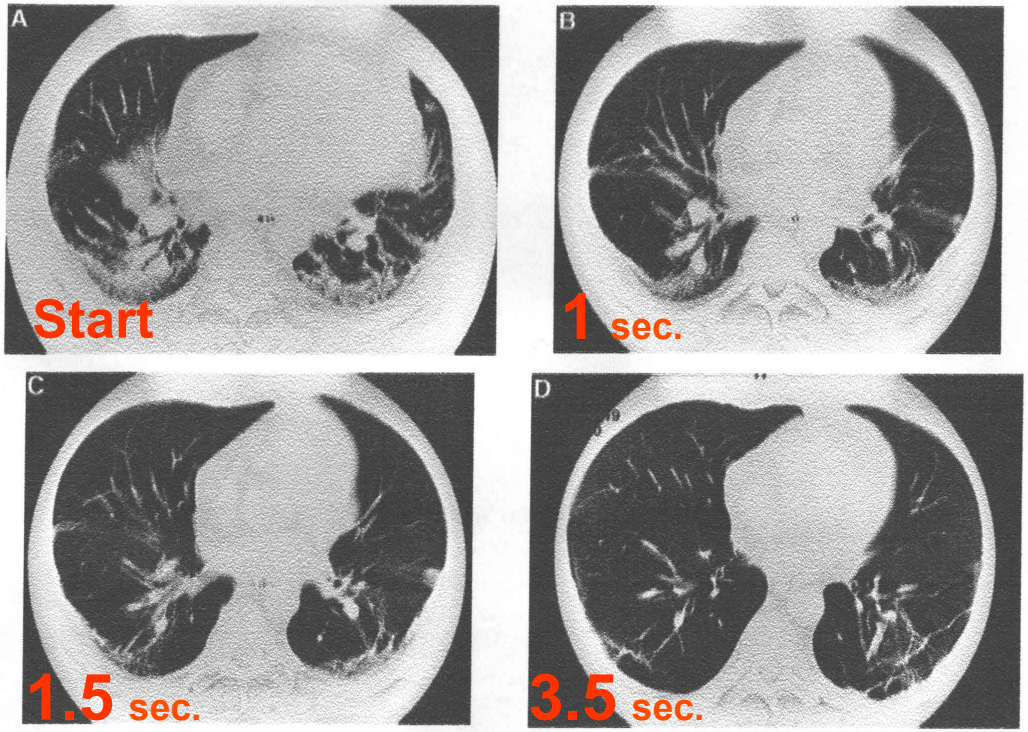


Fig 2 CT scan during the VC manoeuvre. A=At start of VC manoeuvre; B=1 s after the start of the VC manoeuvre; C=1.5 s after the start of the VC manoeuvre; and D=3.5 s after the start of the VC manoeuvre.

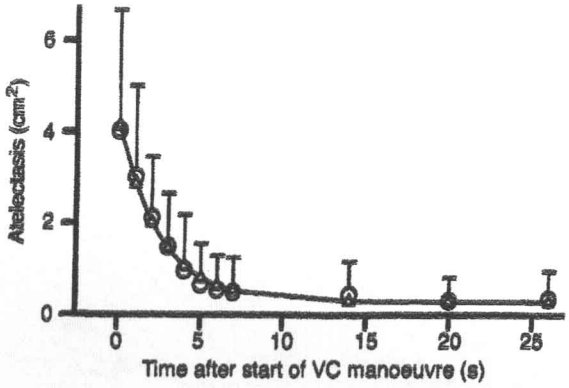


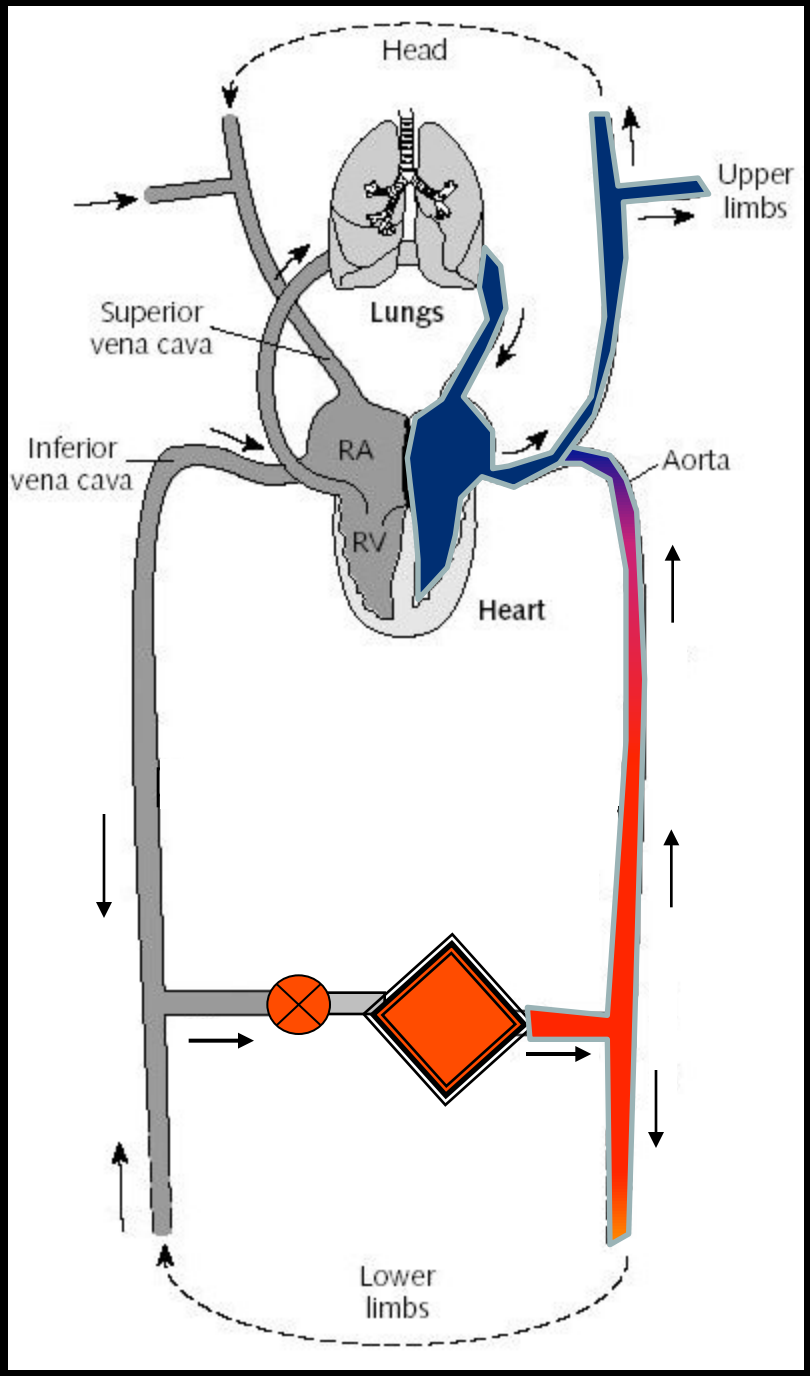
Fig 1 Atelectasis before and during the VC manoeuvre. Mean values (○) and SD (error bars) are shown. Also shown is a curve with negative exponential decay, fitted to individual data (△), connected by a line. For further details, see text.

V-A ECMO

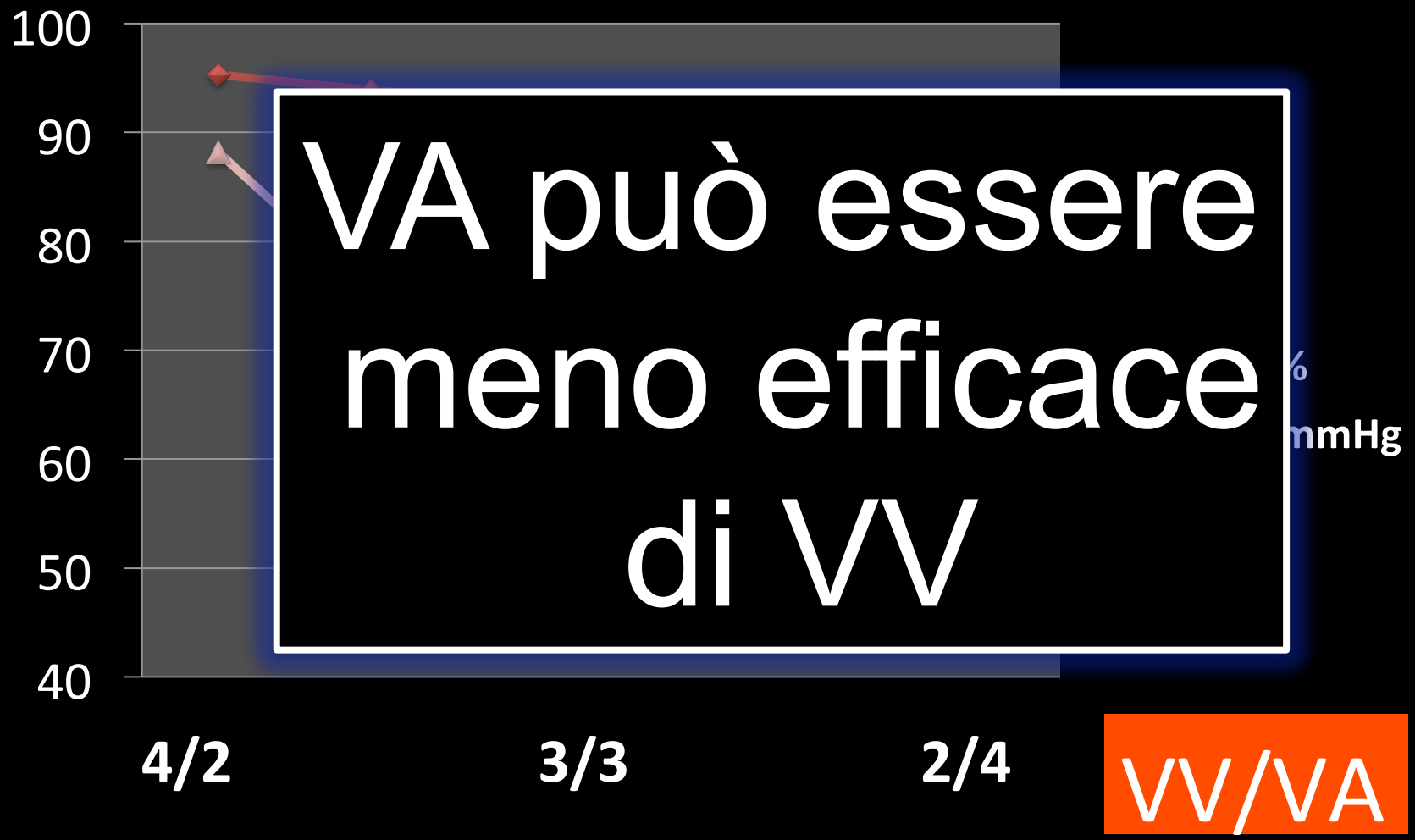
Rimozione di CO_2

Ossigenazione

Assist. Cardiaca



Tipo ECMO e PaO2



VA può essere meno efficace di VV

By pass e Ventilazione

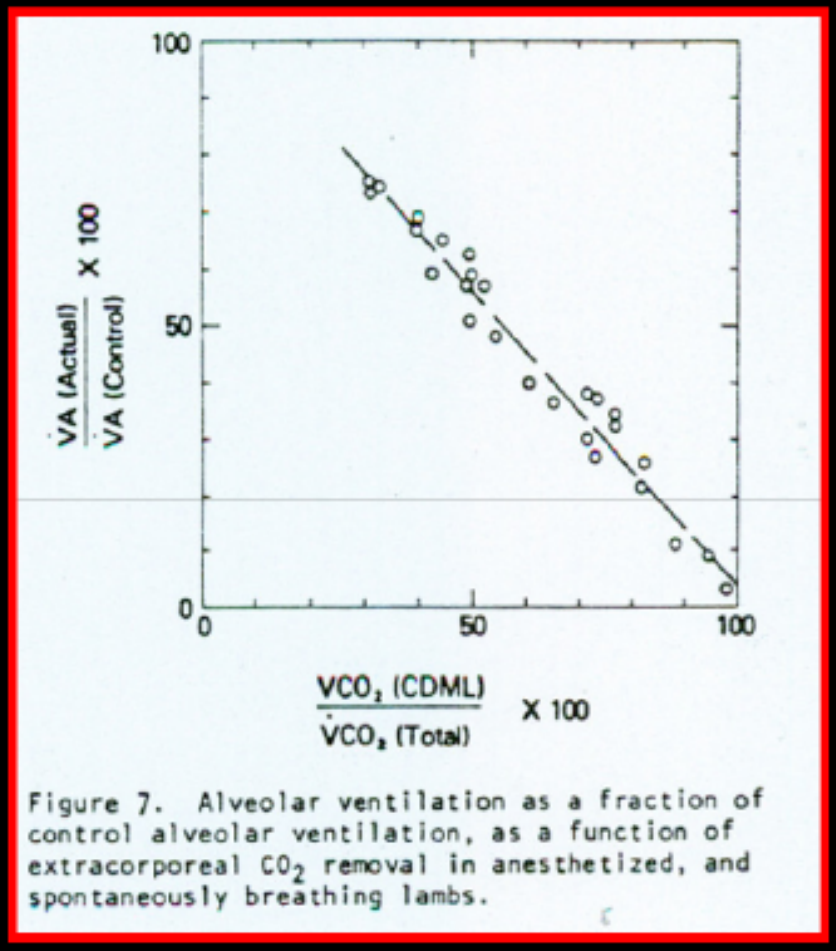


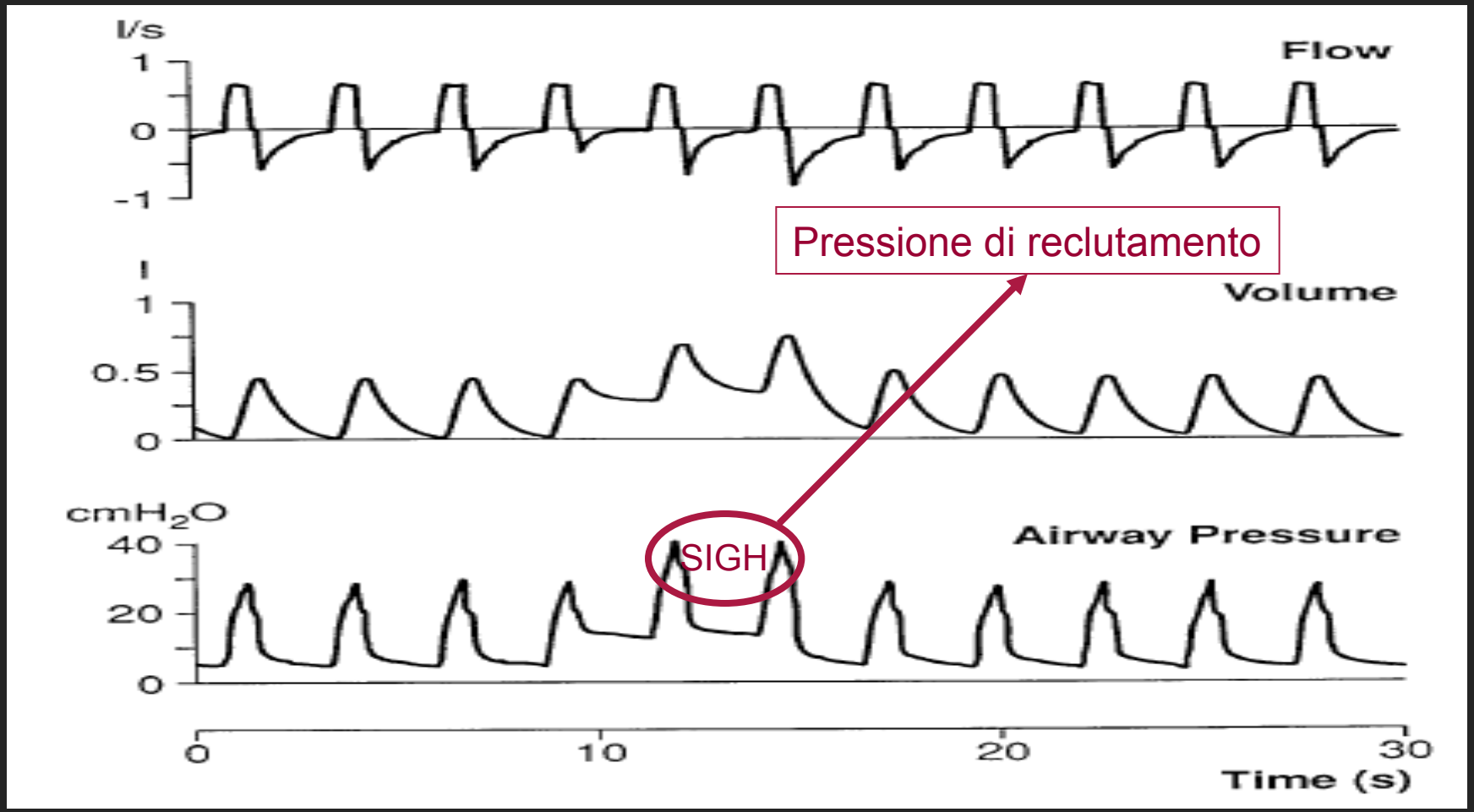
Figure 7. Alveolar ventilation as a fraction of control alveolar ventilation, as a function of extracorporeal CO_2 removal in anesthetized, and spontaneously breathing lambs.

Kolobow et al Trans. Am. Soc. Artif. Intern. Organs. 1977. 23: 17-21

Effects of periodic lung recruitment maneuvers on gas exchange and respiratory mechanics in mechanically ventilated ARDS patients.

G. Foti, M.Cereda, M.E. Sparacino, L. De Marchi,F. Villa, A. Pesenti

Intensive Care Med (2000) 26: 501-507



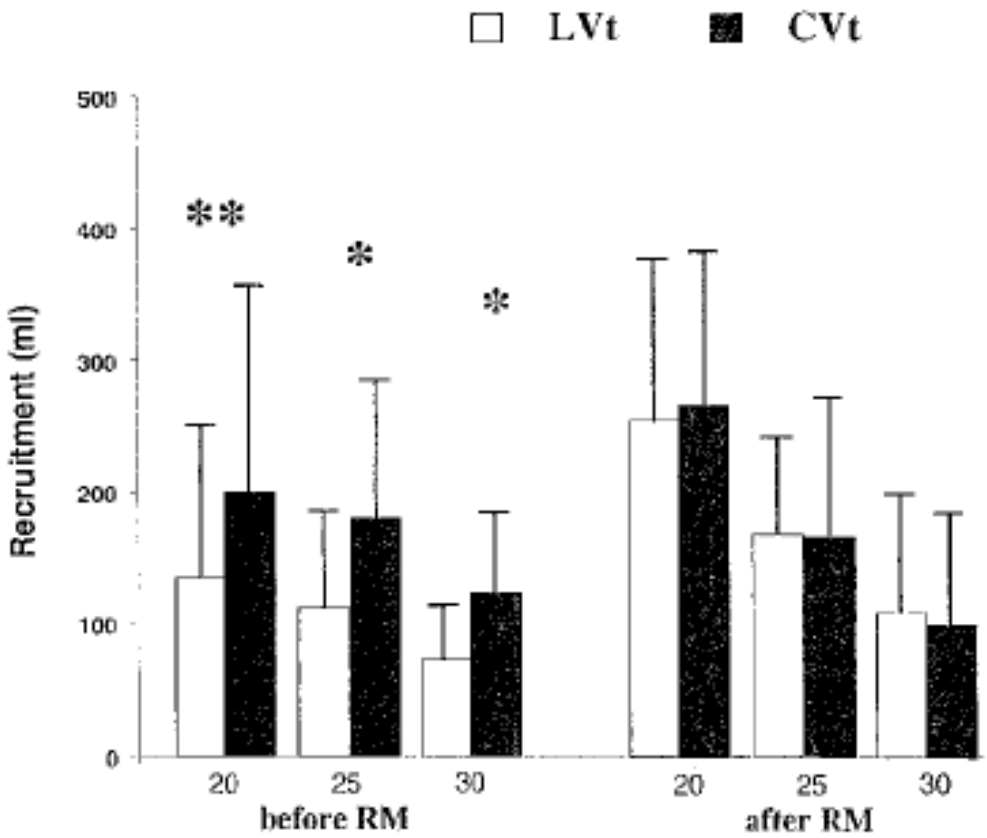
↑Oxygenation
↓ Qva/Qt

Influence of Tidal Volume on Alveolar Recruitment

Respective Role of PEEP and a Recruitment Maneuver

JEAN-CHRISTOPHE RICHARD, SALVATORE M. MAGGIORE, BJORN JONSON, JORDI MANCEBO, FRANCOIS LEMAIRE, and LAURENT BROCHARD

Medical Intensive Care Unit and INSERM U 492, Henri Mondor Hospital, University Paris XII, Créteil, France

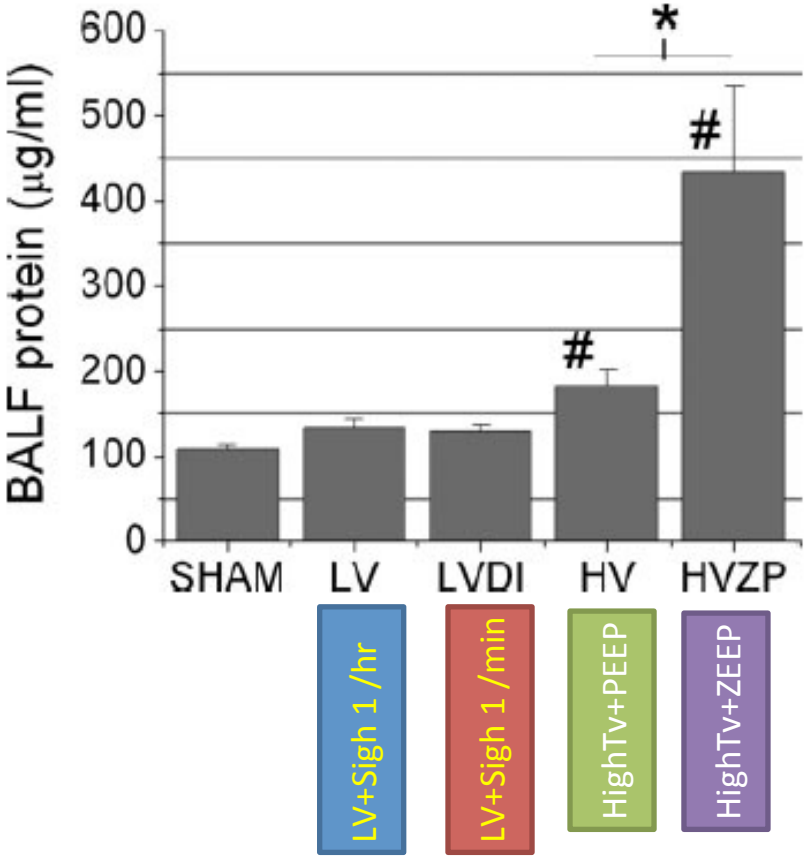


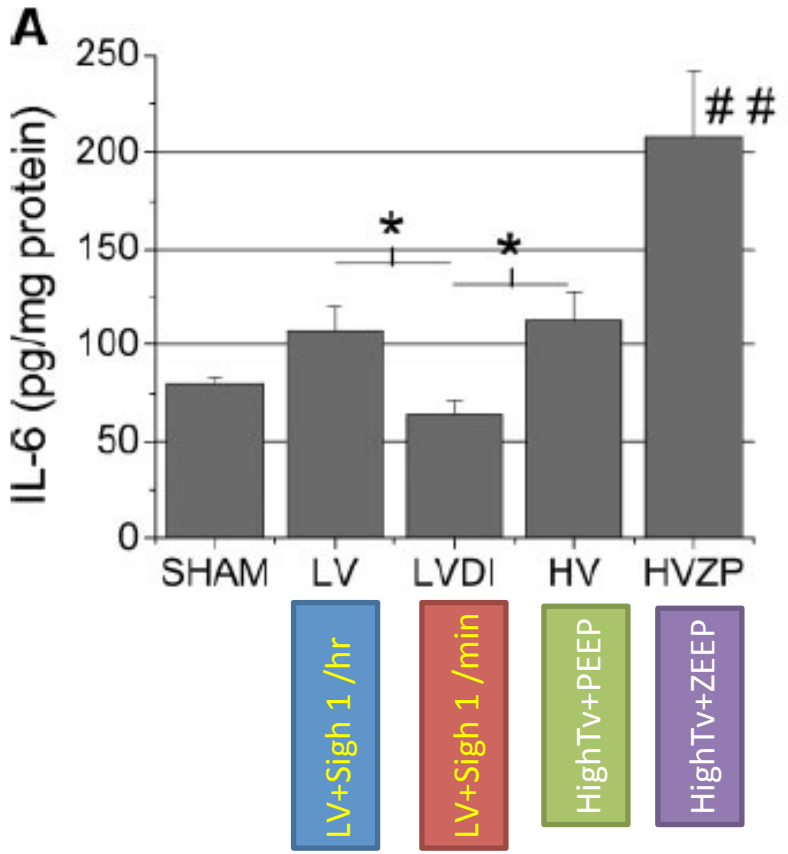
Am J Respir Crit Care Med Vol 163. pp 1609–1613, 2001
Internet address: www.atsjournals.org

Am J Physiol Lung Cell Mol Physiol 291: L710–L717, 2006.
First published May 12, 2006; doi:10.1152/ajplung.00532.2005.

Choosing the frequency of deep inflation in mice: balancing recruitment against ventilator-induced lung injury

Gilman B. Allen,[1,2] Benjamin T. Suratt,[1,2] Lisa Rinaldi,[1] Joseph M. Petty,[1] and Jason H. T. Bates[1,2]
[1]*Vermont Lung Center, Department of Medicine, University of Vermont, and* [2]*Fletcher Allen Health Care, Burlington, Vermont*





Intensive Care Med (2000) 26: 501–507

ORIGINAL

G. Foti
M. Cereda
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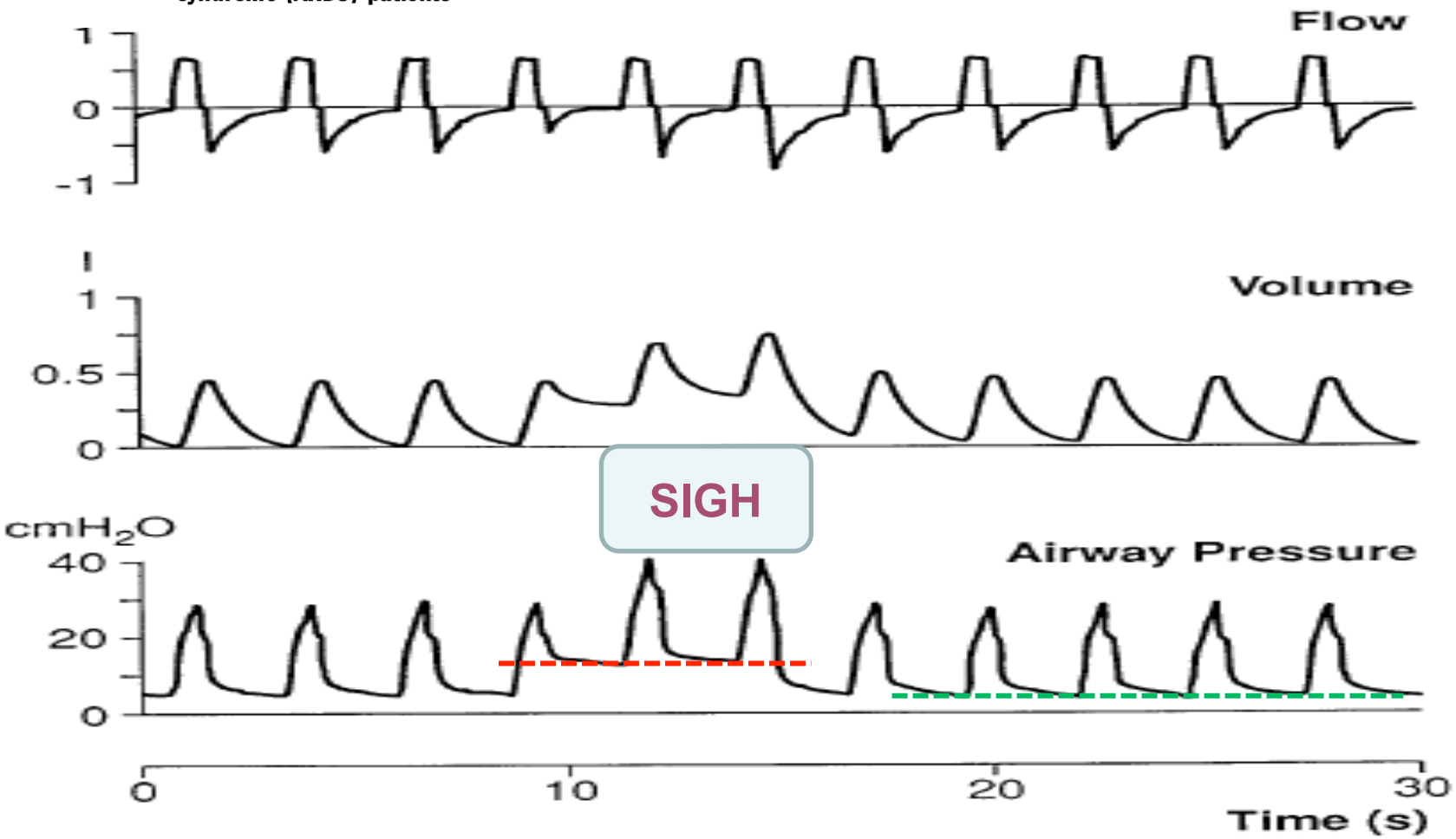
L. De Marchi
F. Villa
A. Pesenti

Effects of periodic lung recruitment maneuvers on gas exchange and respiratory mechanics in mechanically ventilated acute respiratory distress syndrome (ARDS) patients



----- Low PEEP

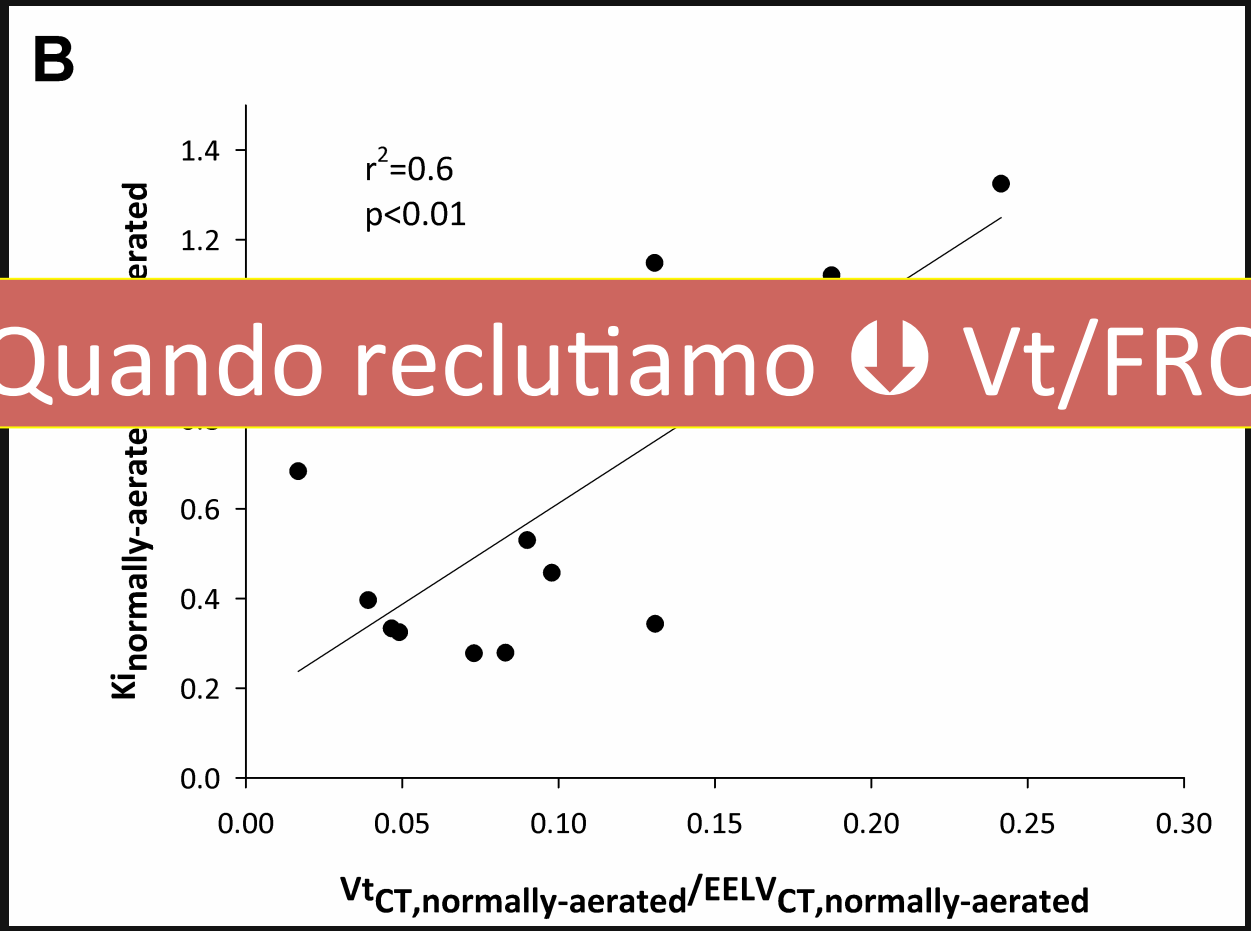
----- High PEEP

…….ma adesso che sono in bypass,
il ventilatore
serve ancora ?

VENTILAZIONE

OSSIGENAZIONE

Paradigm shift: Vt/IBW vs. Vt/FRC



Quando reclutiamo ⇩ Vt/FRC

13 ARDS pts, PET, no correlation with Vt/IBW

Bellani, Am J Respir Crit Care Med 2011