

ECMO for Respiratory Support

UPDATE on

Extracorporeal CO₂ removal : When and how

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Conflict of Interests

- Received travel support
 - Maquet, Drager
- Received research support
 - Maquet, Drager, Bellco
- Consulting for
 - Maquet, Novalung, Gambro, Bellco

Adult respiratory distress syndrome (ARDS): Why did ECMO fail?

T. Kolobow^o, M. Solca^o, L. Gattinoni^{oo}, A. Pesenti^o

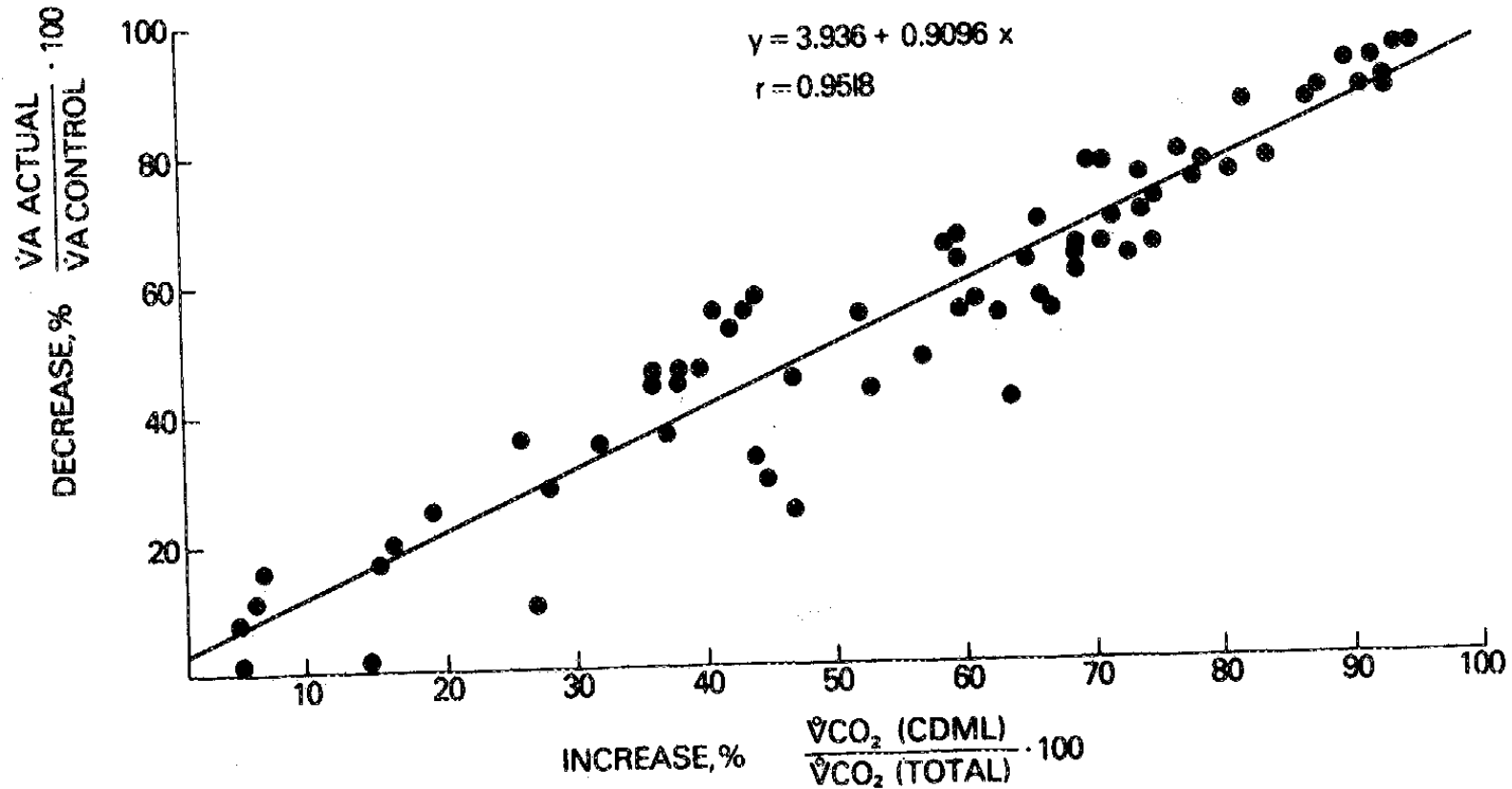
The International Journal Of Artificial Organs / Vol. 4 no. 2, 1981 / p. 59

© by Wichtig Editore srl, 1981

Laboratory Report

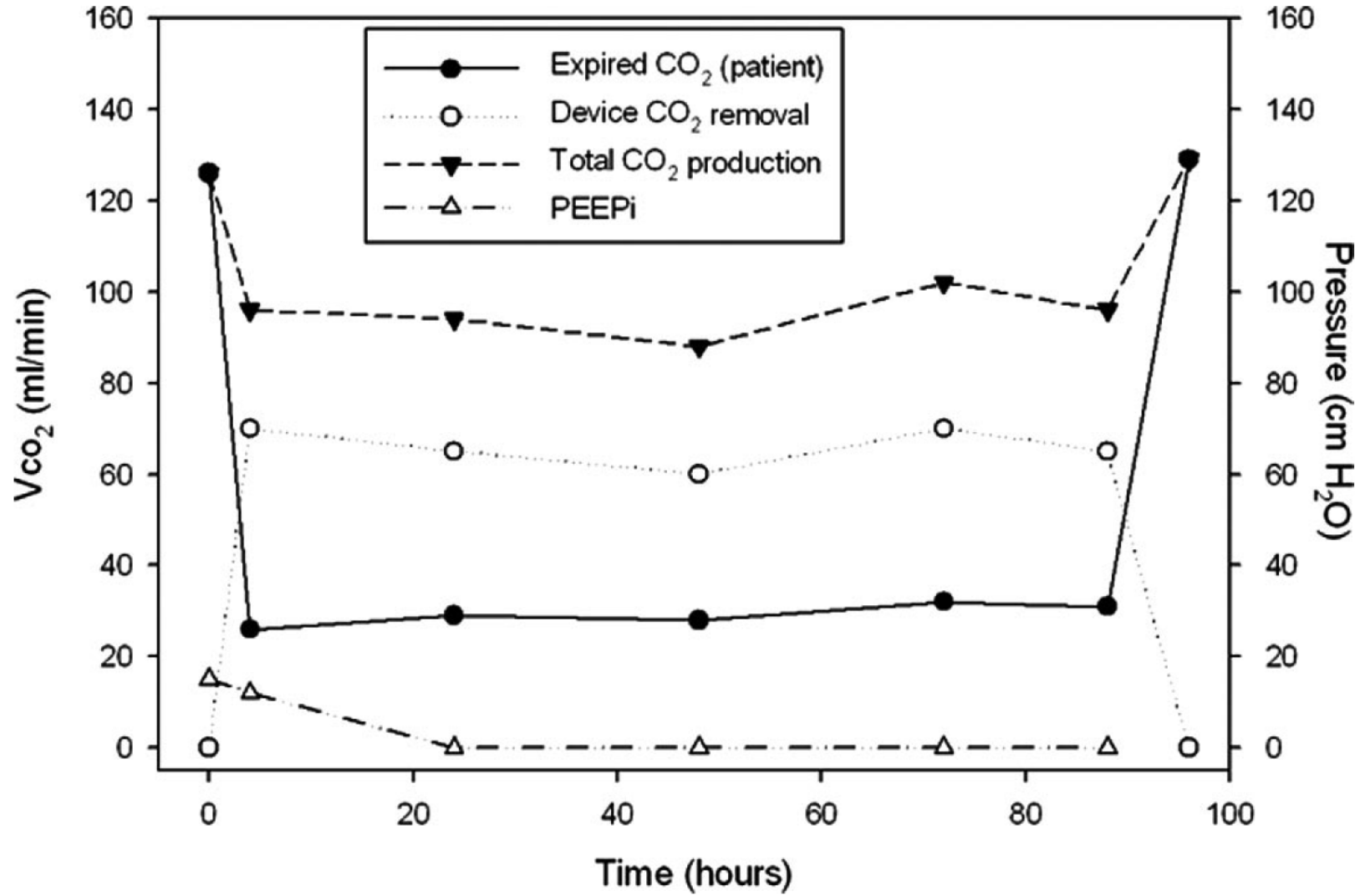
Control of Breathing Using an Extracorporeal Membrane Lung

Theodor Kolobow, M.D.,* Luciano Gattinoni, M.D.,* Timothy A. Tomlinson, B.S.,* Joseph E. Pierce, D.V.M.†



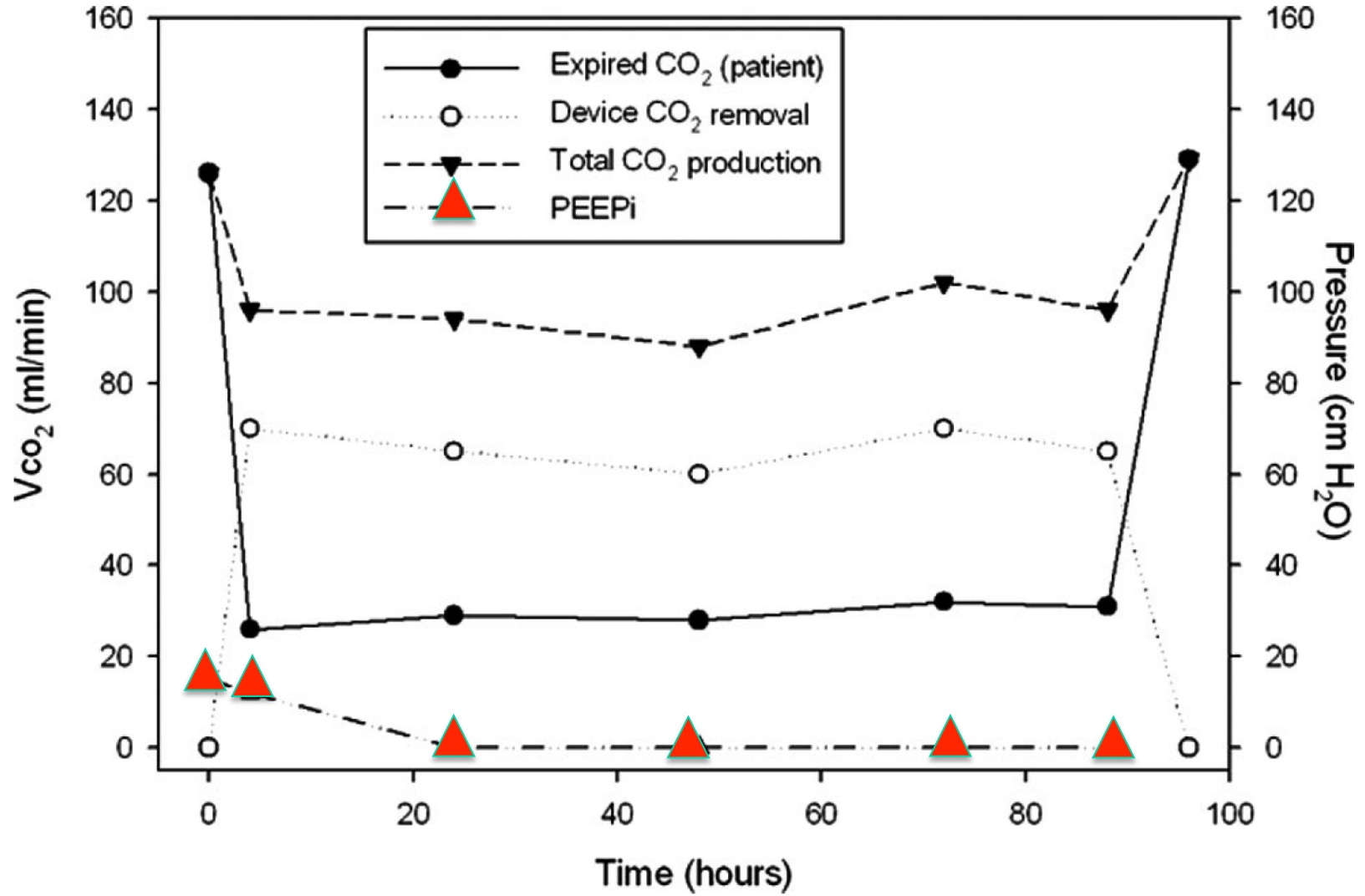
Venovenous Carbon Dioxide Removal in Chronic Obstructive Pulmonary Disease

Cardenas et al ASAIO J 2009



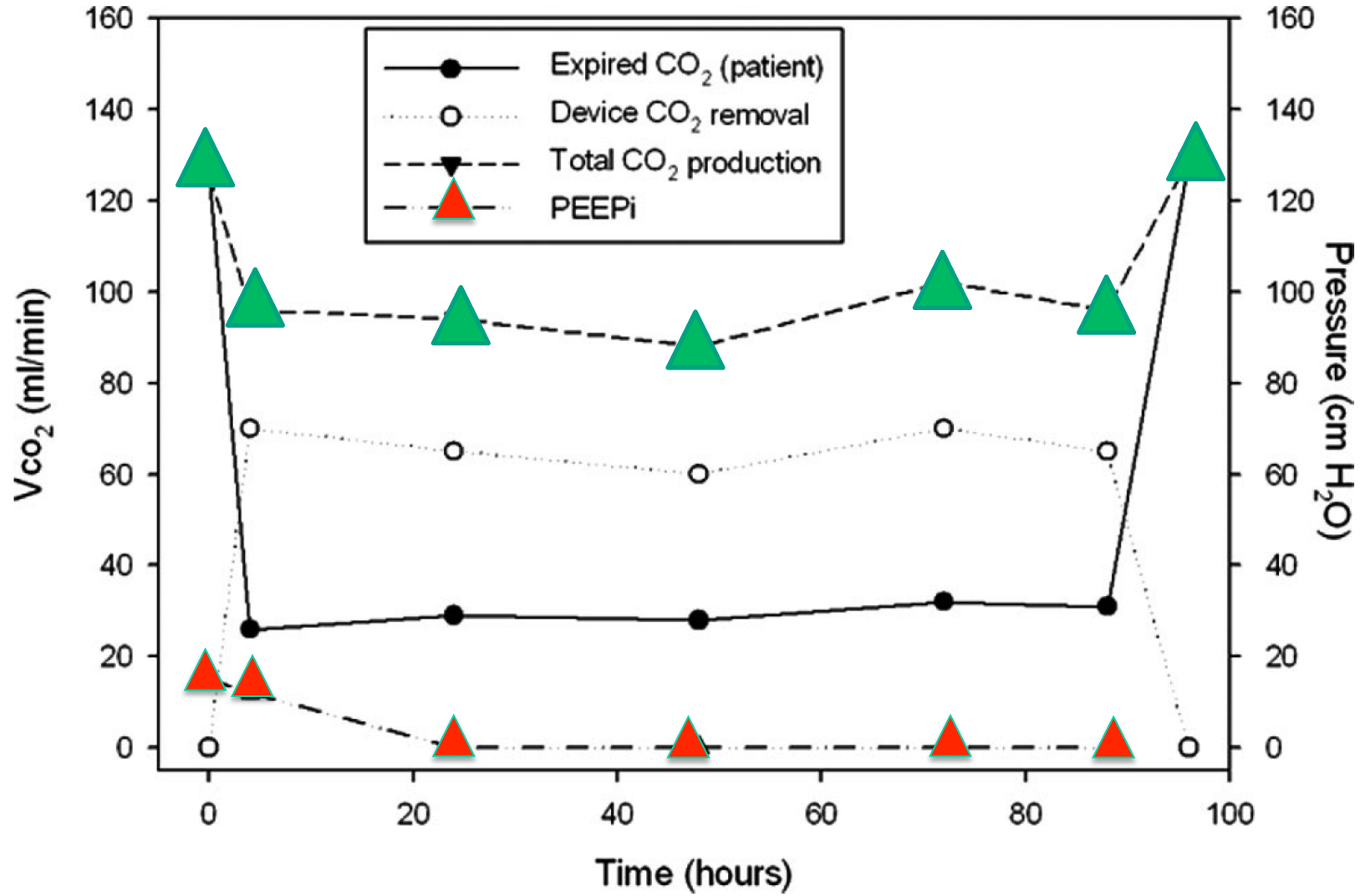
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Extracorporeal CO₂ Removal Physiological Side Effects

- Decreased P_A O₂: (Due to decreased QR)
- Decreased TV - Decrecruitment
 - Higher PEEP Maintain Paw
- Ineffective Coughing (?)
- Control of breathing ?

ECCO2R in ARDS

Rationale

- ARDS is not Just Hypoxemia: Co2 elimination is a problem
- ARDS High PAP and RVF (dysfunction)
- Severe respiratory alkalosis of Dead Space regions
- **Barotrauma Ventilator Induced Lung Injury**
- VAP
- Sedation

The technique seems to prevent the pulmonary barotrauma and extrapulmonary derangements caused by conventional mechanical ventilation

**Istituto di Anestesiologia e Rianimazione, †Istituto di Clinica Medica VII, and ‡Istituto di Clinica Chirurgica III, Università di Milano; and §National Institutes of Health, Bethesda, Maryland, U.S.A.*

Summary Terminal respiratory failure was reversed in three patients with a combination of extracorporeal CO₂ removal through a membrane lung and oxygen diffusion into the diseased lungs between mechanical breaths induced at a frequency of 2–3/min. The technique seems to prevent the pulmonary barotrauma and extrapulmonary derangements caused by conventional mechanical ventilation.

ARDS Status

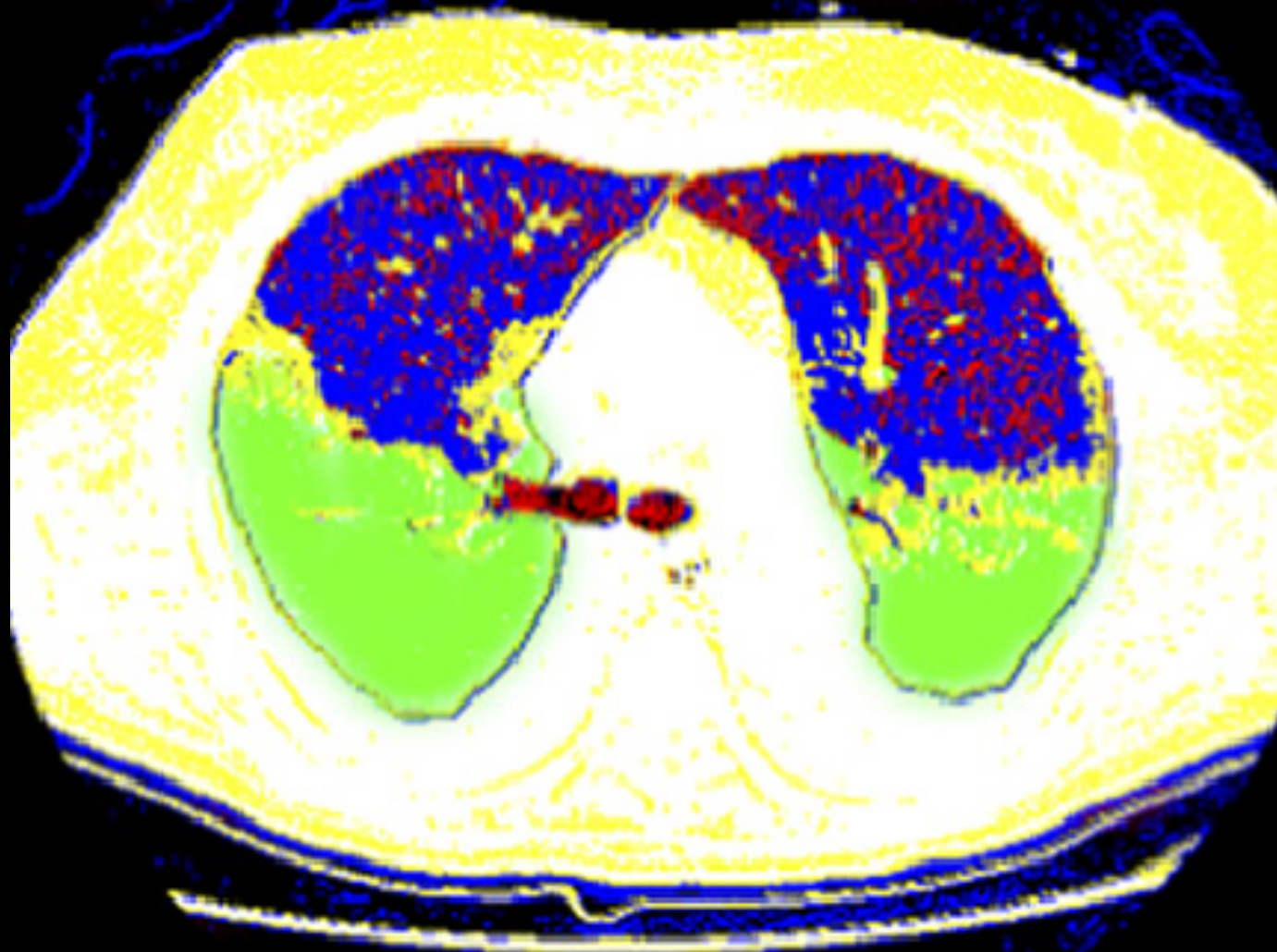
- ECCO2R to :
 - go from 6 to 3ml/kg and lower

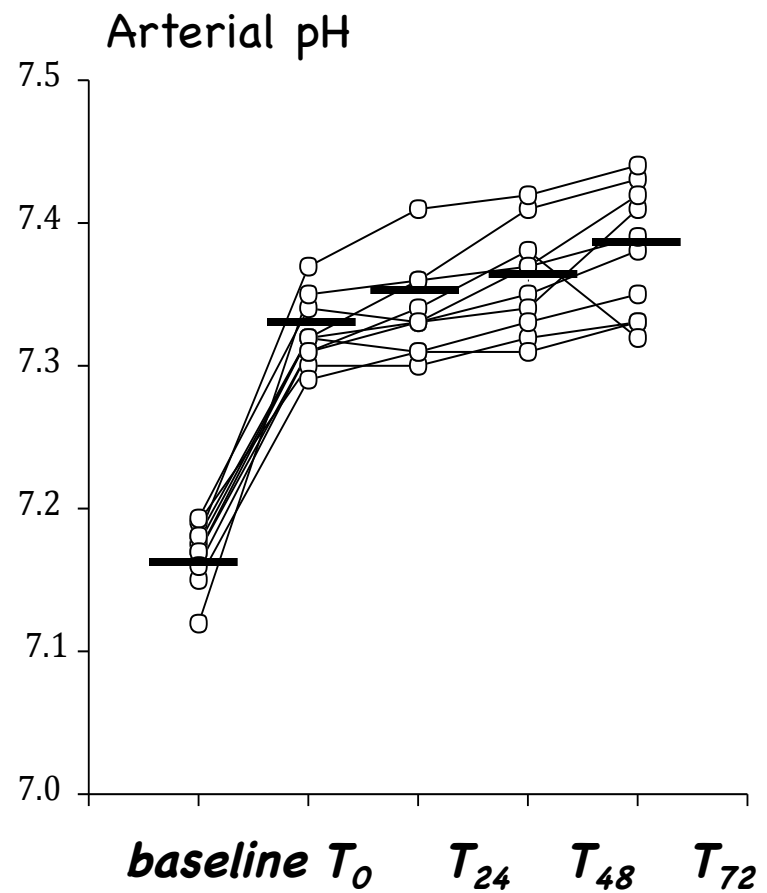
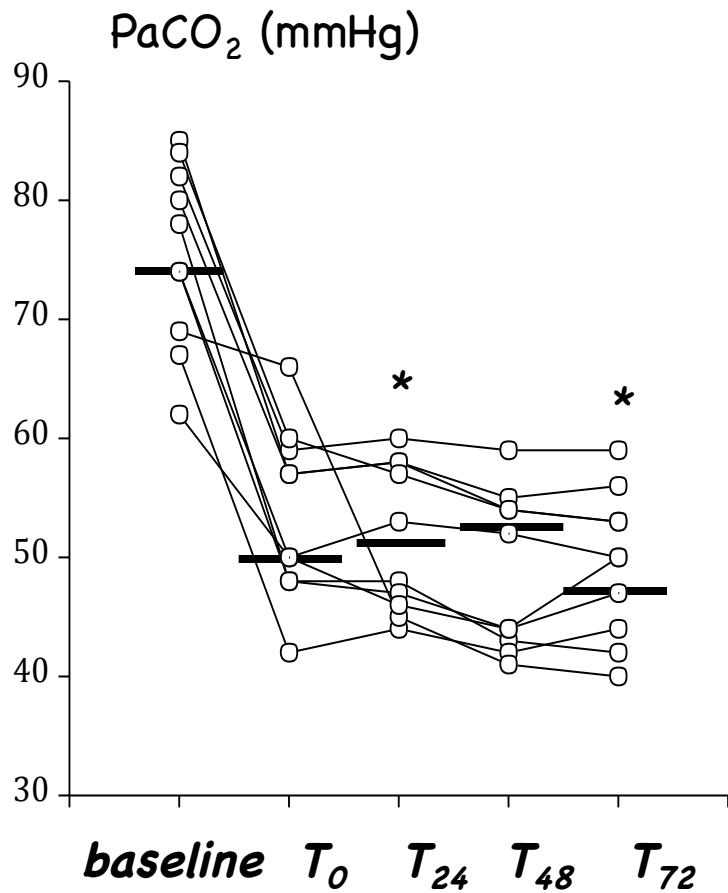
SUPERNOVA STUDY

Sponsored by ESICM

PIs : A.Combes VM Ranieri

End Inspiratory





T. Bein et al : Intensive Care Med 2013

**Lower tidal volume strategy (≈ 3 ml/kg)
combined with extracorporeal CO₂ removal
versus ‘conventional’ protective ventilation
(6 ml/kg) in severe ARDS**

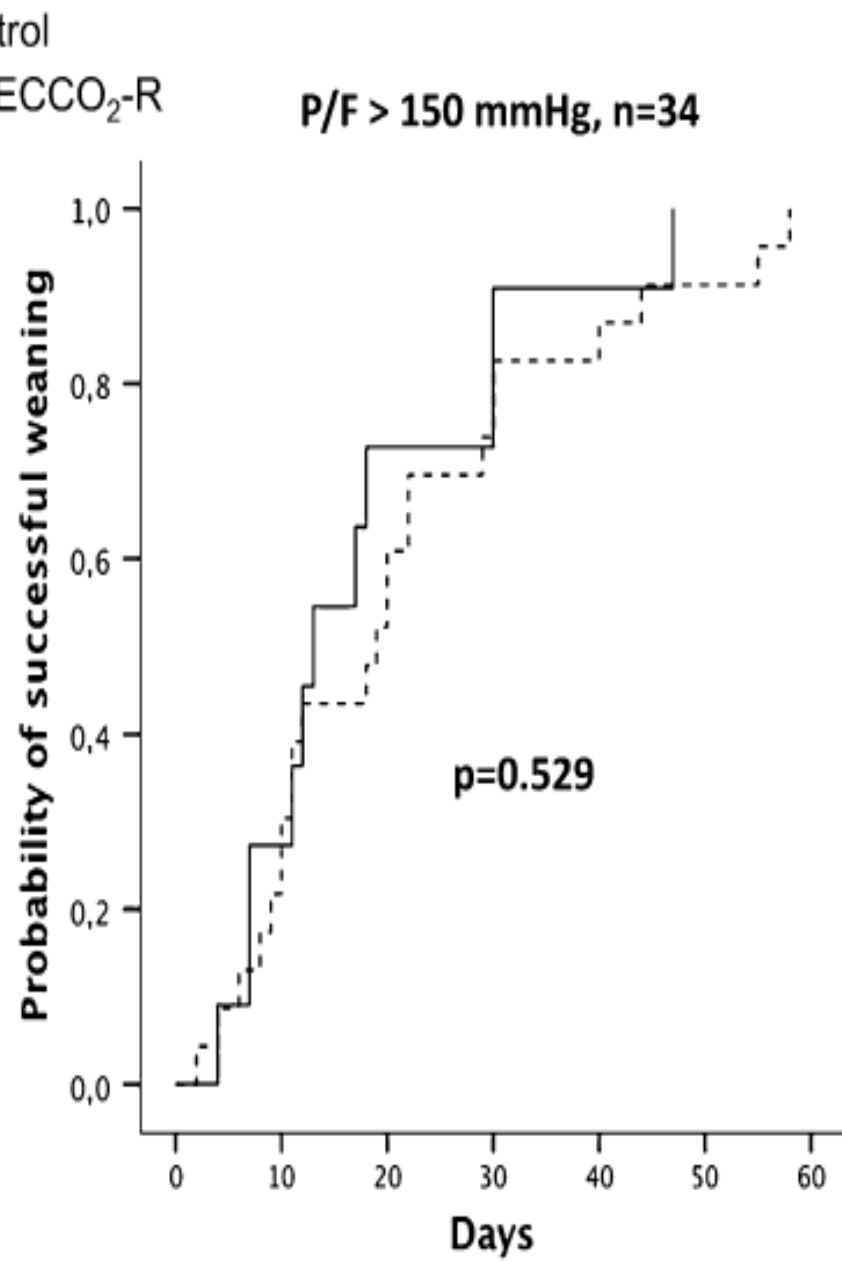
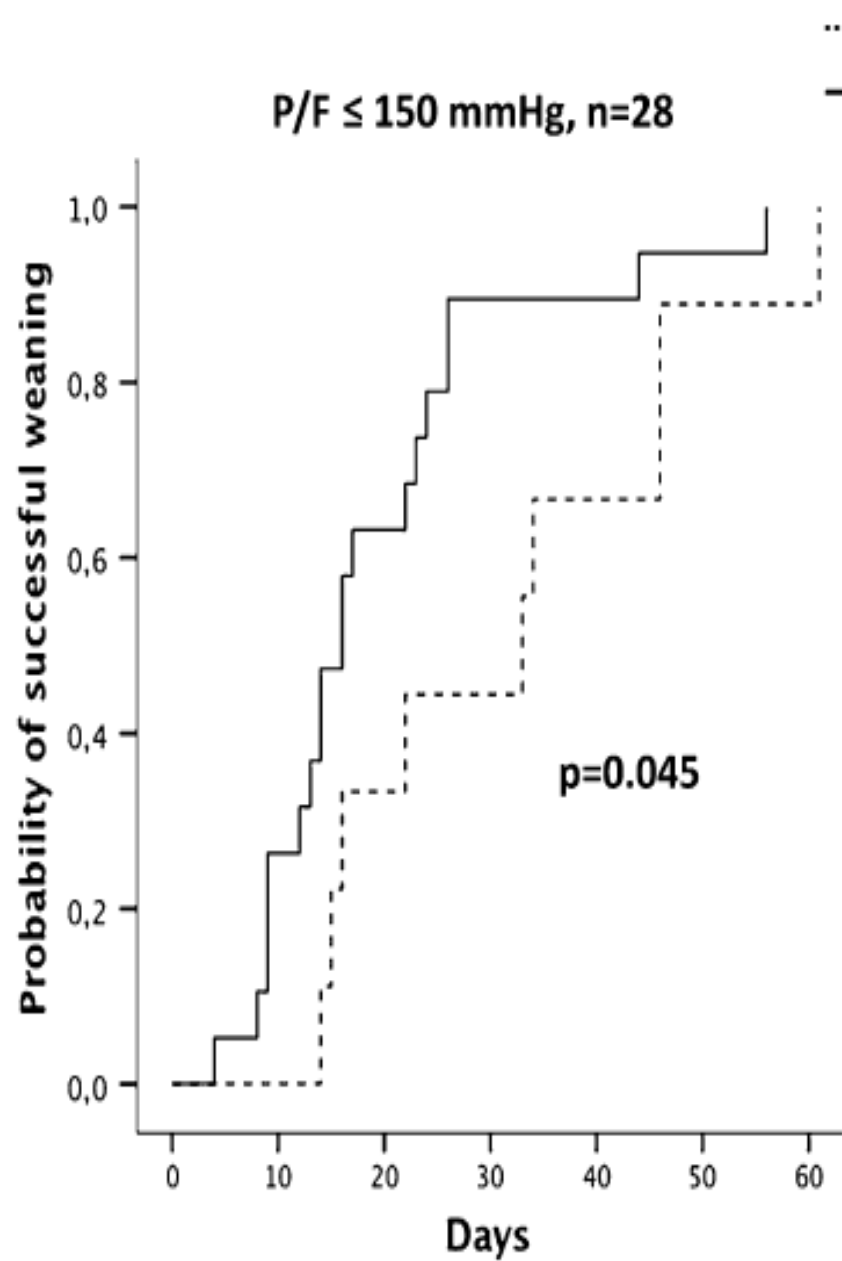
The prospective randomized Xtravent-study



Stabilization over 24 hrs:

- V_T 6 ml/kg/IBW
- ARDSNet „high-PEEP“
- CVP 10 – 16 mmHg
- MAP \geq 70 mmHg
- echocardiography

Screening \rightarrow 305 patients:
acute respiratory failure
 $PaO_2/FIO_2 \leq 200$



Early ARDS

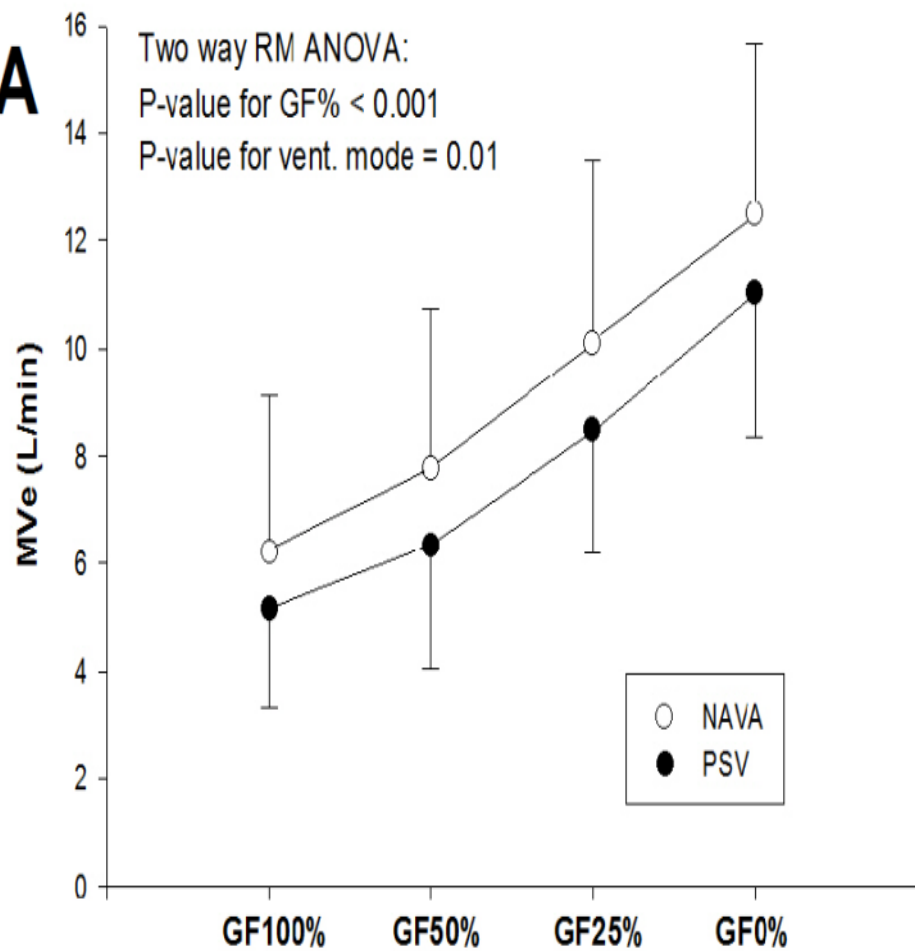
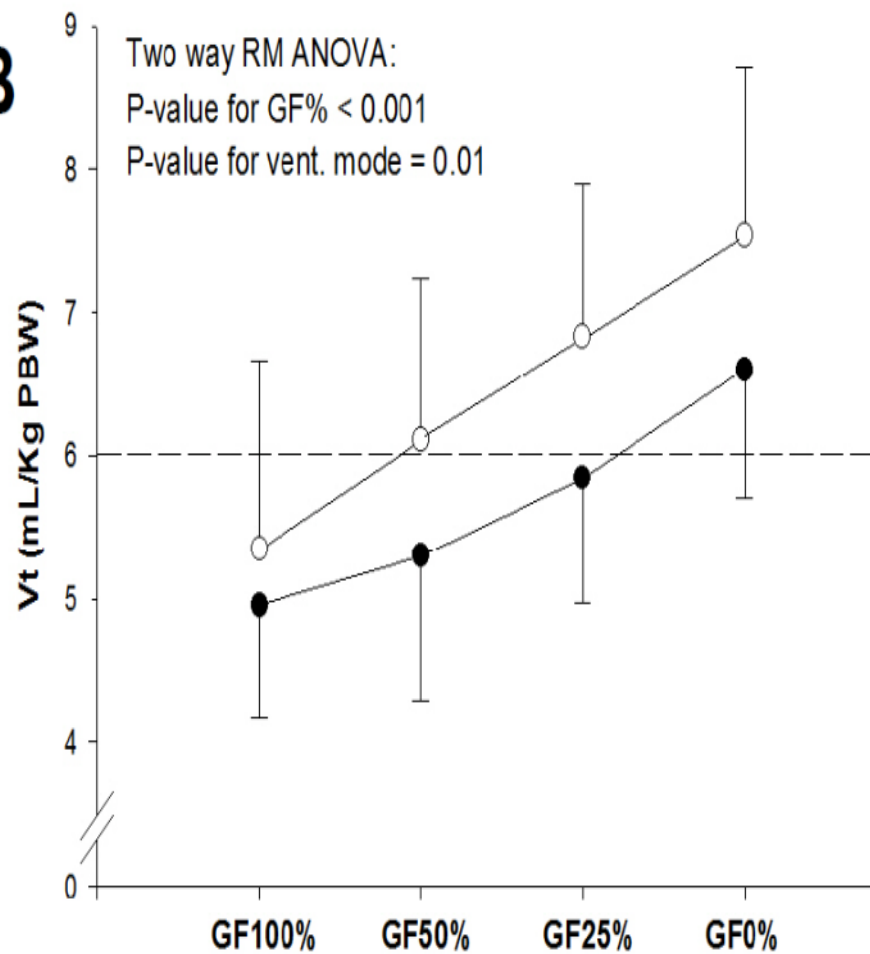
- ECCO2R to :
 - prevent intubation
 - extend NIV application

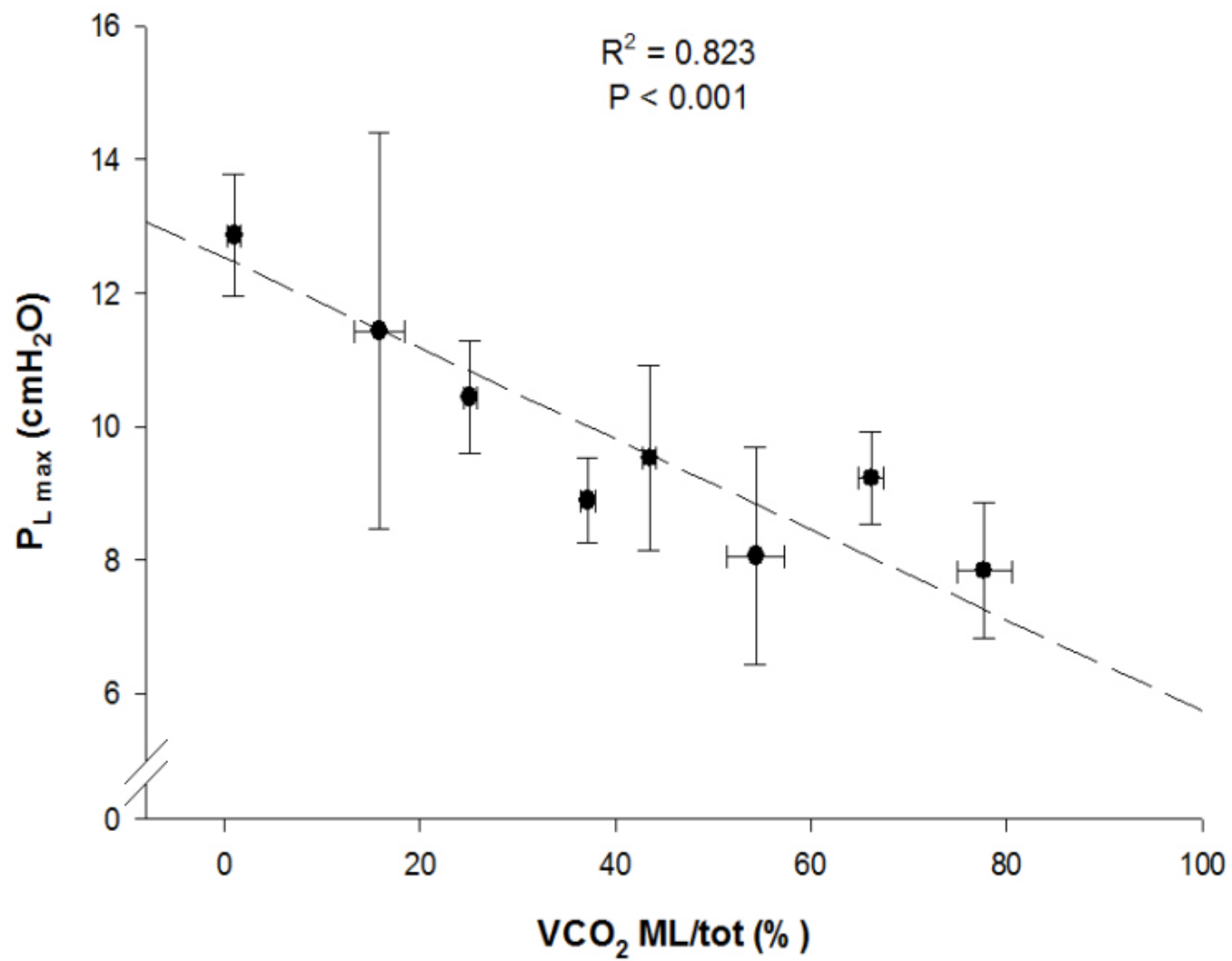


ARDS Recovering

- ECCO2R to allow :
 - early spontaneous breathing
 - early extubation
 - early NIV or CPAP



A**B**



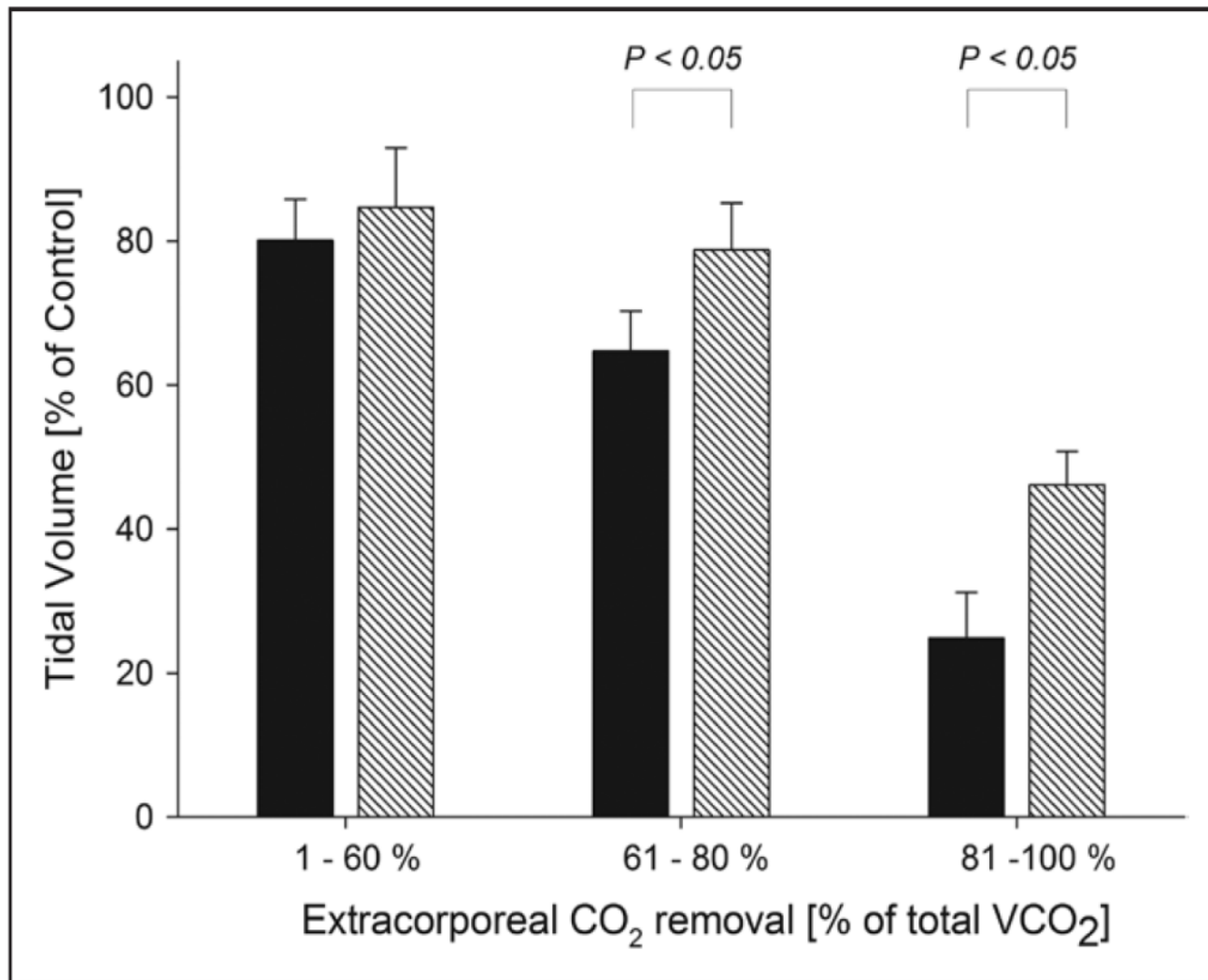


Figure 4. Variations in tidal volume (expressed as % of control measurements) caused by different amounts of extracorporeal CO₂ removal expressed as percentage of total CO₂ production. Experimental points were grouped in three categories of extracorporeal CO₂ removal: 1–60%, 61–80%, and 81–100%. *Black bars* represent healthy sheep, while *hatched bars* represent sheep with acute respiratory distress

Avoiding invasive mechanical ventilation by extracorporeal carbon dioxide removal in patients failing noninvasive ventilation

Kluge S Intensive Care Med (2012) 38:1632

In this study the use of extracorporeal carbon dioxide removal allowed avoiding intubation and invasive mechanical ventilation in the majority of patients with acute on chronic respiratory failure not responding to NIV

ORIGINAL RESEARCH

Pilot Study of Extracorporeal Carbon Dioxide Removal to Facilitate Extubation and Ambulation in Exacerbations of Chronic Obstructive Pulmonary Disease

Darryl C. Abrams¹, Keith Brenner¹, Kristin M. Burkart¹, Cara L. Agerstrand¹, Byron M. Thomashow¹, Matthew Bacchetta^{2*}, and Daniel Brodie^{1*}

¹Division of Pulmonary, Allergy, and Critical Care, Department of Medicine; and ²Division of Thoracic Surgery, Department of Surgery, Columbia University College of Physicians and Surgeons/New York-Presbyterian Hospital, New York, New York

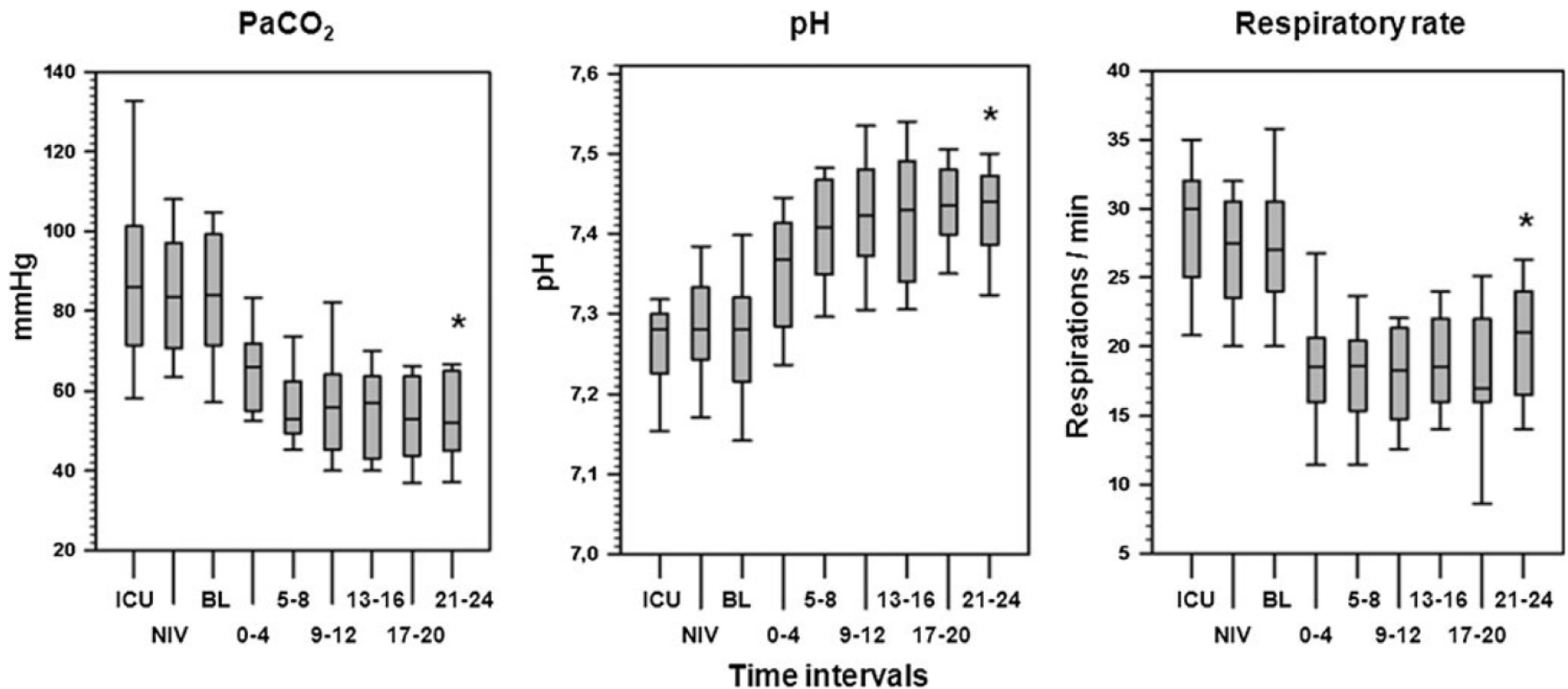
Ecco2R in COPD exacerbation

Abrams DC Annals ATS 2013

- 5 COPD pts on MV (failed NIV)
- pH 7.23 ± 0.05 ; PaCO₂ 82 ± 16 mmHg
- P/F 256 ± 58 mmHg

- Blood flow 1- 1.7 l/min
- 20-23 F double lumen cannula

Kluge S Intensive Care Med (2012) 38:1632

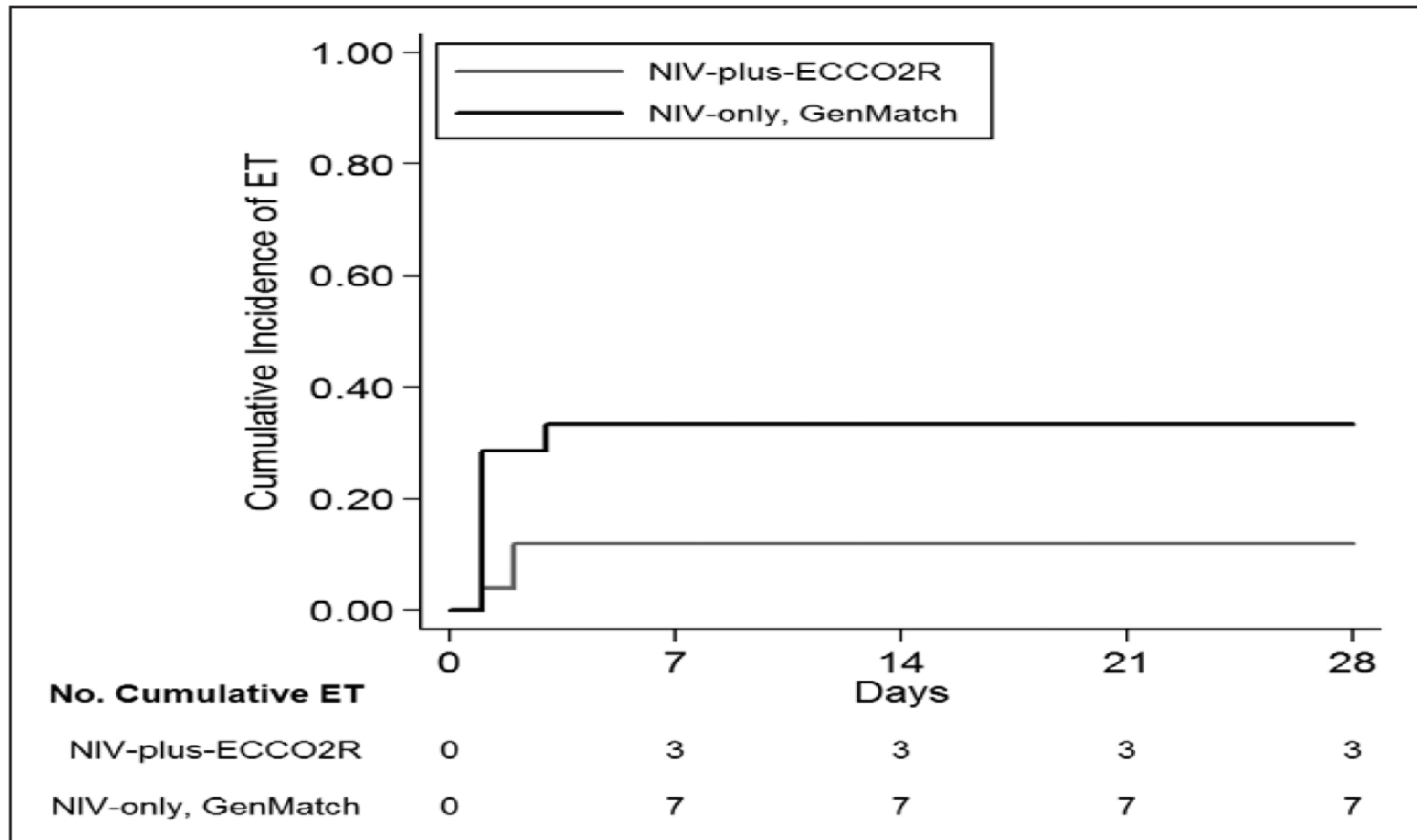


(on ICU admission (ICU), during NIV (NIV), baseline pre PECLA (BL), 0-24 hours after start of PECLA)

Fig. 2 Sequential changes in arterial partial pressure of carbon dioxide (PaCO₂), pH, and respiratory rate over time from ICU admission until 24 h after PECLA implantation. Boxplots display medians, 10th, 25th, 75th and 90th percentiles. **p* < 0.001 BL vs. 21–24 h

Extracorporeal Co₂ Removal in Hypercapnic Patients At Risk of Noninvasive Ventilation Failure: A Matched Cohort Study With Historical Control*

Del Sorbo Crit Care Med 2015



CO₂ removal blood flows

- High flow (> 2 l/min)
 - Contribute to oxygenation (if v-v)
 - Total CO₂ removal
- Intermediate ($0.5 < \text{flow} < 2$ l/min)
 - Minor oxygenation
 - Partial to total CO₂ removal
- Low flow (< 0.5 l/min)
 - Clinically irrelevant oxygenation
 - Partial (10 to 40%) CO₂ removal

Regional Blood Acidification Enhances Extracorporeal Carbon Dioxide Removal

A 48-hour Animal Study

Alberto Zanella, M.D., Paolo Mangili, M.D., Sara Redaelli, M.D., Vittorio Scaravilli, M.D., Marco Giani, M.D., Daniela Ferlicca, M.D., Diletta Scaccabarozzi, Federica Pirrone, D.V.M., Ph.D., Mariangela Albertini, D.V.M., Ph.D., Nicolò Patroniti, M.D., Antonio Pesenti, M.D.

Anesthesiology 2014; 120:416-24

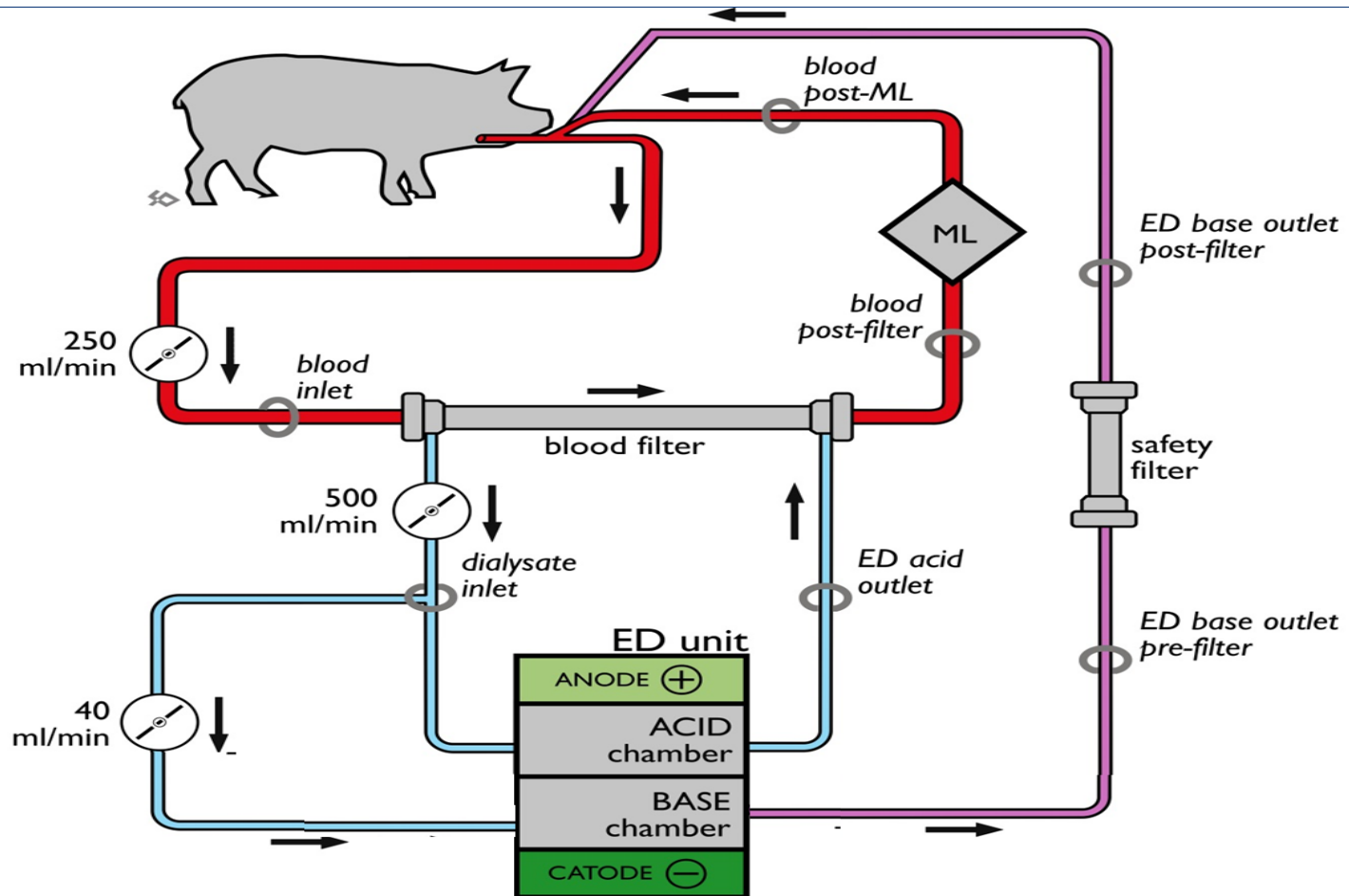
Some more interesting data.....

QA1 Respiratory Electrodesialysis

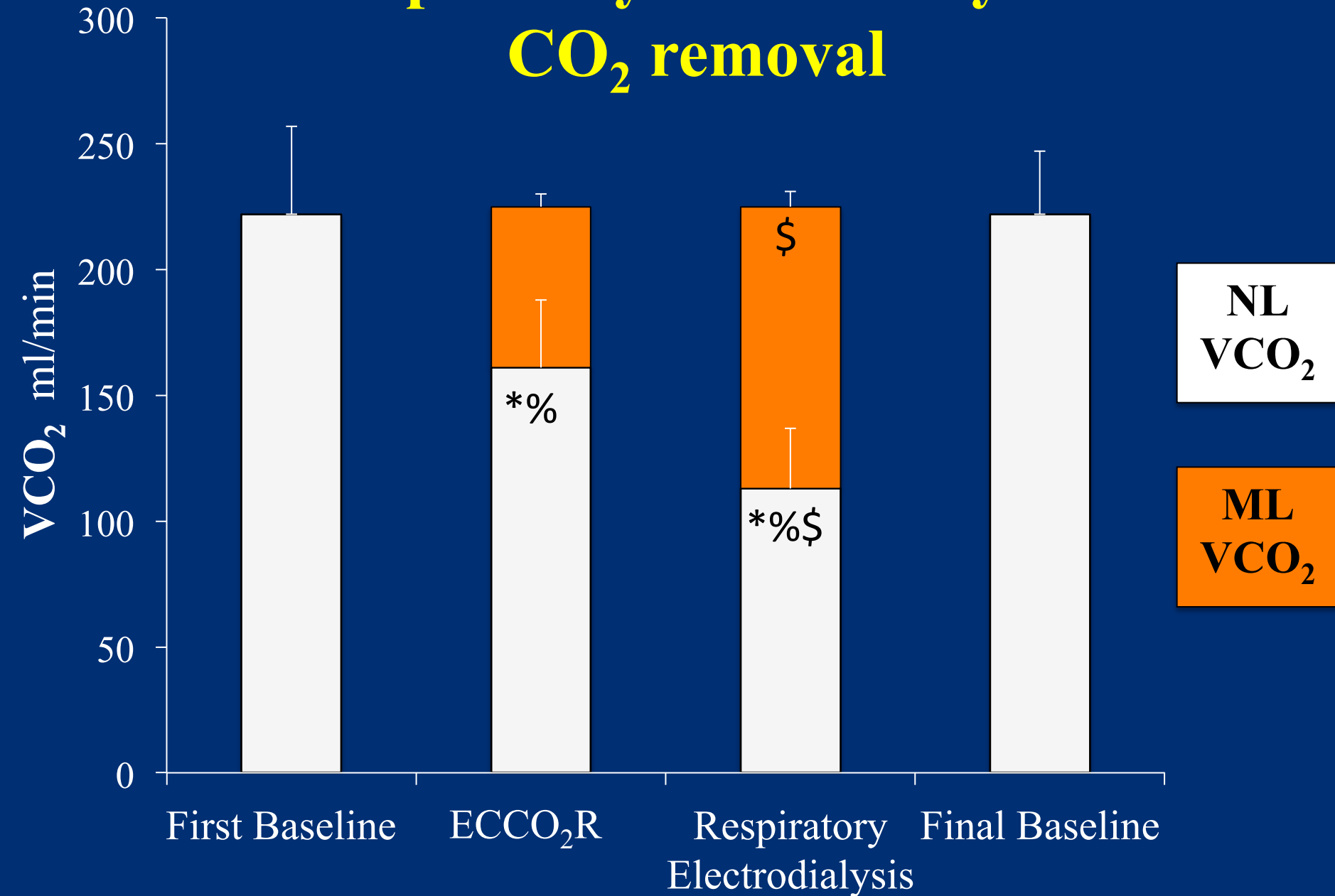
A Novel, Highly Efficient Extracorporeal CO₂ Removal Technique

Alberto Zanella¹, Luigi Castagna¹, Domenico Salerno¹, Vittorio Scaravilli¹, Salua Abd El Aziz El Sayed Deab¹, Federico Magni¹, Marco Giani¹, Silvia Mazzola², Mariangela Albertini², Nicolò Patroniti^{1,3}, Francesco Mantegazza¹, and Antonio Pesenti^{1,3}

¹Dipartimento di Scienze della Salute, Università degli Studi di Milano Bicocca, Monza, Italy; ²Dipartimento di Scienze Veterinarie e Sanità Pubblica, Università degli Studi di Milano, Italy; and ³Dipartimento di Anestesia e Rianimazione, Ospedale San Gerardo, Monza, Italy



Respiratory electro dialysis CO₂ removal



Extracorporeal CO2 Removal

- It is an experimental technique
- Many things we do not know yet
- There are more things in heaven and earth,
Horatio,
Than are dreamt of in your philosophy.

– *Hamlet Act 1, scene 5, 159–167*