KİŞİSELLEŞTİRİLMİŞ MEKANİK VENTILASYON STRATEJİLERİ

Dr. Mehtap Pehlivanlar Küçük

Karadeniz Teknik Üniversitesi Tıp Fakültesi

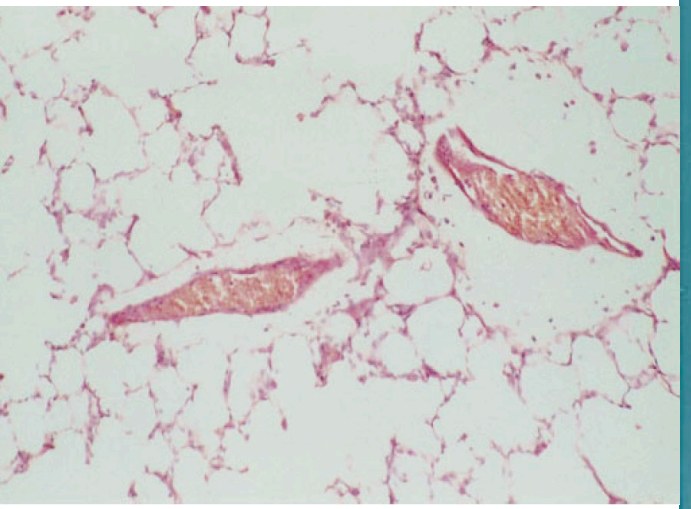
Göğüs Hastalikları Ana bilim Dali

Yoğun Bakım Bilim Dali

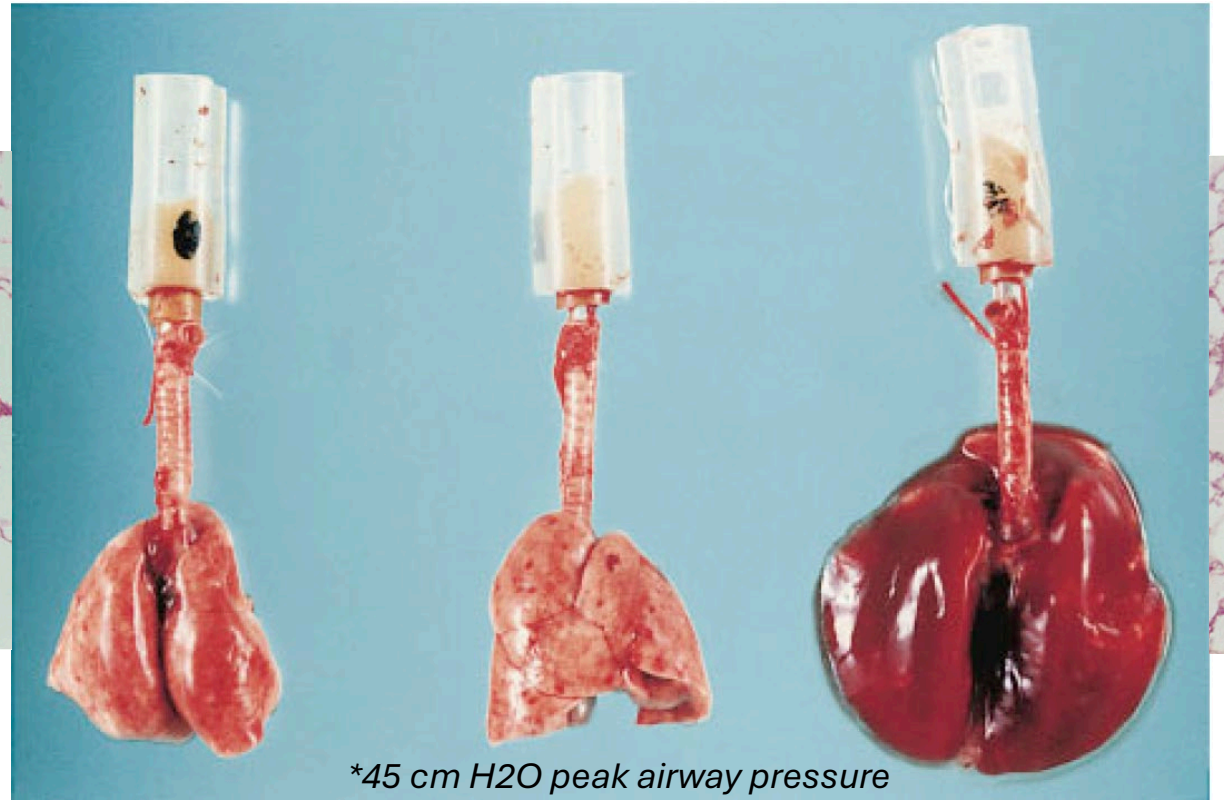
Ventilator-induced Lung Injury
Lessons from Experimental Studies

DIDIER DREYFUSS and GEORGES SAUMON

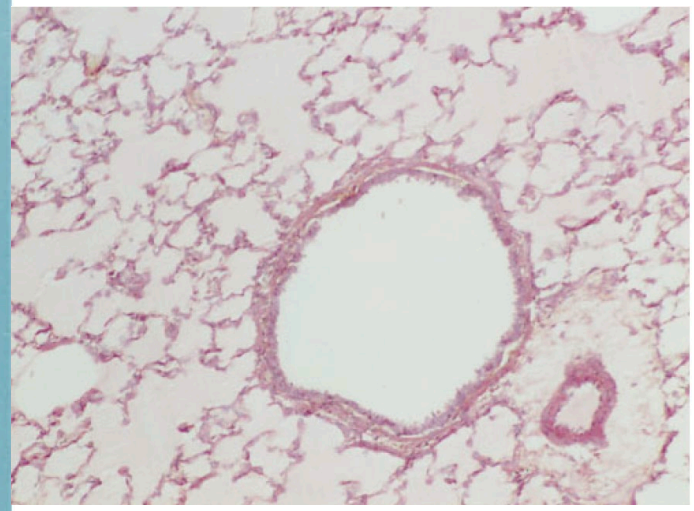
Am J Respir Crit Care Med Vol 157. pp 294–323, 1998



** 5. dk geniş perivasküler belirgin interstisyel ödem*



**45 cm H2O peak airway pressure*



**20. dk, tüm alveolleri dolduran yaygın alveoler ödem*

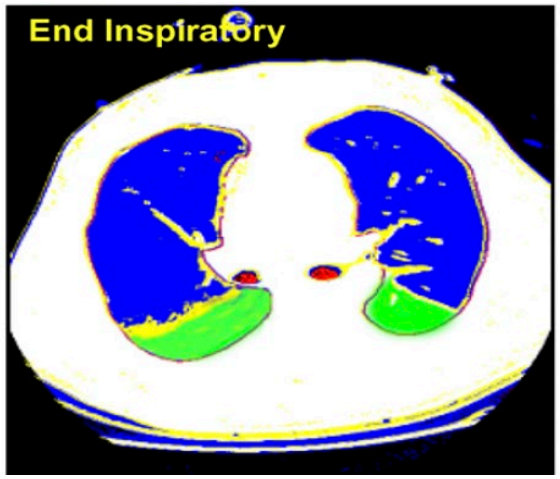
Akciğer Koruyucu Mekanik Ventilasyon Hedefleri

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

Dipartimento di Anestesiologia e Rianimazione, and Dipartimento di Radiologia, Università di Torino, Ospedale S. Giovanni Battista-Molinette, Turin; Istituto di Anestesia e Rianimazione, Fondazione Istituto di Ricovero e Cura a Carattere Scientifico, Ospedale Maggiore Policlinico,

A

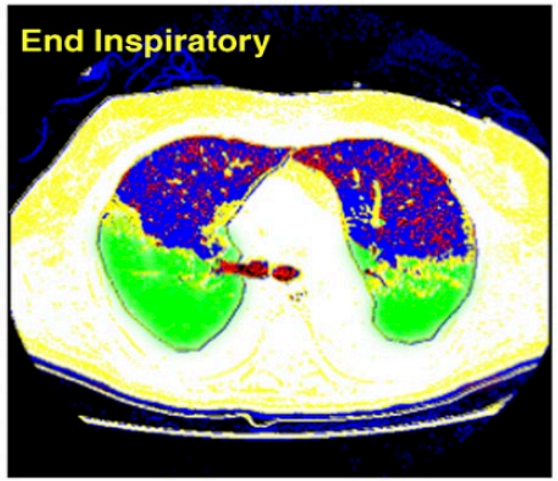


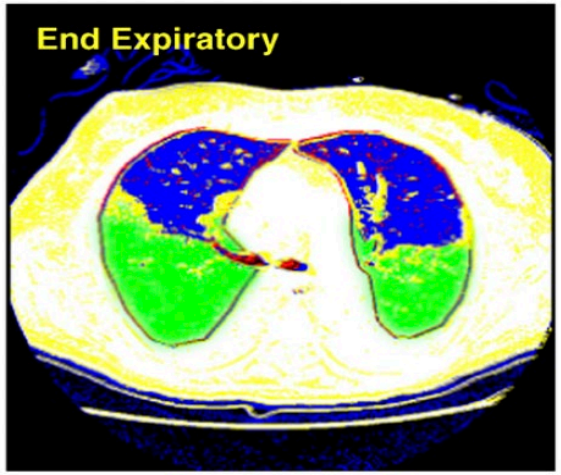
30 patients, TV 6ml/kg PBW

⟷ *20 patients normally aerated "more protected"*

- **Akciğer özellikleri**
- **Mekanikler**
- **Rekrütabilite**
- **PEEP**

B



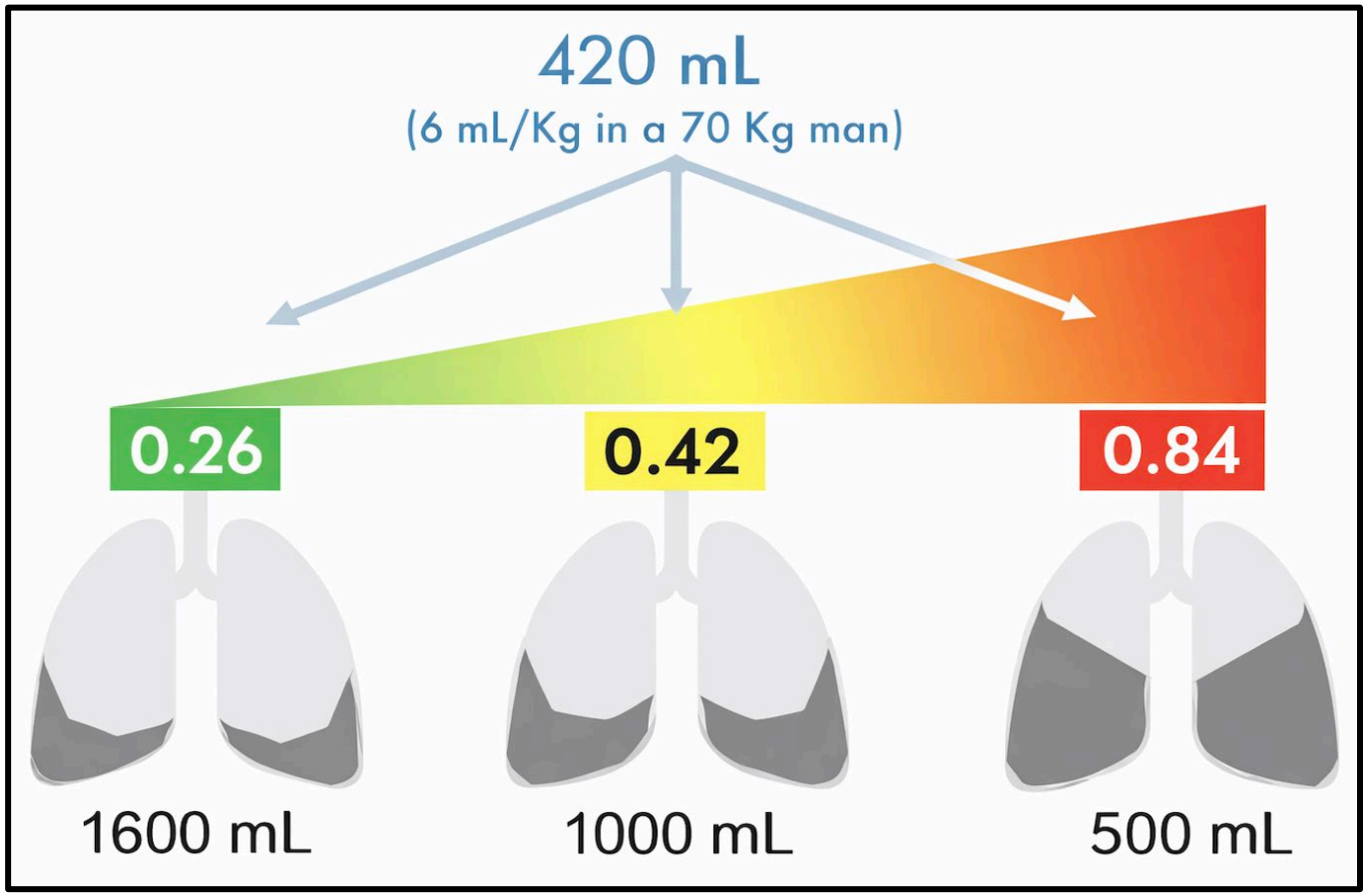


⟷ *10 patients hyperinflated "less protected"*

AMERICAN JOURNAL OF RESPIRATORY AND CRITICAL CARE MEDICINE VOL 175 2007

Tidal Volümün FRC'ye Oranlanması: Strain (Gerilme)

Strain =VT/FRC



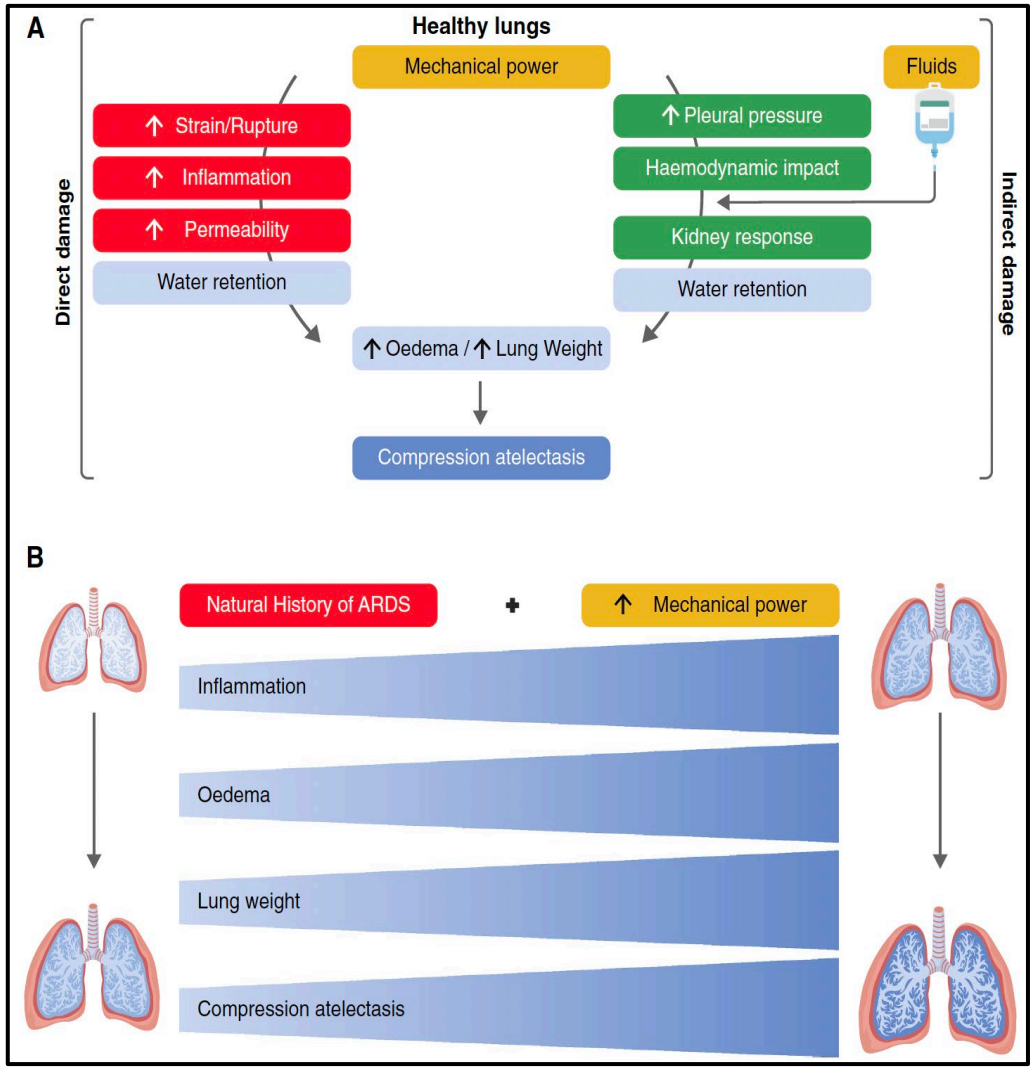
- **6 ml/kg herkese iyi değil**
- VT'yi "vücut ağırlığına" göre değil,
- **Akciğerin gerçek boyutuna (Crs → baby lung)** göre değerlendirmek gerekir

UNDERSTANDING THE DISEASE

Ventilator induced lung injury: a case for a larger umbrella?

Luciano Gattinoni[1*], Francesca Collino[2] and Luigi Camporota[3]

Intensive Care Med (2024) 50:275–278
https://doi.org/10.1007/s00134-023-07296-1



STRAIN (Gerilme)

Akciğerin ne kadar gerildiğinin göstergesi

Strain = VT / FRC (*baby lung*)

STRESS (Gerilme Kuvveti-Basınç)

Akciğeri gerip açmak için gereken "germe kuvveti"
Stress ≈ Transpulmoner basınç

En pratik klinik karşılığı: **ΔP (Driving pressure)**

STRESS (Basınç), STRAIN'i (Hacim değişimini) belirler

Aynı Strainde Farklı Stress! Elastans Etkisi

Hasta	FRC (mL)	Elastans (cmH_2O/L)	VT (mL)	Strain	Stress (≈ ΔP)
A	1000	**20**	400 ml	0.40	8 cm H_2O
B	1000	**50**	400 ml	0.40	20 cm H_2O

Sadece TV bakmak yetersizdir!!

«Stiff lung=Yüksek Elastans= Sert Akciğer»

→

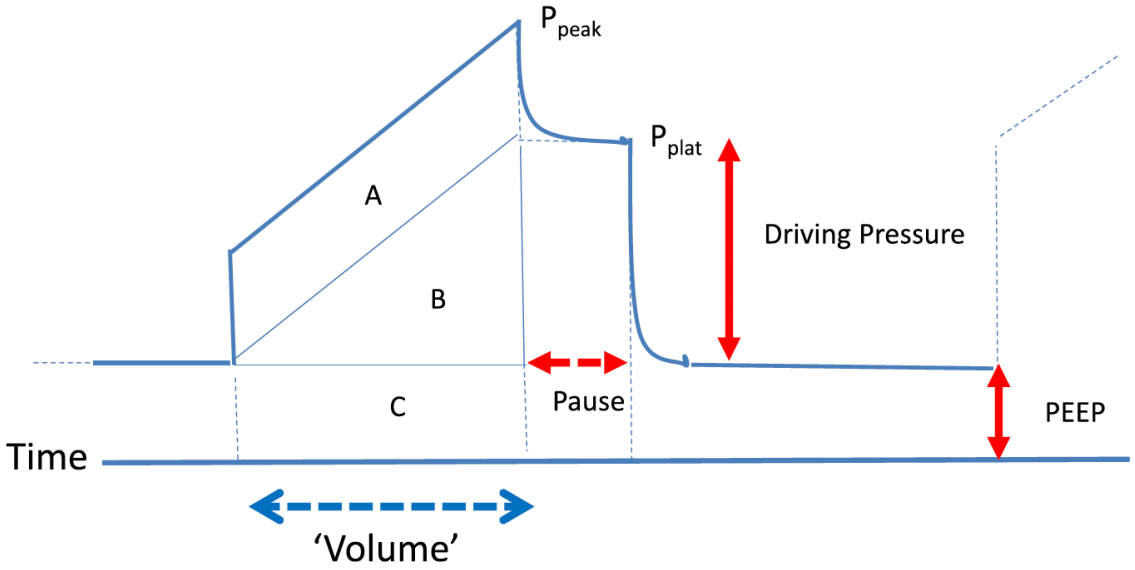
Aynı **strain**, sert akciğerde daha yüksek **stress**

→

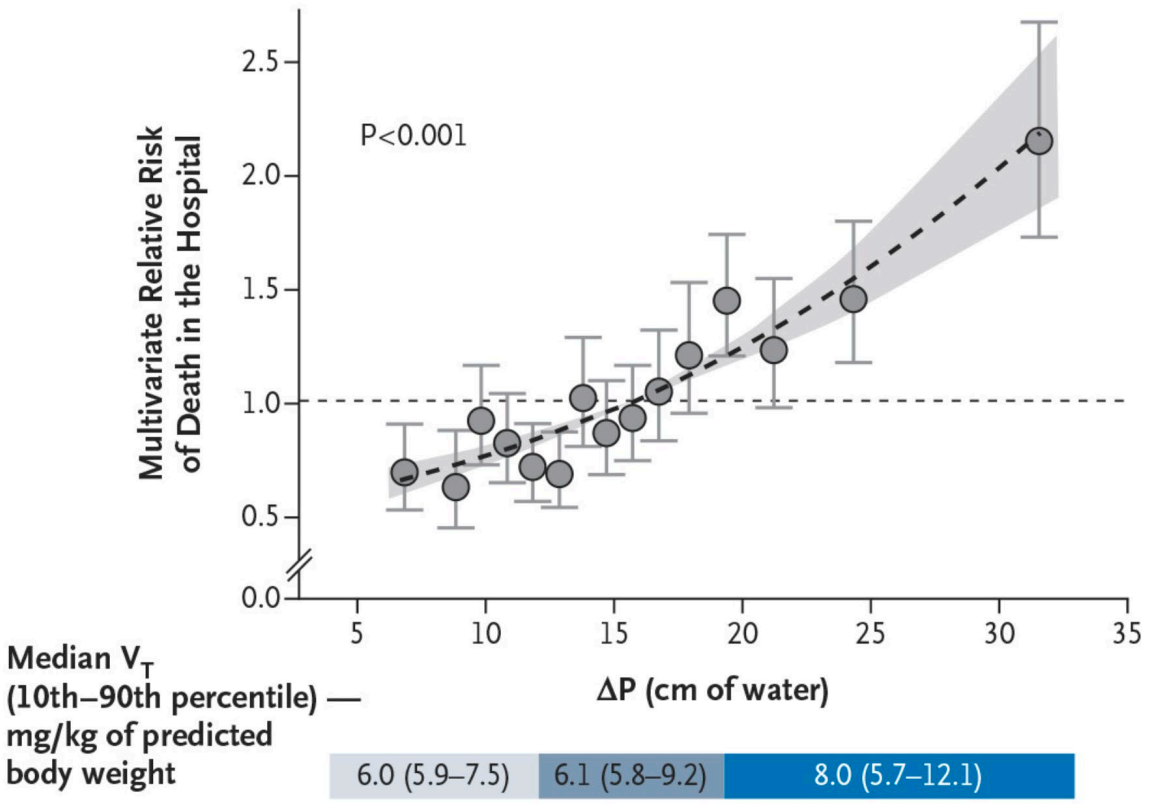
VILI Riski!!

Stress ≈ Driving Pressure ΔP

Tidal volümün fonksiyonel akciğer boyutuna **(baby lung)** oranını temsil eder



ΔP = Pplat – PEEP
= VT / C_{ST}
= VT × Elastans



Amato et al, 2015

The NEW ENGLAND JOURNAL of MEDICINE

SPECIAL ARTICLE

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.

Sonuç: ARDS'de sonlanımlarla ilişkili olan TV değil, DP

DP

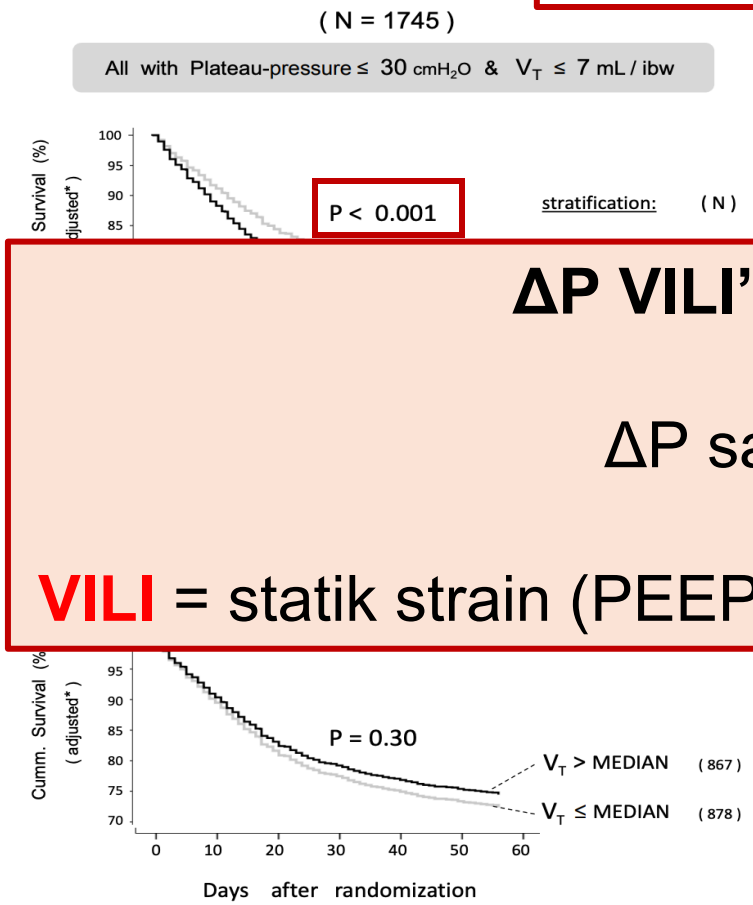
Pplat

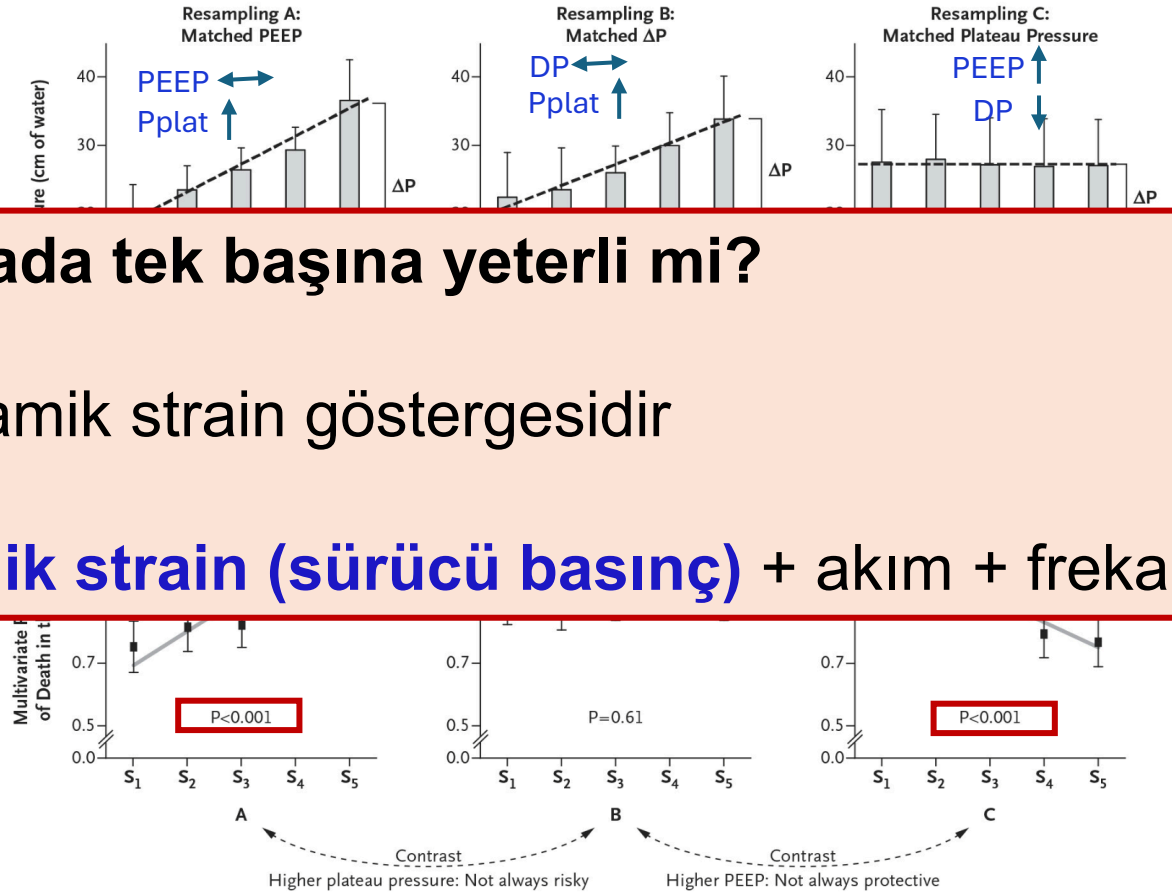
VT

ΔP VILI'yi azaltmada tek başına yeterli mi?

ΔP sadece dinamik strain göstergesidir

VILI = statik strain (PEEP) + **dinamik strain (sürücü basınç)** + akım + frekans



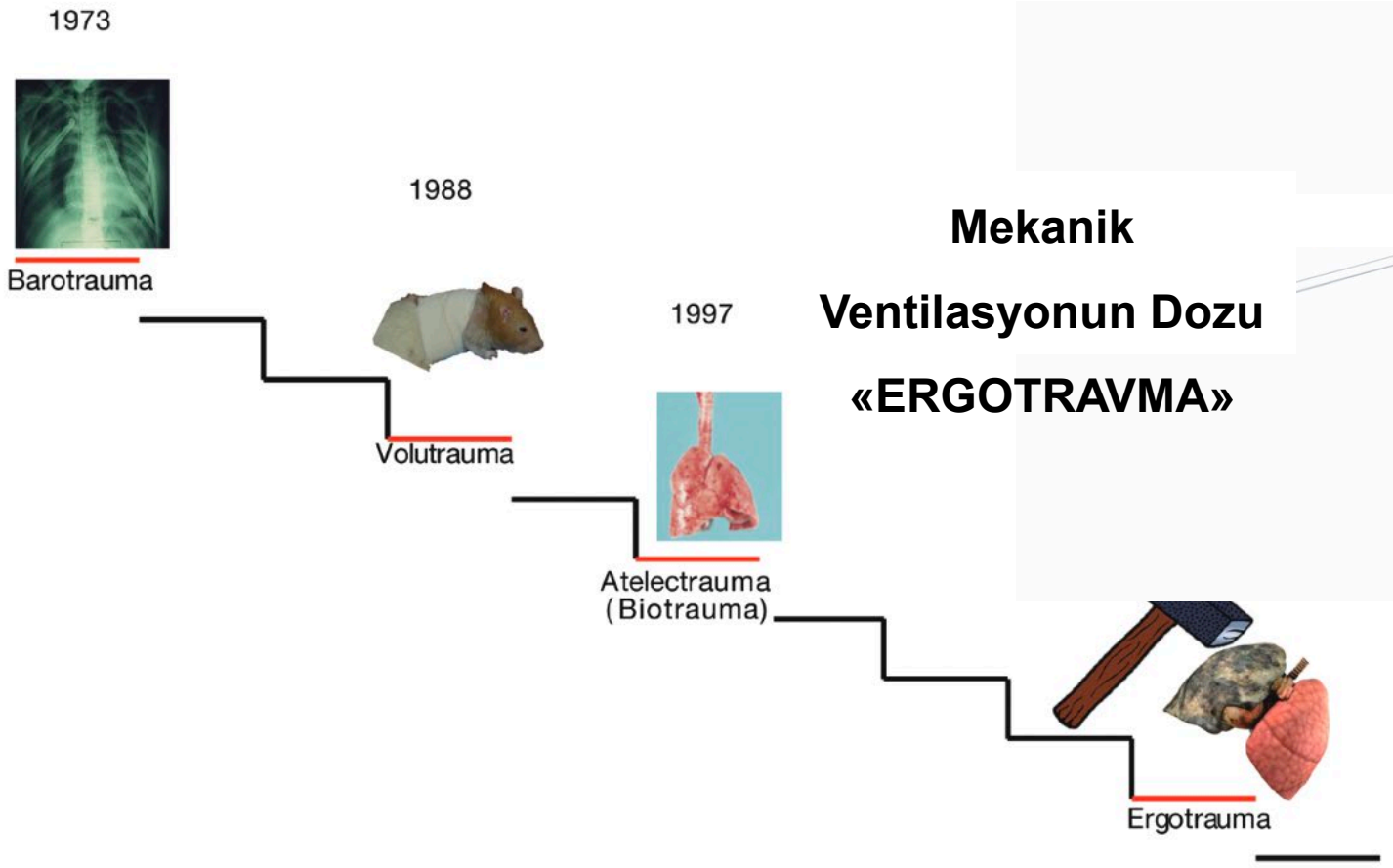


Mekanik Güç

Driving pressure and mechanical power: new targets for VILI prevention

Ann Transl Med 2017;5(14):286

Tommaso Tonetti[1], Francesco Vasques[1], Francesca Rapetti[1], Giorgia Maiolo[1], Francesca Collino[1], Federica Romitti[1], Luigi Camporota[2,3], Massimo Cressoni[4], Paolo Cadringher[5], Michael Quintel[1], Luciano Gattinoni[1]



Mekanik

Ventilasyonun Dozu

«ERGOTRAVMA»

VT

SS

PEEP

Flow

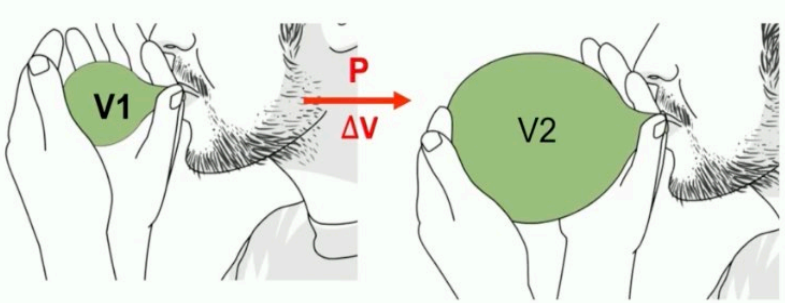
DP

RESEARCH ARTICLES Open Access

Mechanical power ratio threshold for ventilator-induced lung injury

Intensive Care Medicine Experimental (2024) 12:65
https://doi.org/10.1186/s40635-024-00649-0

Rosanna D'Albo[1,2†], Tommaso Pozzi[1,3†], Rosmery V. Nicolardi[1,4], Mauro Galizia[1,3], Giulia Catozzi[1,3], Valentina Ghidoni[1,5], Beatrice Donati[1,3], Federica Romitti[1], Peter Herrmann[1], Mattia Busana[1], Simone Gattarello[1,4], Francesca Collino[6], Aurelio Sonzogni[7], Luigi Camporota[8], John J. Marini[9], Onnen Moerer[1], Konrad Meissner[1] and Luciano Gattinoni[1*]



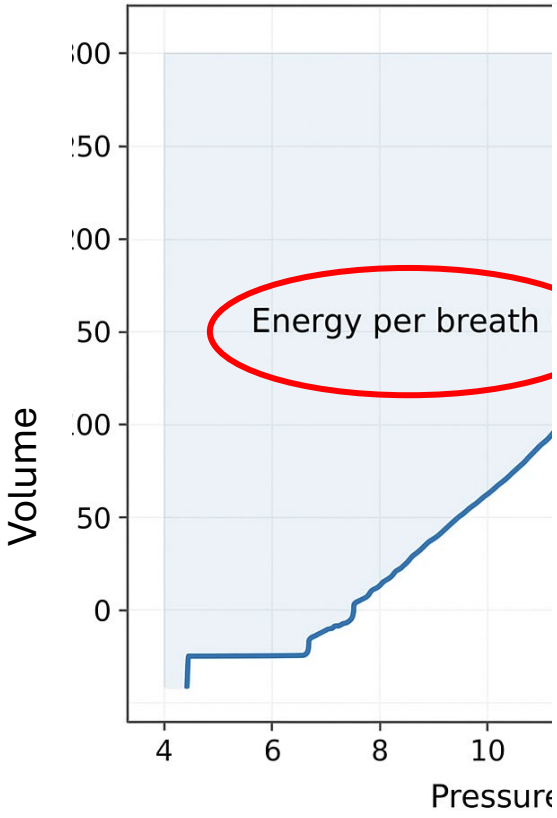
P * ΔV = Energy

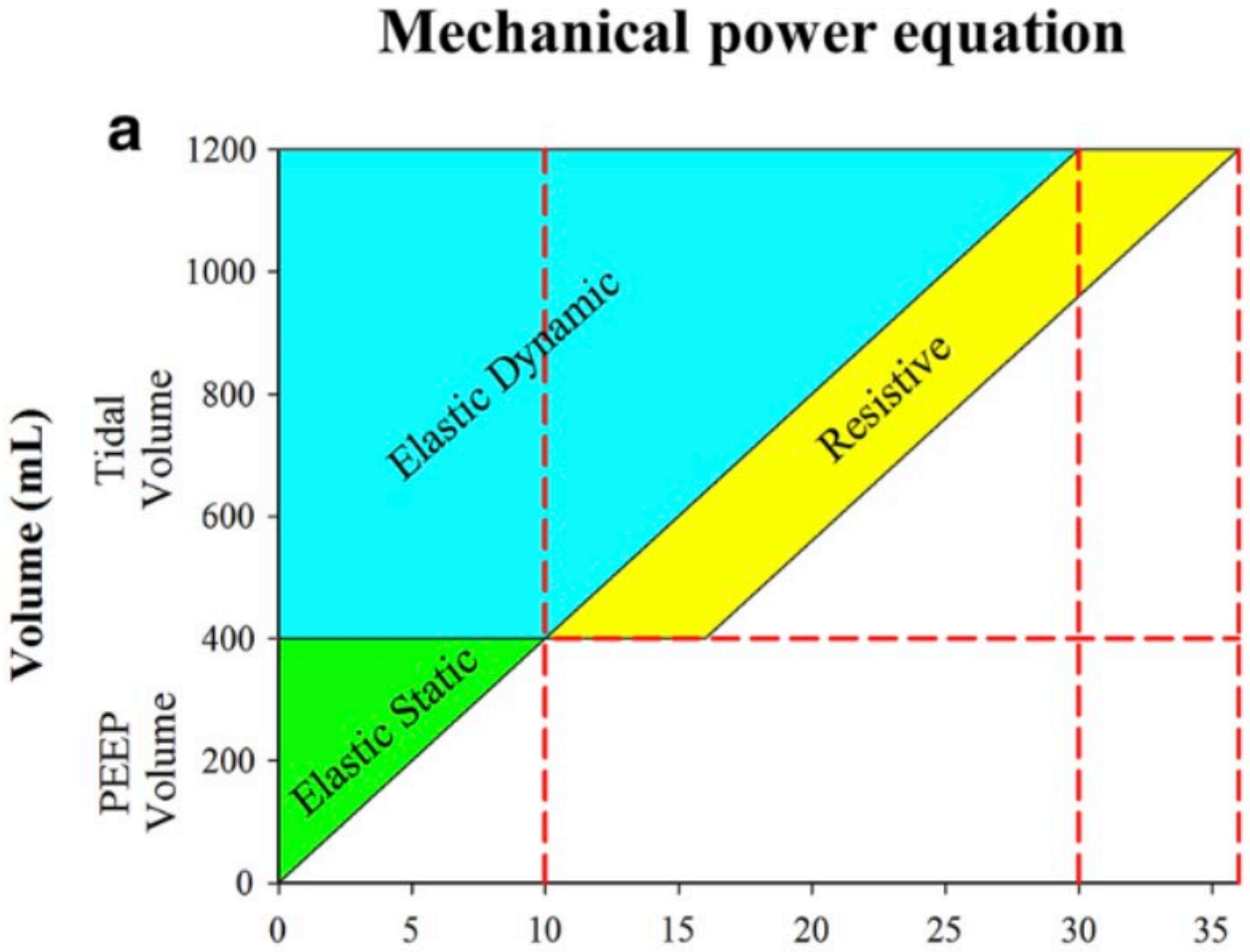
MP >14-17J X

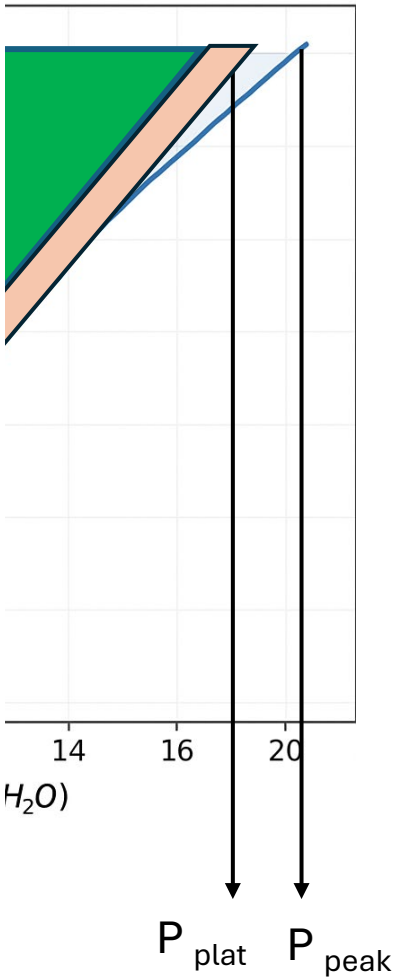
- Mekanik Güç «**ENERJİ**»
- Akciğer expansiyonu için enerji ihtiyacımız var
  (Spontan soluyan ve ventile hastalarda)

$$MP = 0.098 \times RR \times \left\{ {V_T}^2 \times \left[\frac{1}{2} \times EL_{rs} + RR \times \frac{1 + I:E}{60 \times I:E} \times R_{aw} \right] + V_T \times PEEP \right\}$$

Distend the lung	Move the gas	Keep open
Rezistans	**Dinamik Strain (sürücü basınç)**	**(Statik Strain)**







TV*PEEP **TV*Driving P/2** **TV*Presist**

Elastic static **+ Elastic dynamic** **+ Resistive**

Intensive Care Med (2016) 42:1567–1575
DOI 10.1007/s00134-016-4505-2

Ventilator-related causes of lung injury: the mechanical power

Intensive Care Med (2016) 42:1567–1575

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]

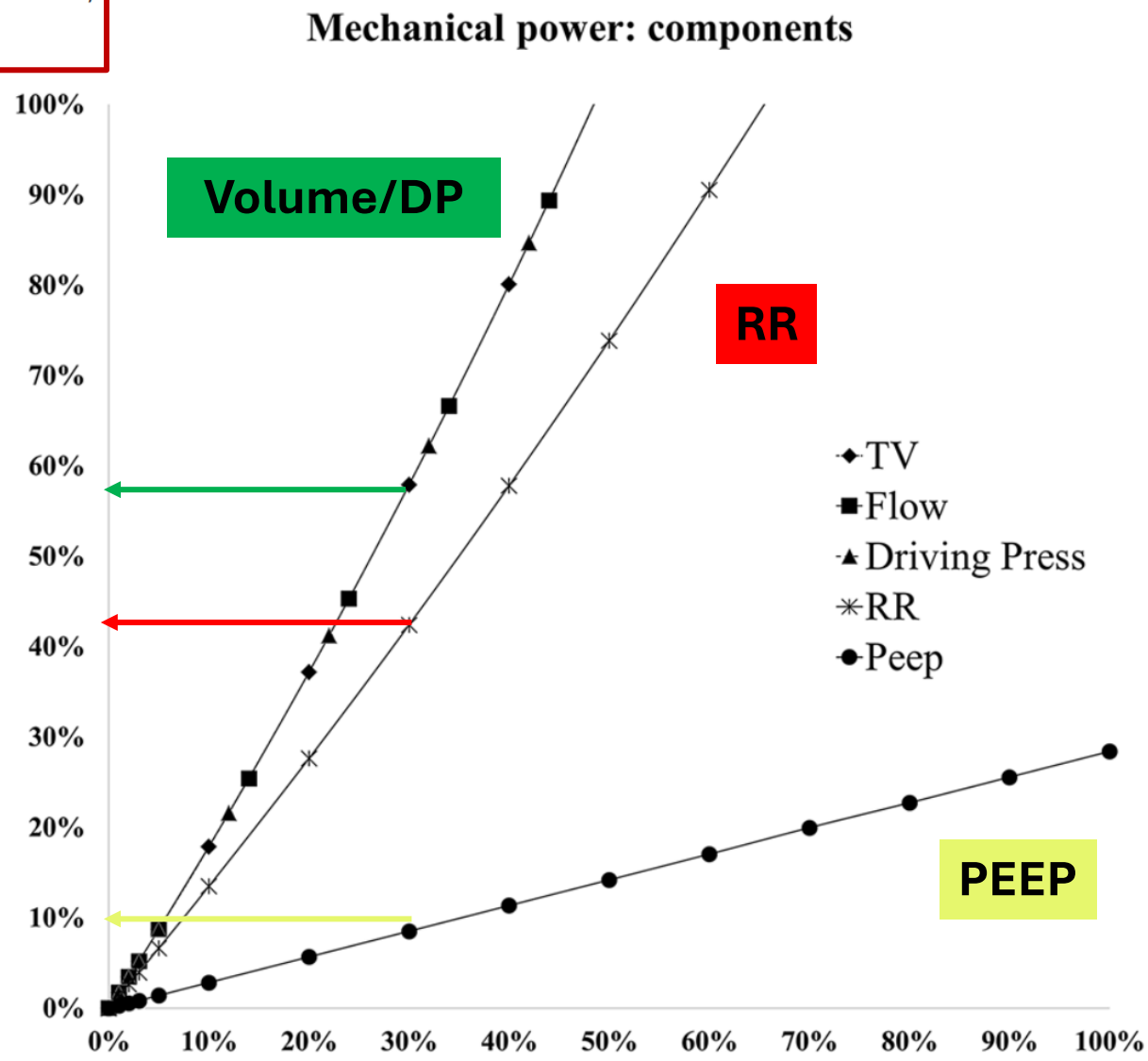
{ TV * PEEP + (TV * Driving P)/2 + TV * (Ppeak - Pplat) }

X

RR * 0.098 = Joule/min

Mathematical passages.....

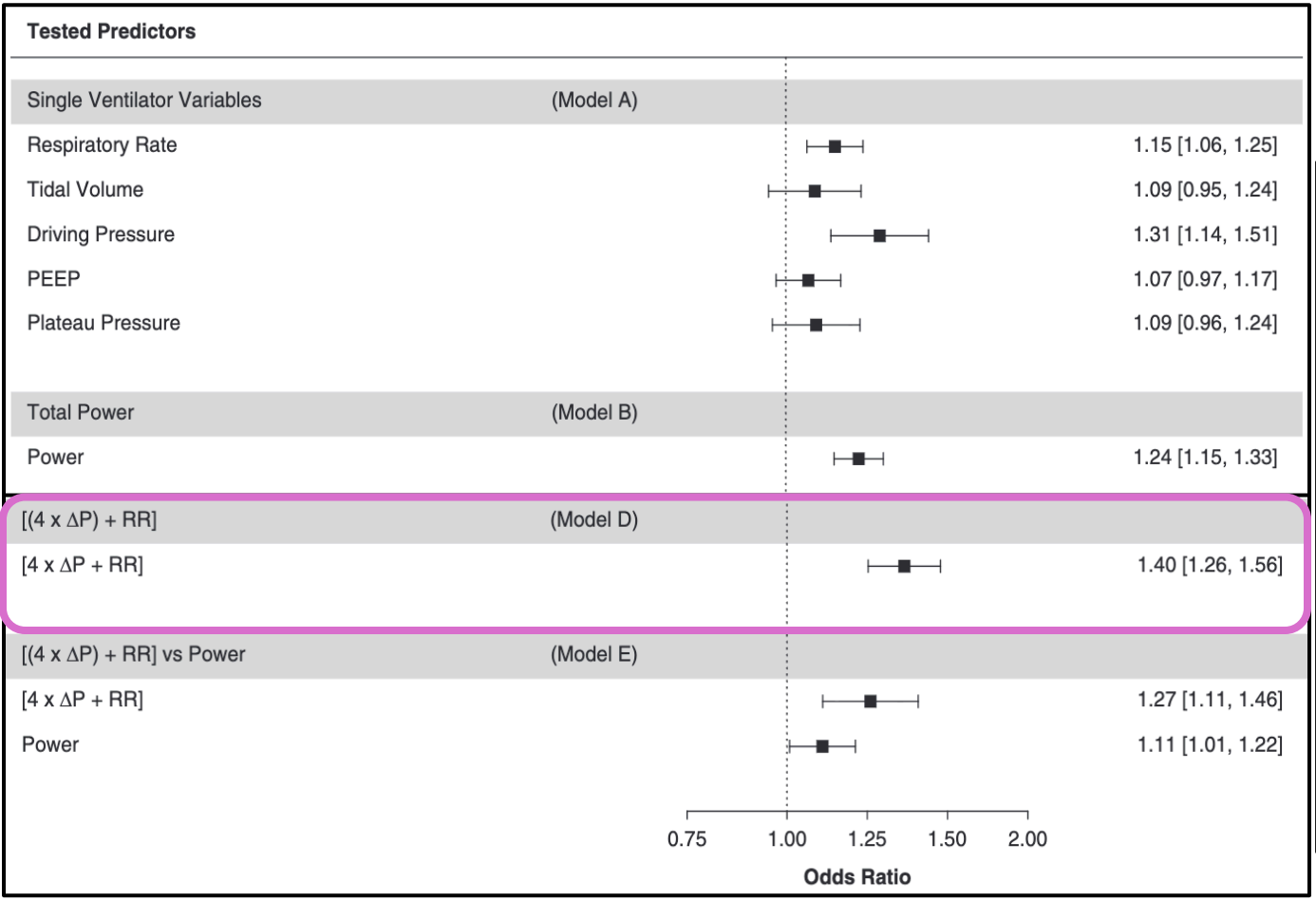
((Ppeak - 0.5 * Driving P) * TV * RR * 0.1) = J/min



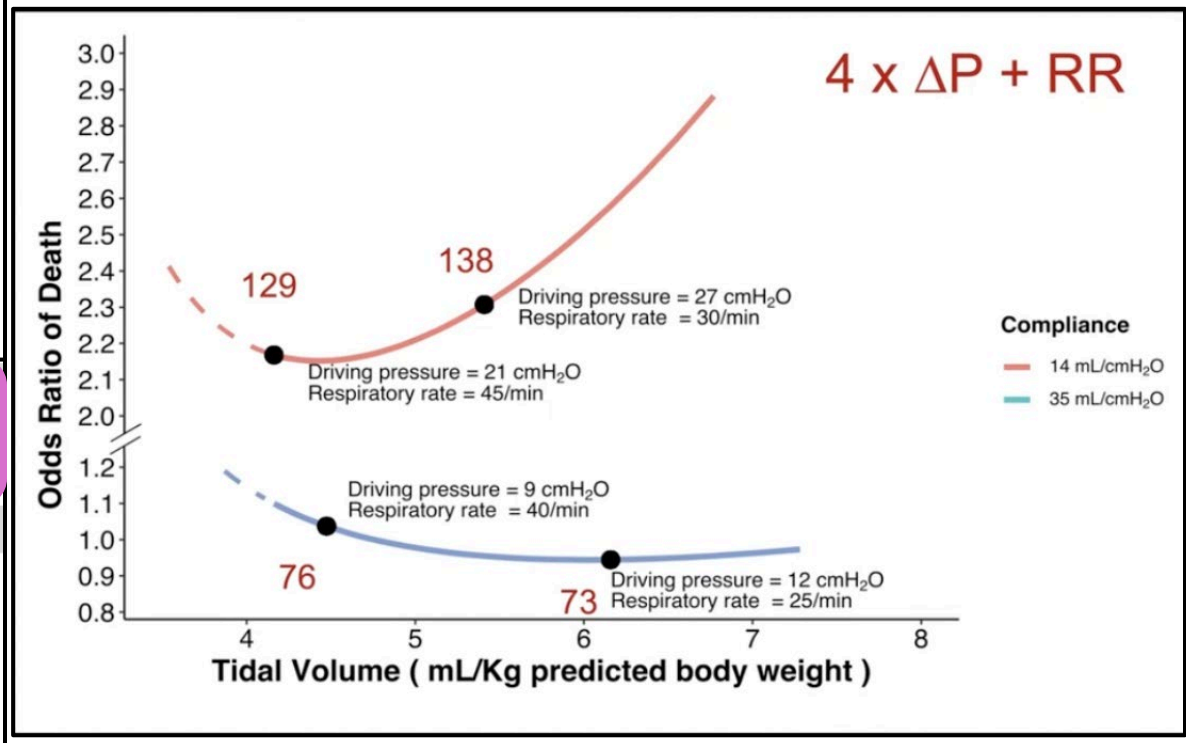
Ventilatory Variables and Mechanical Power in Patients with Acute Respiratory Distress Syndrome

Eduardo L. V. Costa[1,2], Arthur S. Slutsky[3,4], Laurent J. Brochard[3,4*], Roy Brower[5], Ary Serpa-Neto[6], Alexandre B. Cavalcanti[7], Alain Mercat[8], Maureen Meade[9], Caio C. A. Morais[1], Ewan Goligher[3,10,11], Carlos R. R. Carvalho[1], and Marcelo B. P. Amato[1]

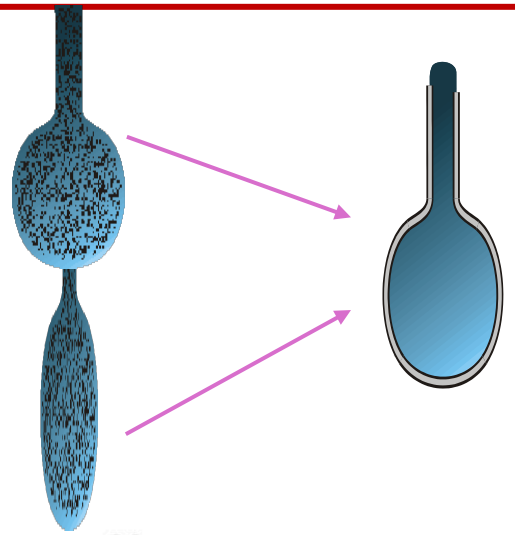
[1]Laboratório de Pneumologia, Laboratório de Investigação Médica 09, Disciplina de Pneumologia, Instituto do Coração, Hospital das Clínicas, Faculdade de Medicina, Universidade de São Paulo, São Paulo, São Paulo, Brazil; [2]Instituto de Ensino e Pesquisa, Hospital Sírio Libanes, São Paulo, São Paulo, Brazil; [3]Interdepartmental Division of Critical Care Medicine, University of Toronto, Toronto, Ontario, Canada; [4]Keenan Research Centre, Li Ka Shing Knowledge Institute, St. Michael's Hospital, Toronto, Ontario, Canada; [5]Division of Pulmonary and Critical Care Medicine, School of Medicine, Johns Hopkins University, Baltimore, Maryland; [6]Hospital Israelita Albert



ΔP'nin mortalite etkisi RR'den 4 kat daha güçlü
$(4 \times \Delta P) + RR$ = MPdaha iyi mortalite tahmini!!



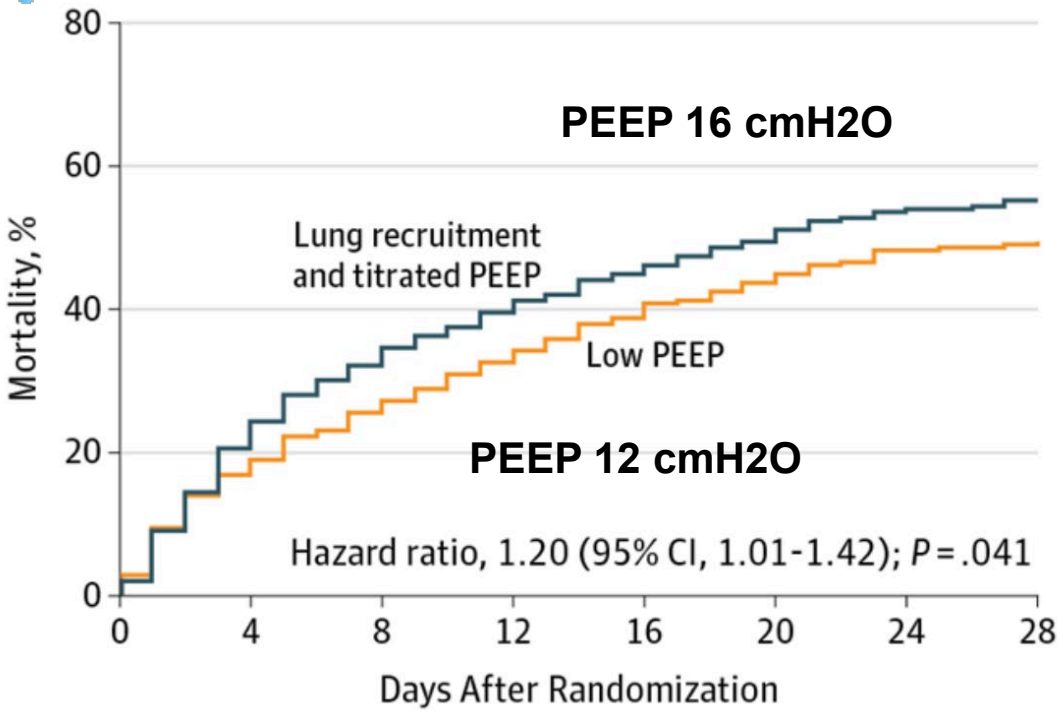
Optimal PEEP nedir?



Effect of Lung Recruitment and Titrated Positive End-Expiratory Pressure (PEEP) vs Low PEEP on Mortality in Patients With Acute Respiratory Distress Syndrome
A Randomized Clinical Trial

Writing Group for the Alveolar Recruitment for Acute Respiratory Distress Syndrome Trial (ART)

n= 1,010
Open-lung ventilation
Long recruitment maneuver
Decremental PEEP

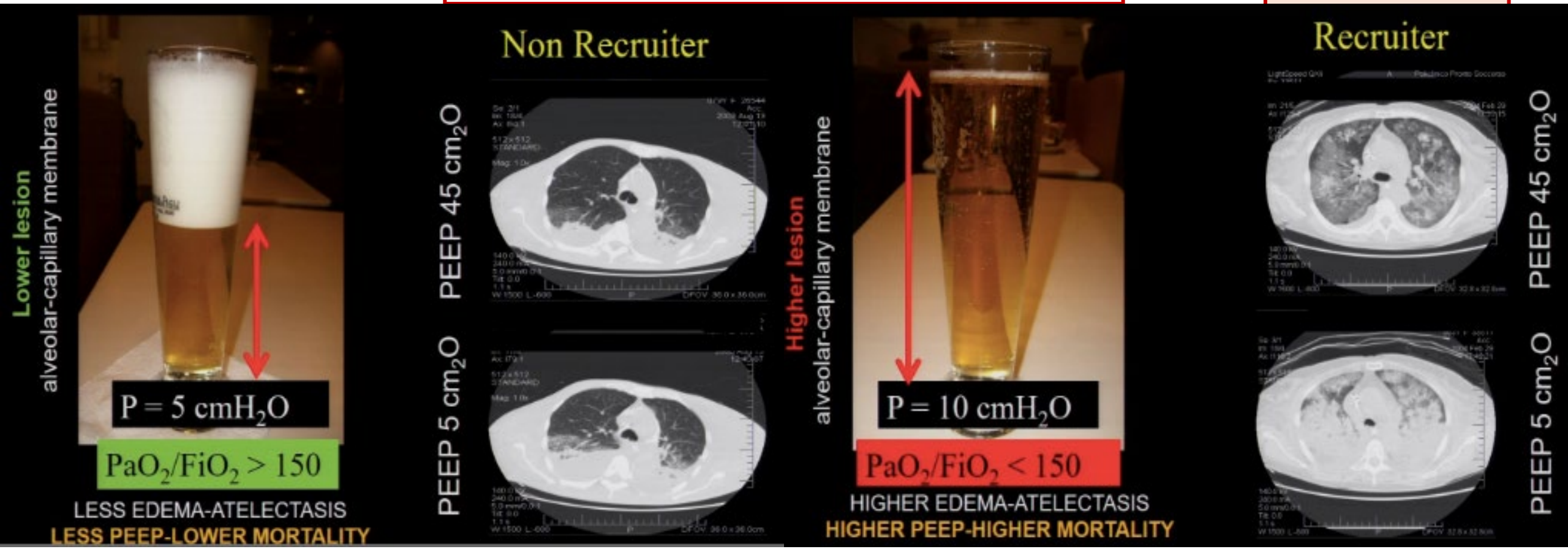


- 28-day mortality: 55.3% vs. 49.4%
  Hazard ratio (HR), 1.20; 95% CI,1.01–1.42; ***p* = 0.041**
- 6-month mortality: 65.3% vs. 59.9%
  HR, 1.18; 95% CI, 1.01–1.38; *p* = 0.04
- Pneumothorax ve barotrauma daha fazla

Optimal PEEP nedir?

Recruitment Maneuvers and PEEP Titration

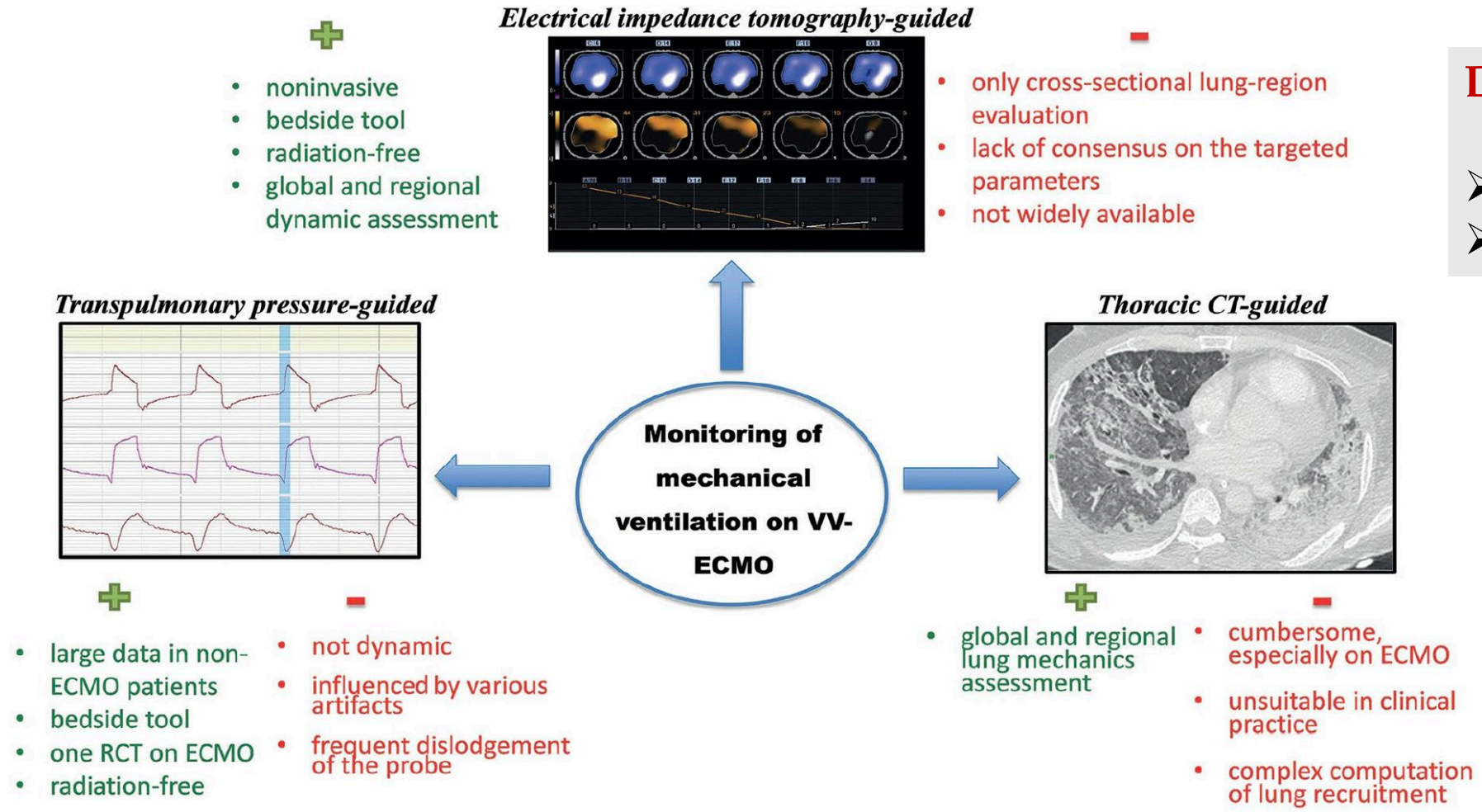
Dean R Hess PhD RRT FAARC



Optimal PEEP Ayarı

Tonna JE, ASAIO J. 2021;67:601–10.

- Uluslararası bir ECMO uzman anketinde hastaların %77'sinde **PEEP ≤10 cmH_2O**
- ELSO da ECMO sırasında ılımlı bir **PEEP düzeyi (≈10 cmH_2O)** önerilmekte

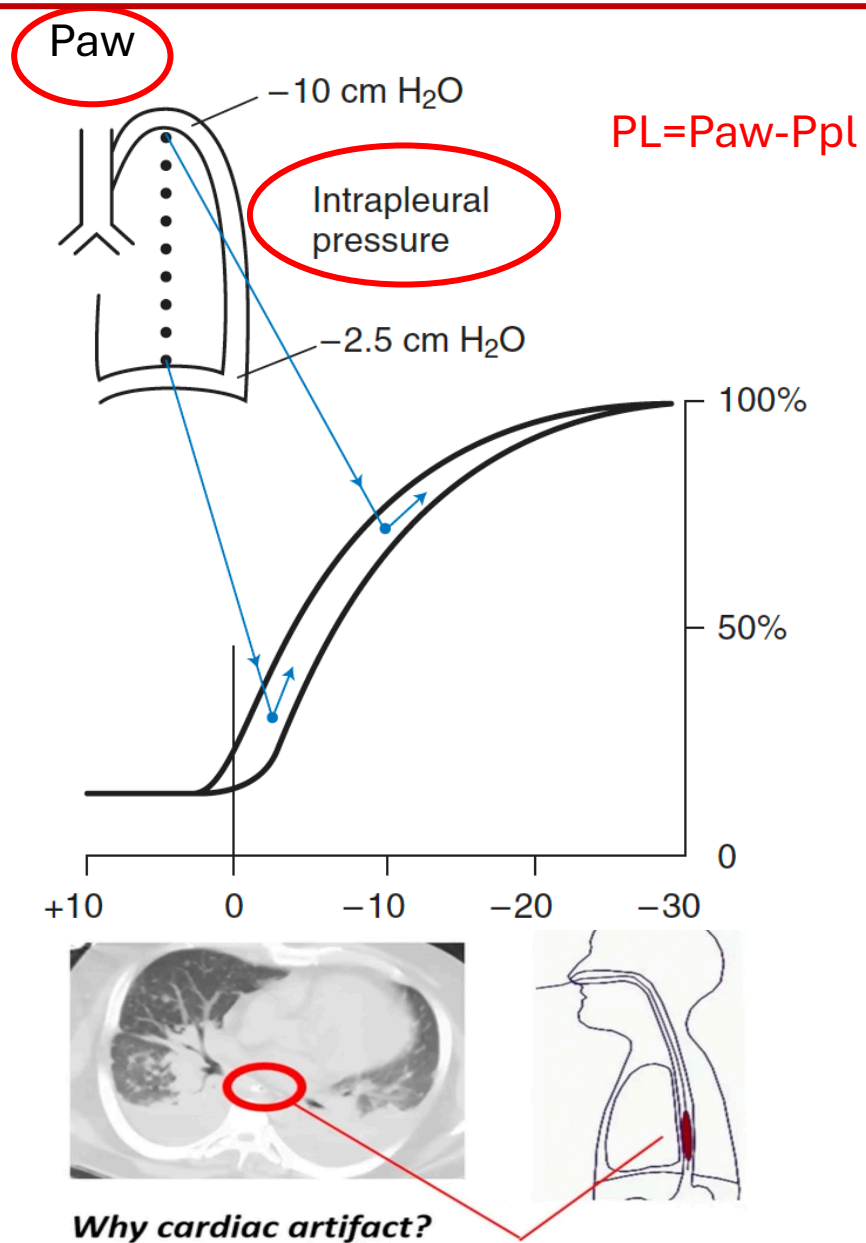


Diğer Yöntemler

- Akciğer Ultrasonu
- *(R/I) ratio*

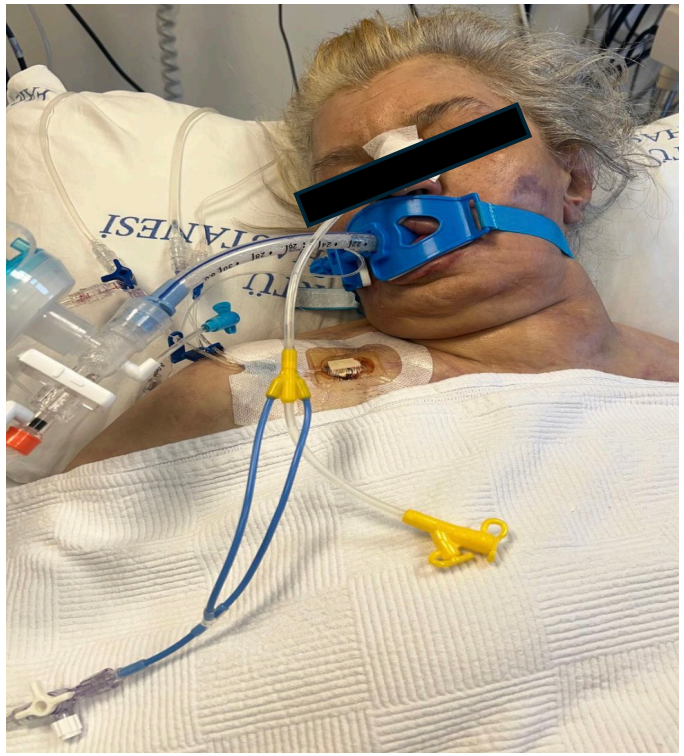
Optimal PEEP Ayar

Transpulmonary Pressure-Guided Strategy

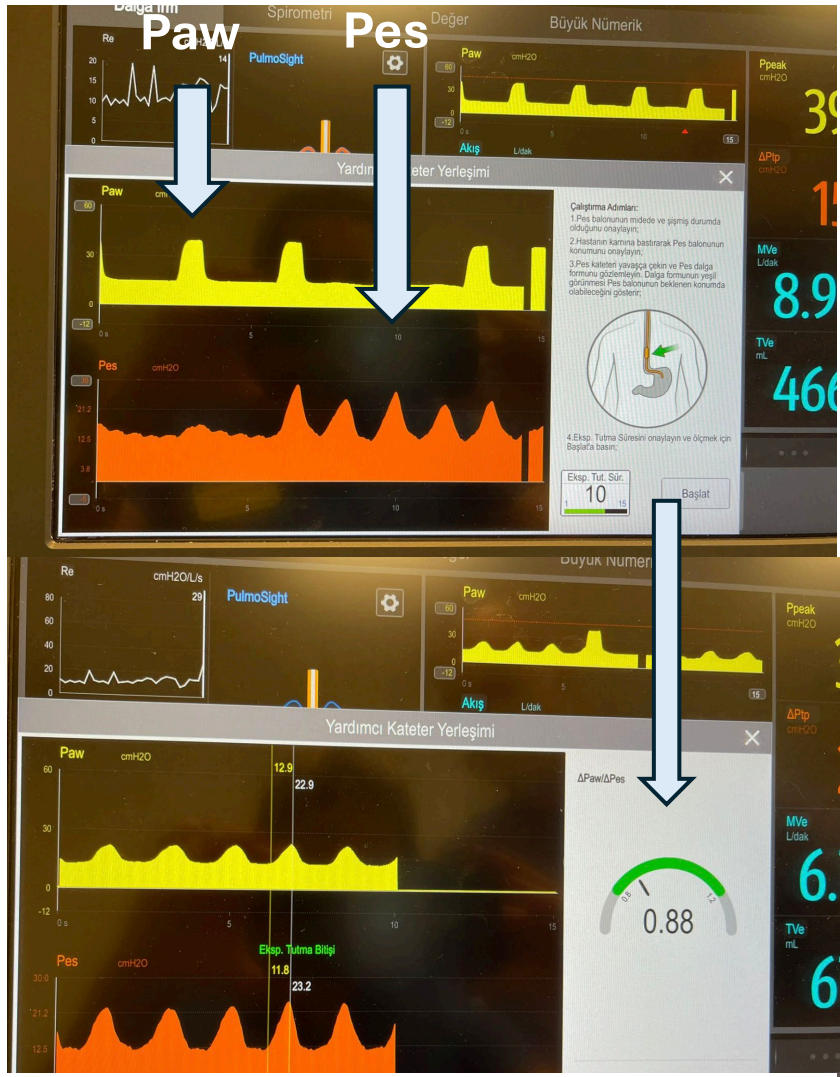


PL=Paw-Ppl

1. Ösefageal Balon



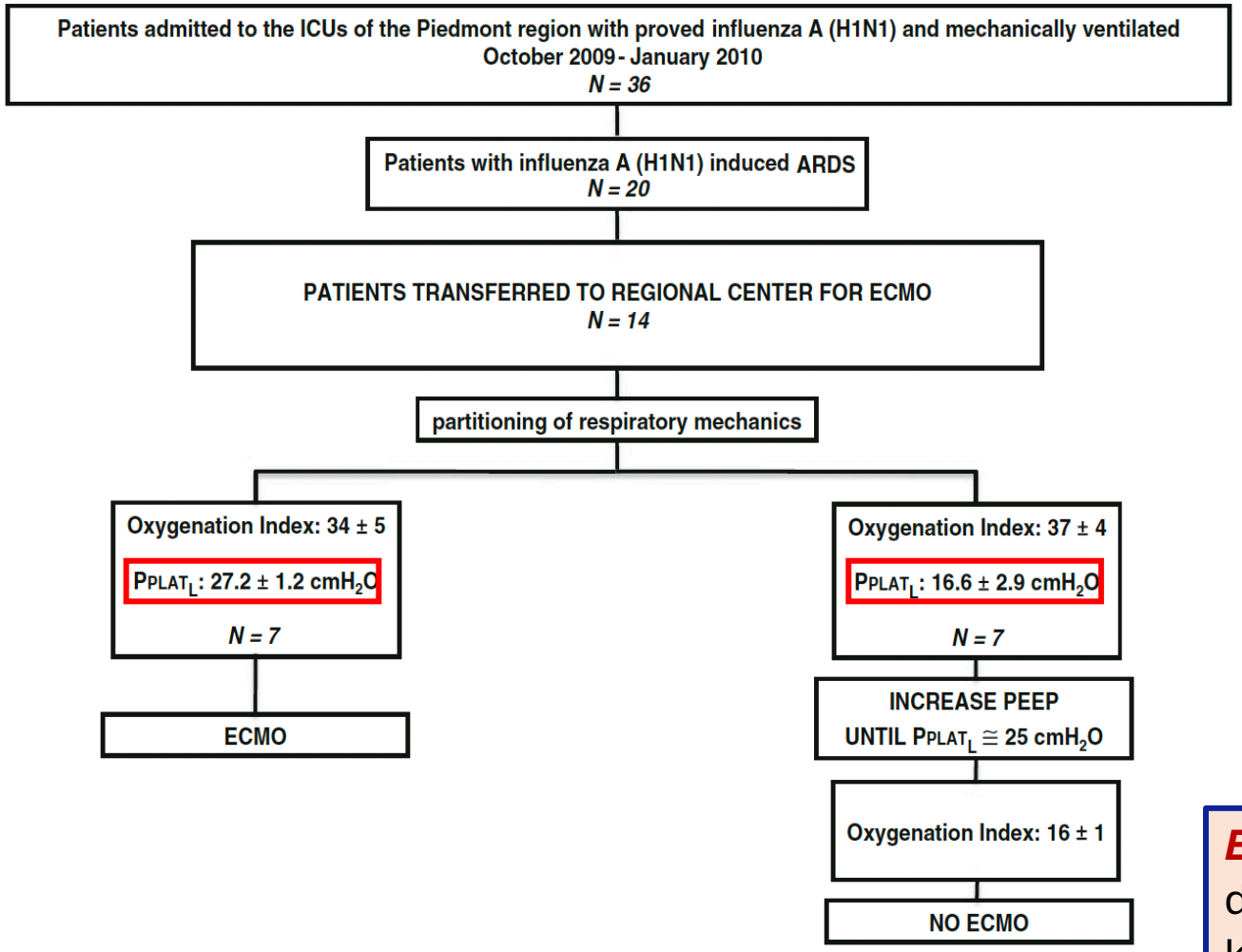
1. Kardiyak Artefaktlar



2. Exp.oklüzyon/kompresyon manevrası Paw/Pes=0,8-1,2

Optimal PEEP Ayarı

Transpulmonary Pressure-Guided Strategy



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) 38:395–403
DOI 10.1007/s00134-012-2490-7

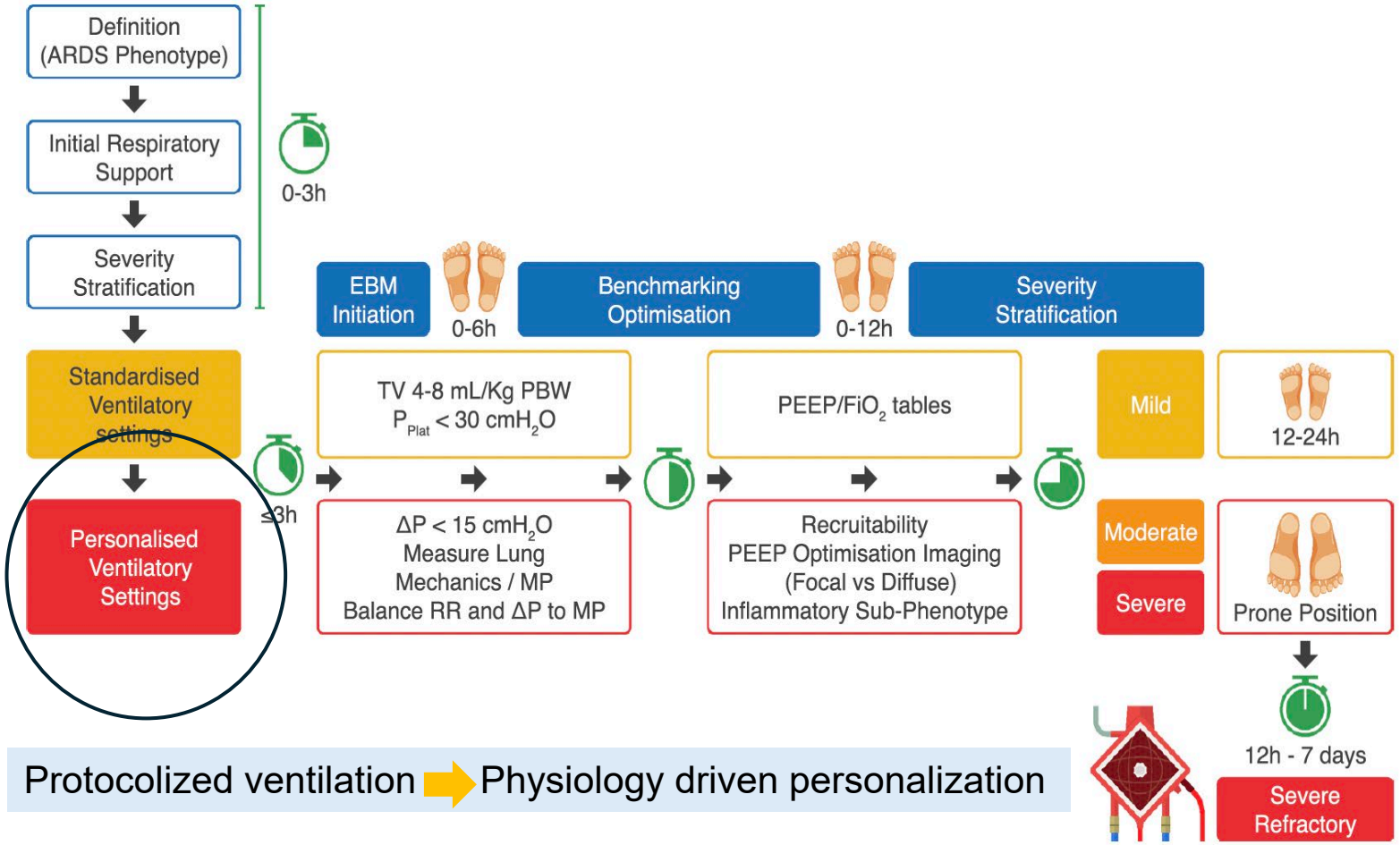
Conclusions: Abnormalities of chest wall mechanics may be present in some patients with influenza A (H1N1)-associated ARDS. These abnormalities may not be inferred from measurements of end-inspiratory plateau pressure of the respiratory system ($PPLAT_{RS}$). In these patients, titrating PEEP to $PPLAT_{RS}$ may overestimate the incidence of hypoxemia refractory to conventional ventilation leading to inappropriate use of ECMO.

ECMO endikasyonu, yalnızca oksijenasyon bozukluğuna değil, transpulmoner basınca ve akciğerin gerçekten ne kadar gerildiğine göre verilmeli

EDITORIAL

Sequencing interventions in ARDS: the critical role of timing and order in standardized management

Abhijit Duggal[1] and Luigi Camporota[2,3*]



Protocolized ventilation ➡ Physiology driven personalization

Akciğer Koruyucu Ventilasyon Hedefleri

1. **Tidal Volüm (VT) 4–8 mL/kg PBW**
2. **Driving Pressure (ΔP = VT/Crs) < 15 cmH_2O**
3. **Plateau Basıncı (Pplat) ≤ 28–30 cmH_2O**
4. **RR: 14-22 ≥ 26 (yüksek risk)**
5. **Transpulmoner Basınç (PL) ΔPL,dyn < 15–20 cmH_2O**

MEKANİK GÜÇ < 14 and 18 J/min

Intensive Care Med (2020) 46:2314–2326
Intensive Care Med (2018) 44:1914–1922

ÖZETLE...

- ***Protokolize ventilasyon değil, fizyoloji temelli bireyselleştirilmiş ventilasyon..***
- *MP >17J VILI' yi gösteren önemli bir parametre..*
- ***Strain, «Baby Lung» boyutu önemli...***
- *Spontan solunumun etkileri de değerlendirilmeli*