Electric impedance tomography guided-PEEP titration for ARDS

2025-11-8

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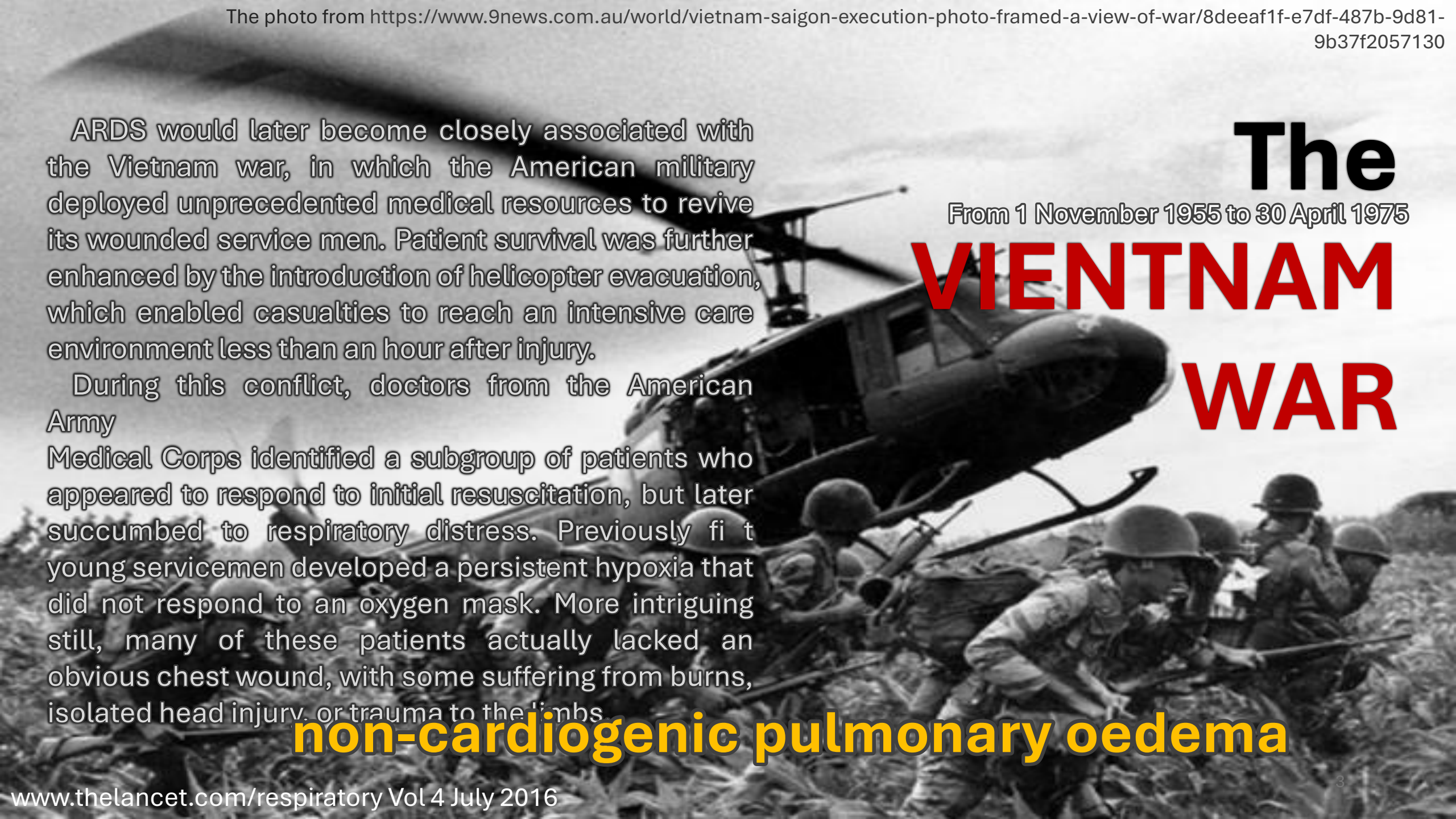
History of ARDS

- Acute respiratory distress syndrome (ARDS) was first described by Ashbaugh in 1967 writing in The Lancet.
- His study was based on a case series of 12 patients treated in a civilian environment in the USA.

The photo from https://www.9news.com.au/world/vietnam-saigon-execution-photo-framed-a-view-of-war/8deeaf1f-e7df-487b-9d81-9b37f2057130



The

From 1 November 1955 to 30 April 1975

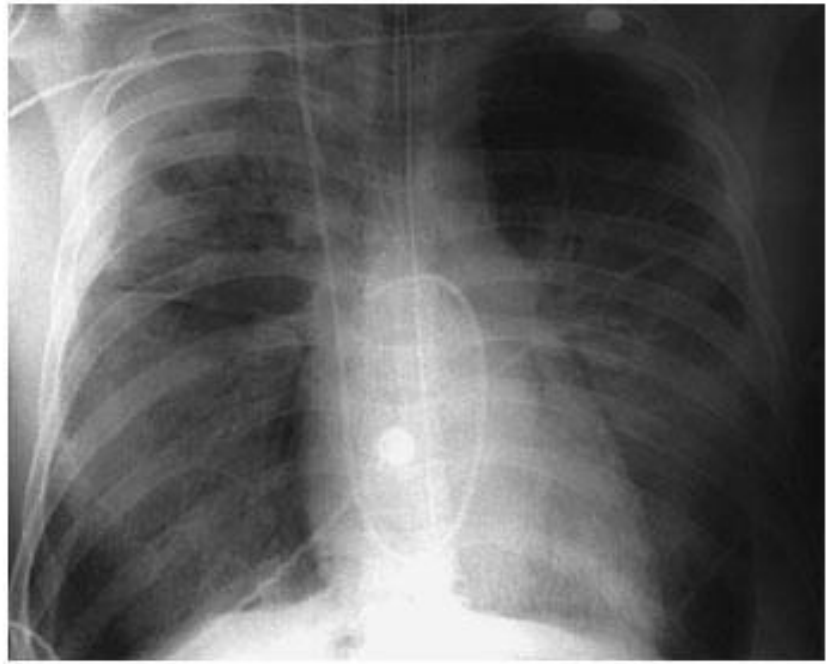
VIENTNAM WAR

ARDS would later become closely associated with the Vietnam war, in which the American military deployed unprecedented medical resources to revive its wounded service men. Patient survival was further enhanced by the introduction of helicopter evacuation, which enabled casualties to reach an intensive care environment less than an hour after injury.

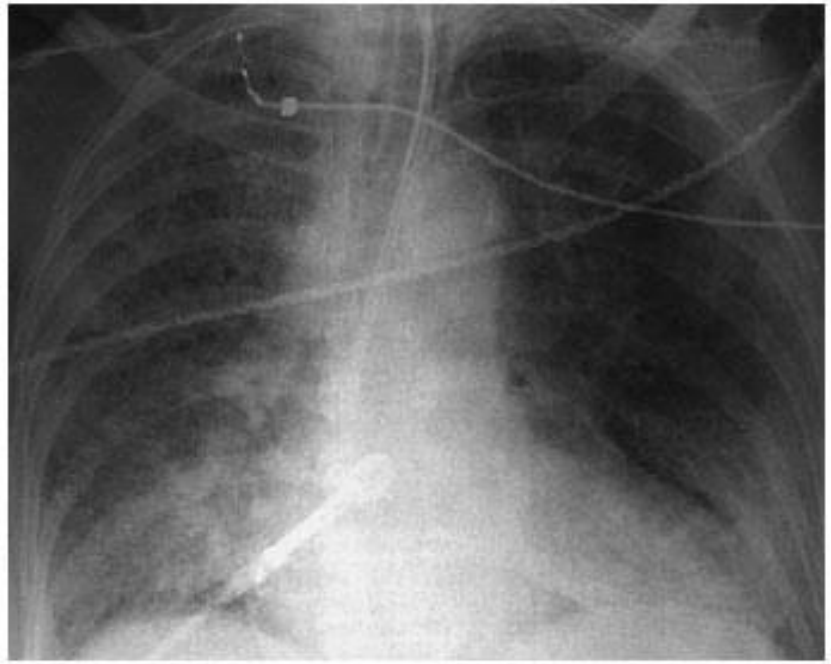
During this conflict, doctors from the American Army
Medical Corps identified a subgroup of patients who appeared to respond to initial resuscitation, but later succumbed to respiratory distress. Previously fi t young servicemen developed a persistent hypoxia that did not respond to an oxygen mask. More intriguing still, many of these patients actually lacked an obvious chest wound, with some suffering from burns, isolated head injury, or trauma to the limbs.

non-cardiogenic pulmonary oedema

www.thelancet.com/respiratory Vol 4 July 2016

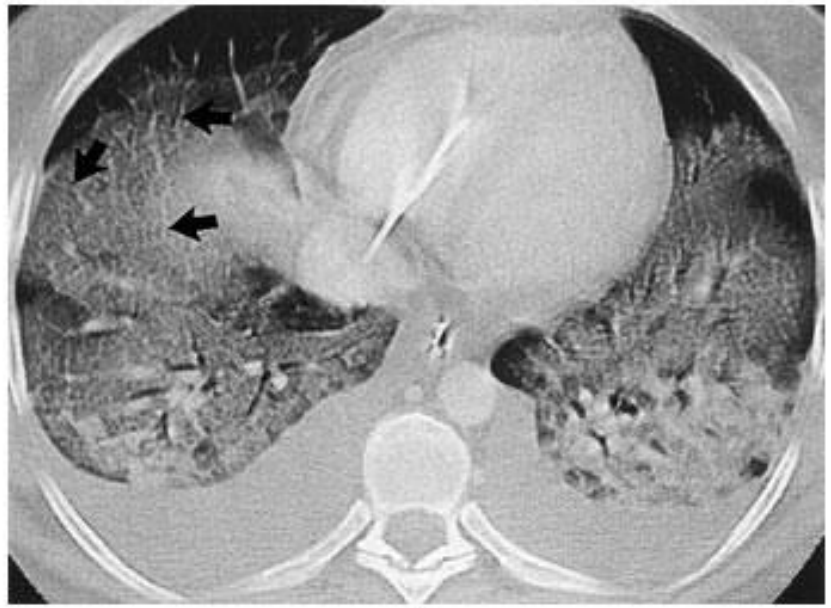


A

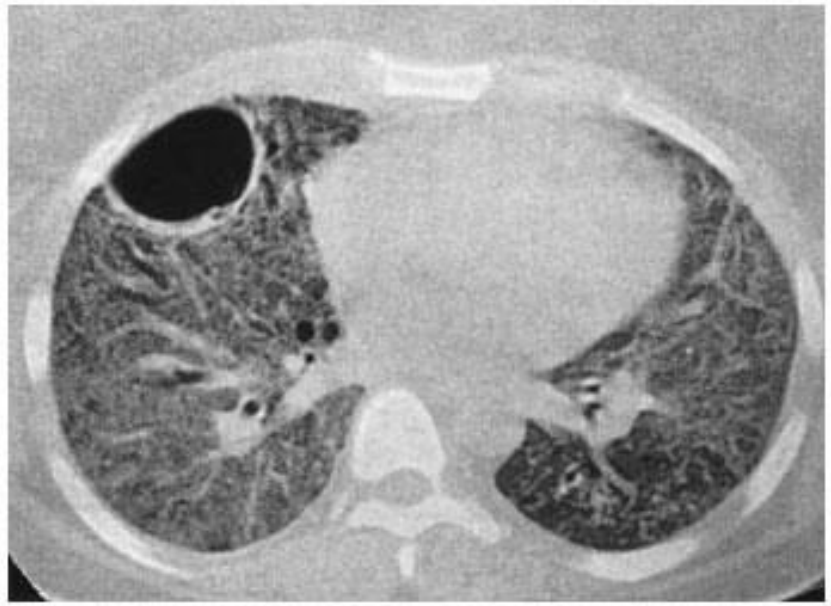


B

Acute, or Exudative, Phase (Panels A and C) Fibrosing-Alveolitis Phase (Panels B and D)

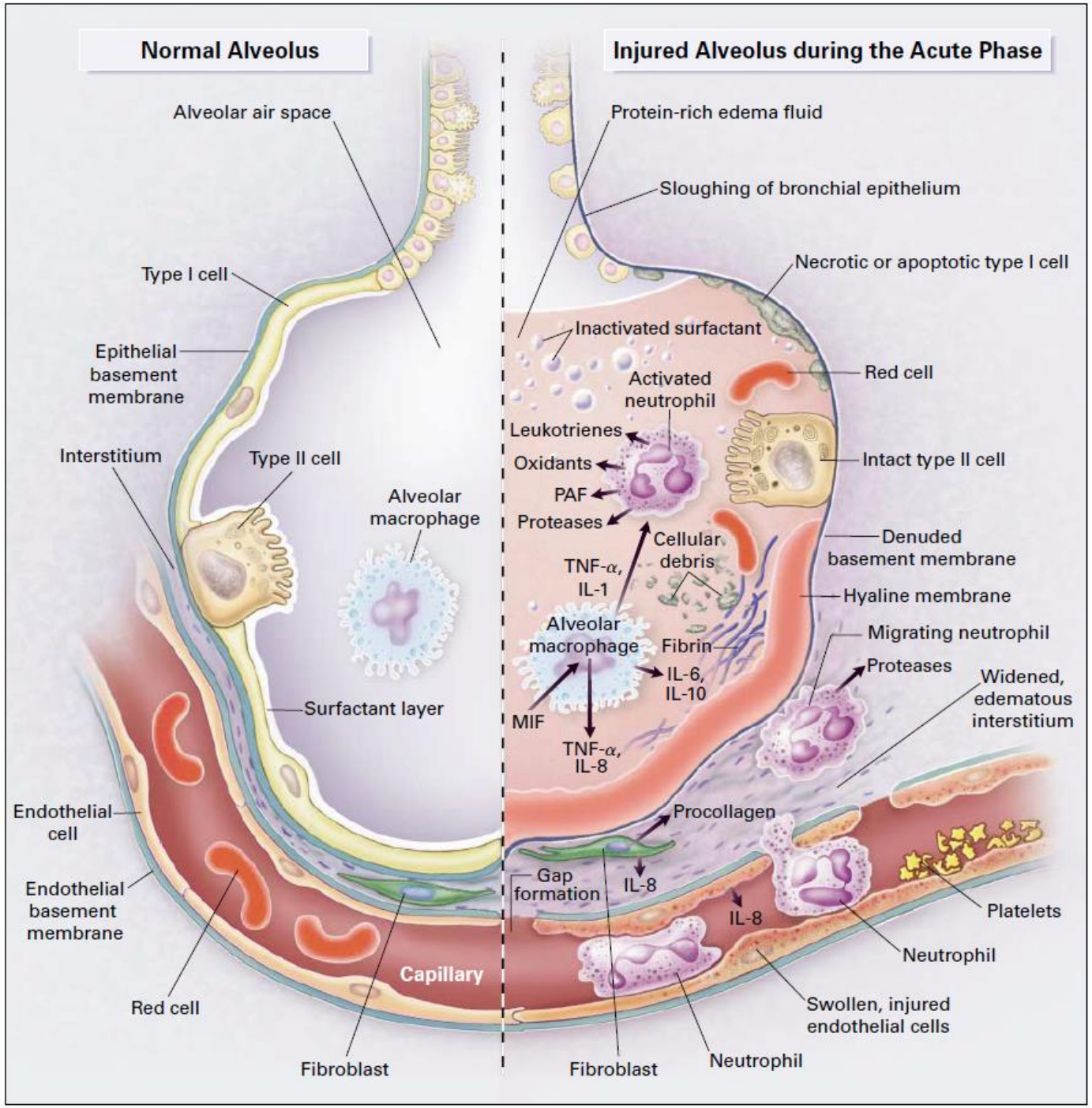


C



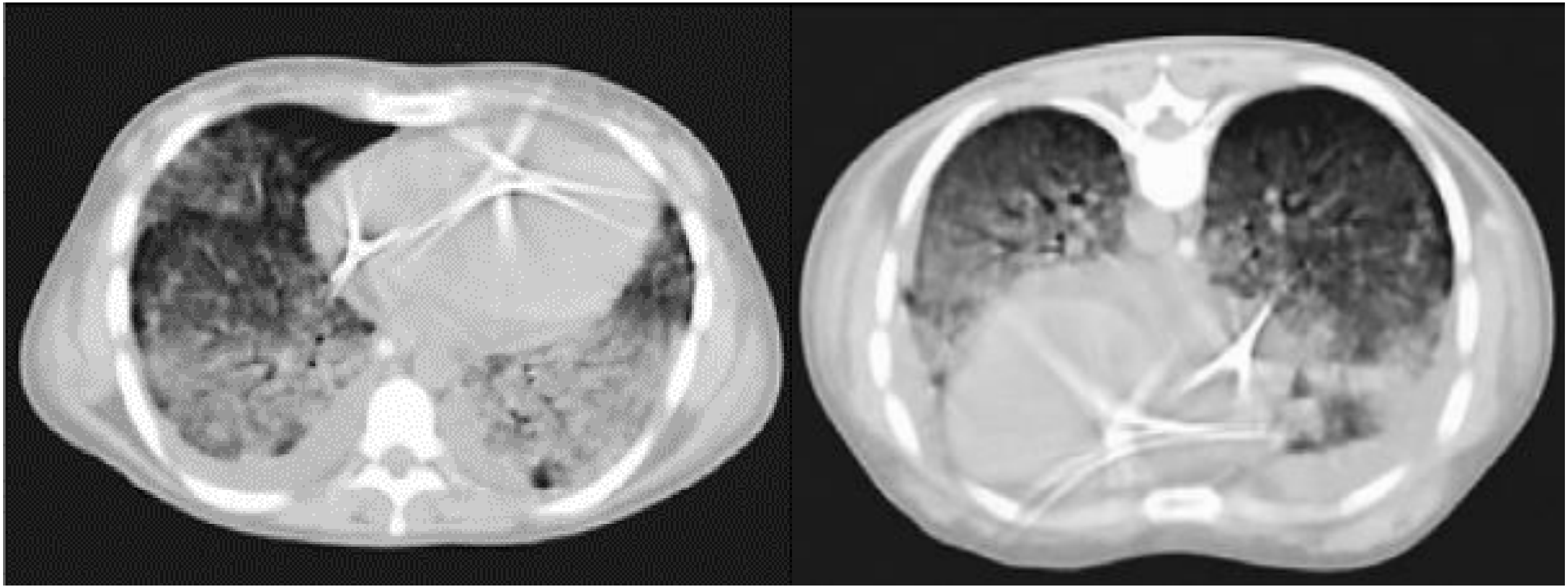
D

Ware LB, Matthay MA. N Engl J Med 2000;342:1334-1349.



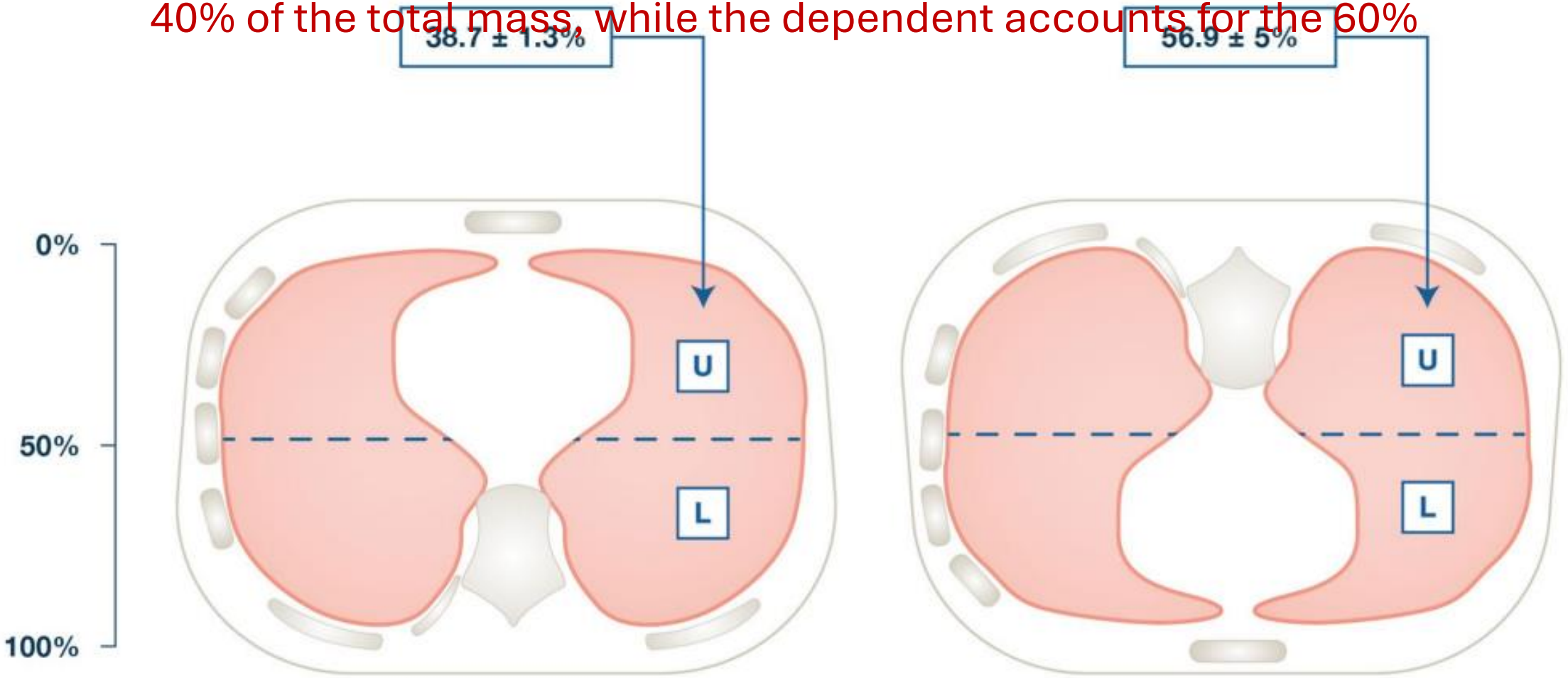
N Engl J Med 2000; 342:1334-1349

Prone Position Therapy



La Presse Médicale
Volume 40, Issue 12, Part 2, December 2011, Pages e585-

The open, non-dependent lung mass (at 50% of the sternum-vertebra distance) is about
40% of the total mass, while the dependent accounts for the 60%

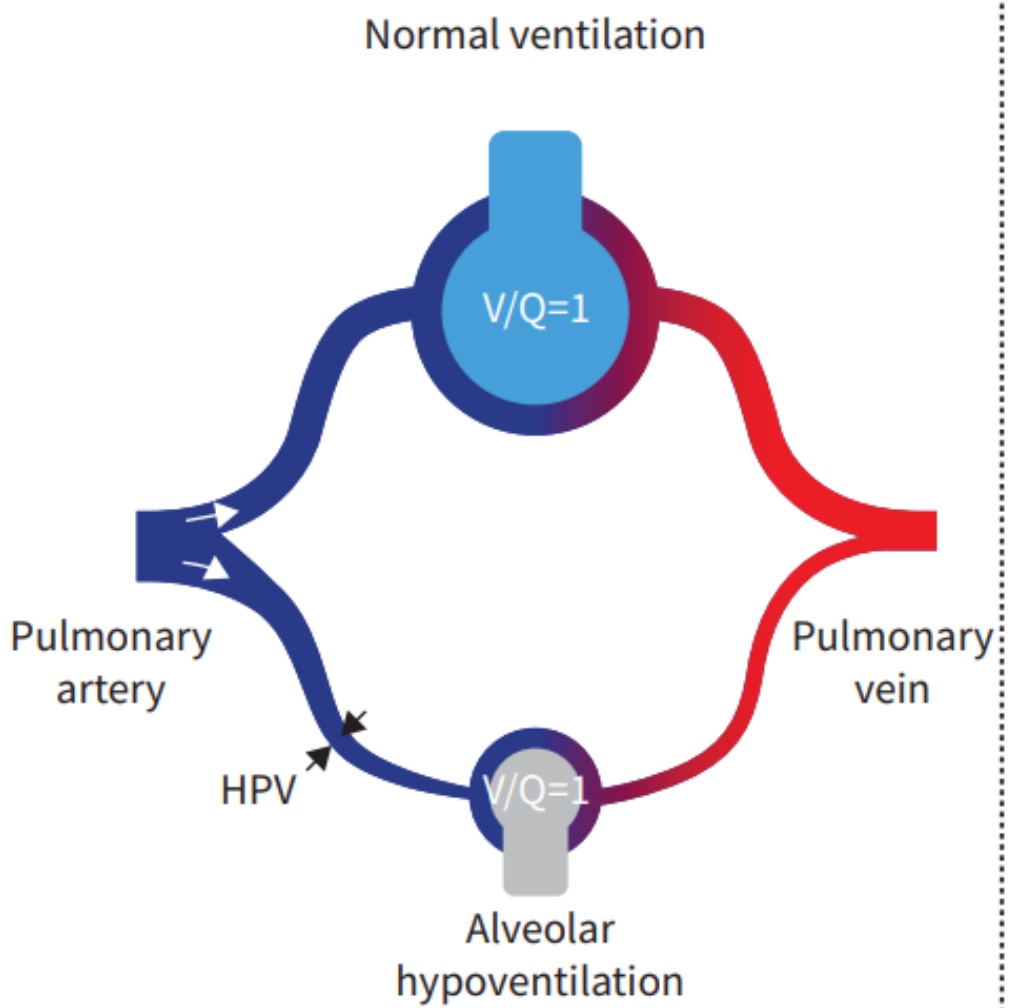


Supine **Prone**

Intensive Care Medicine volume 46, pages2385–2396 (2020)

b)

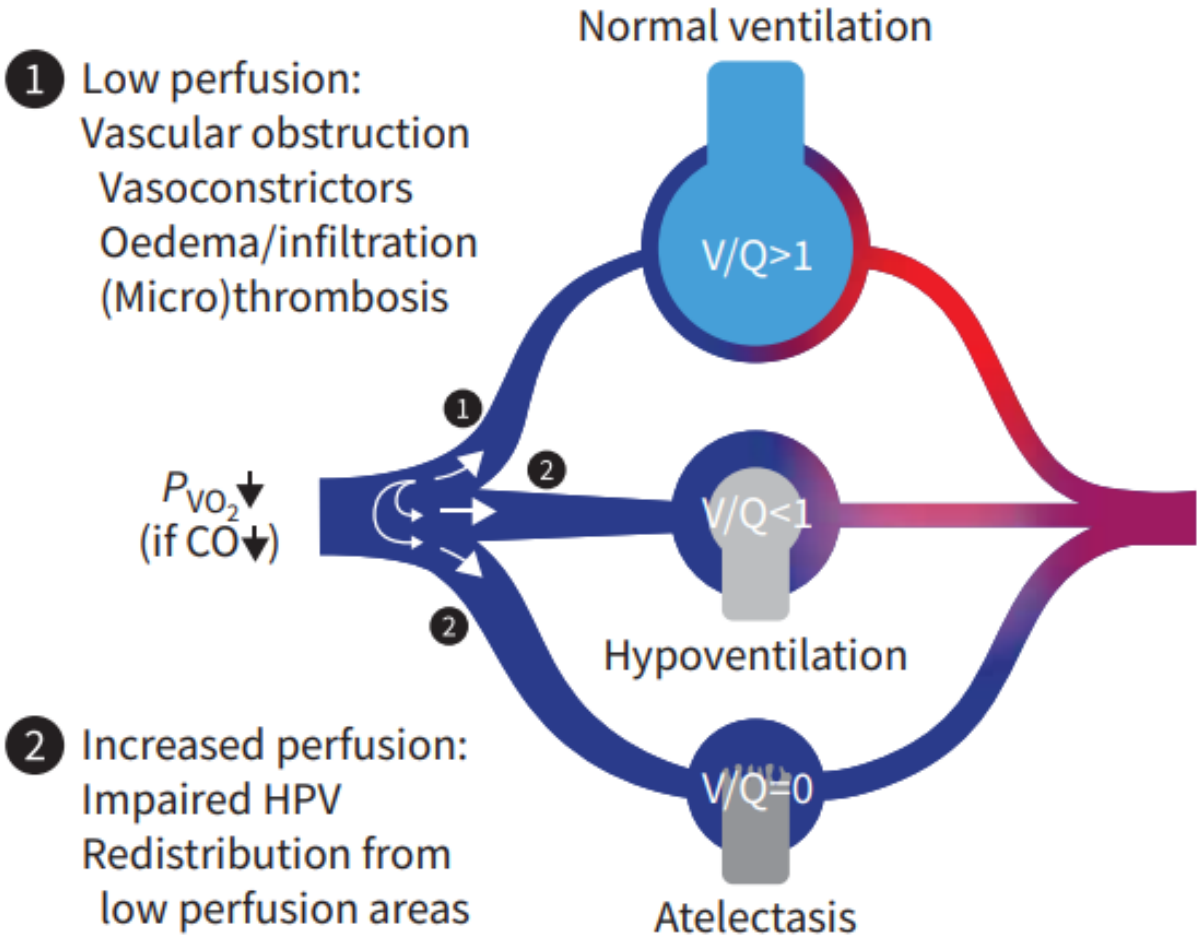
Healthy



V/Q matching

c)

ARDS

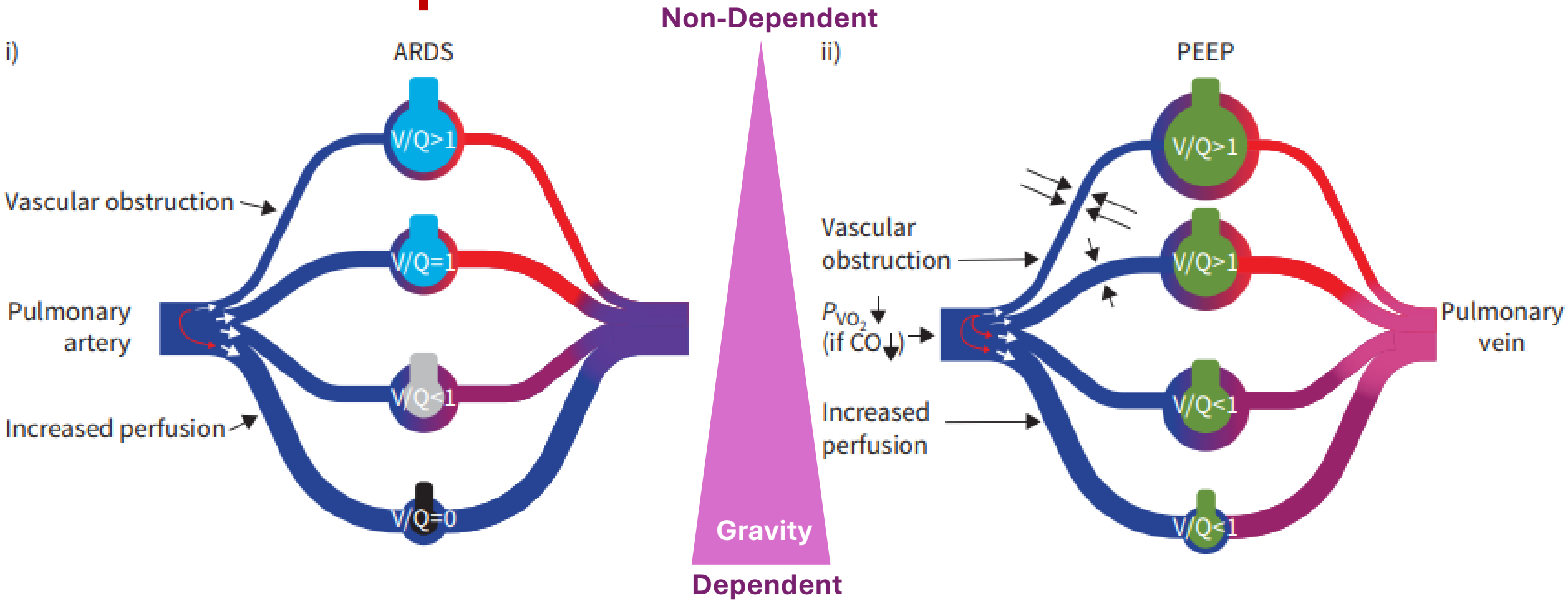


V/Q mismatch

Eur Respir Rev 2021; 30: 210059

Supine

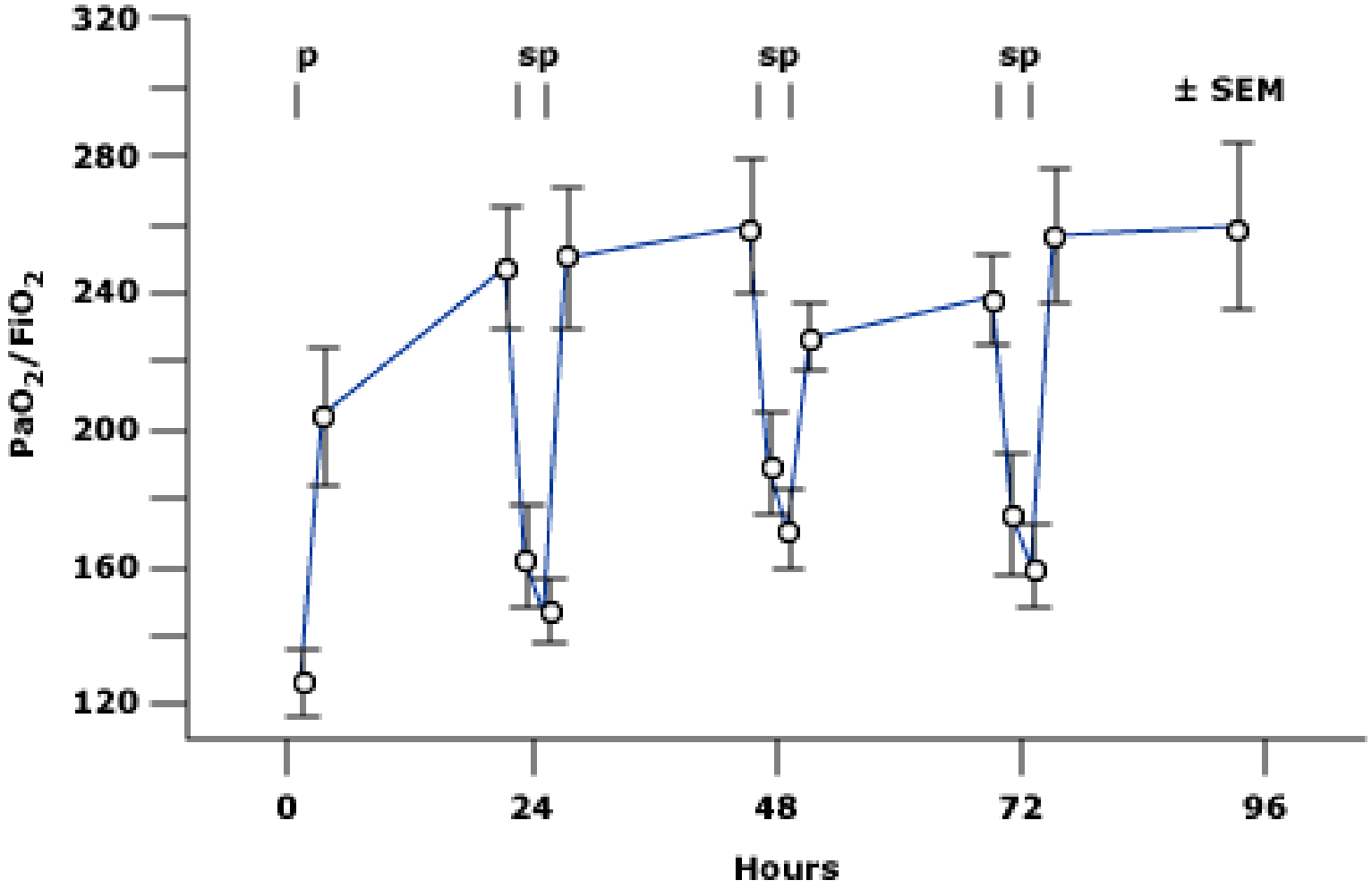
Prone



Eur Respir Rev 2021; 30: 210059

Colour codes: Well-ventilated alveoli; Atelectasis; Hypoventilation; Increased V due to PEEP

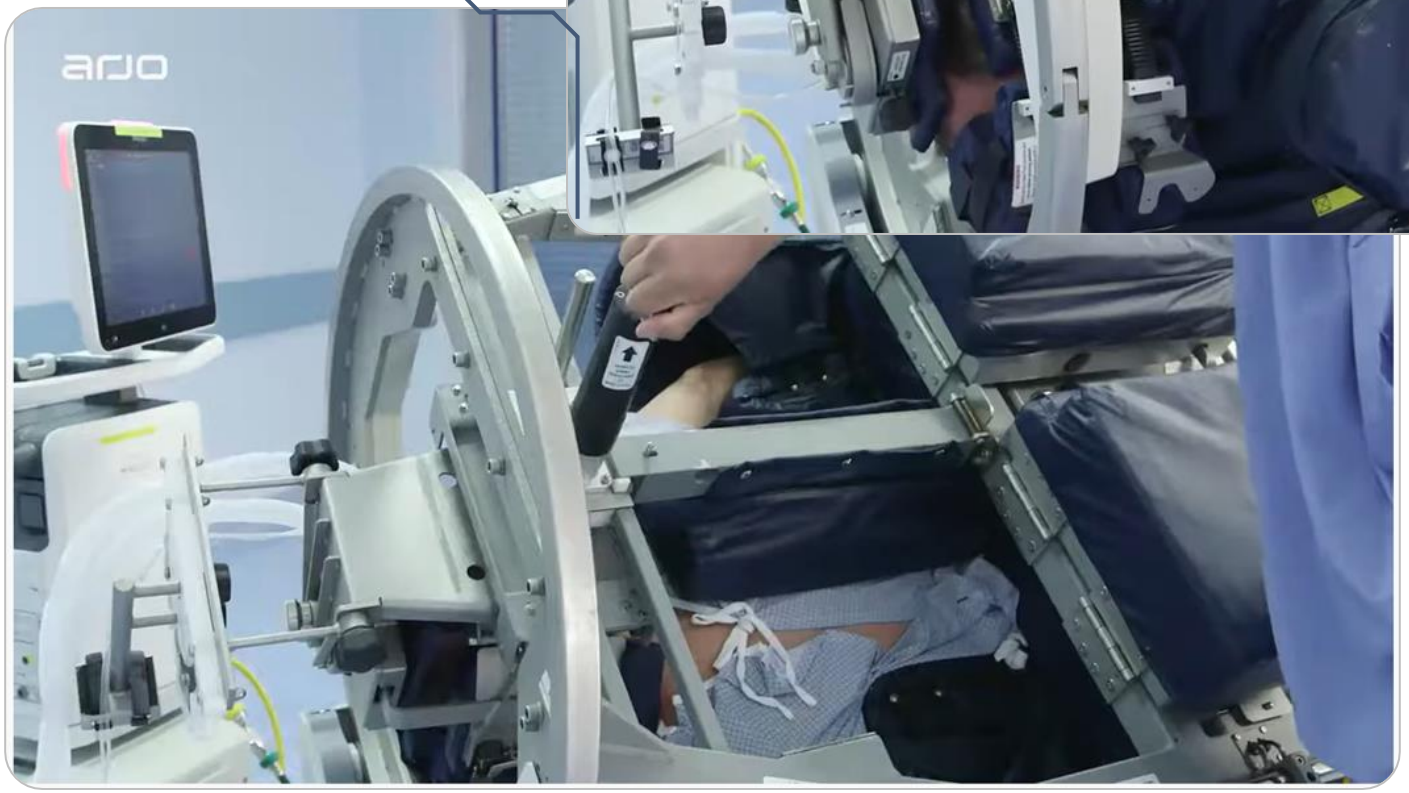
Course of PaO_2/FiO_2 during four consecutive 24-hour periods of prone positioning

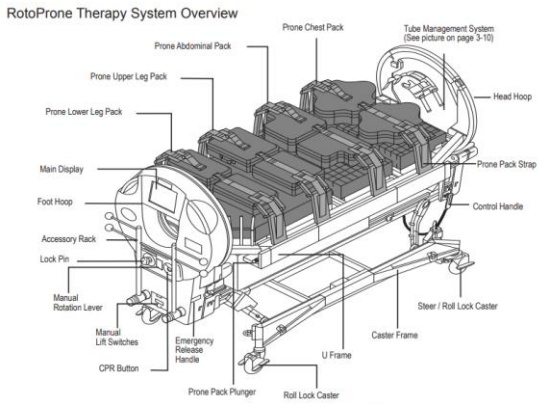


Anesth Analg 1996; 83:1206 UpToDate®

RoToProne

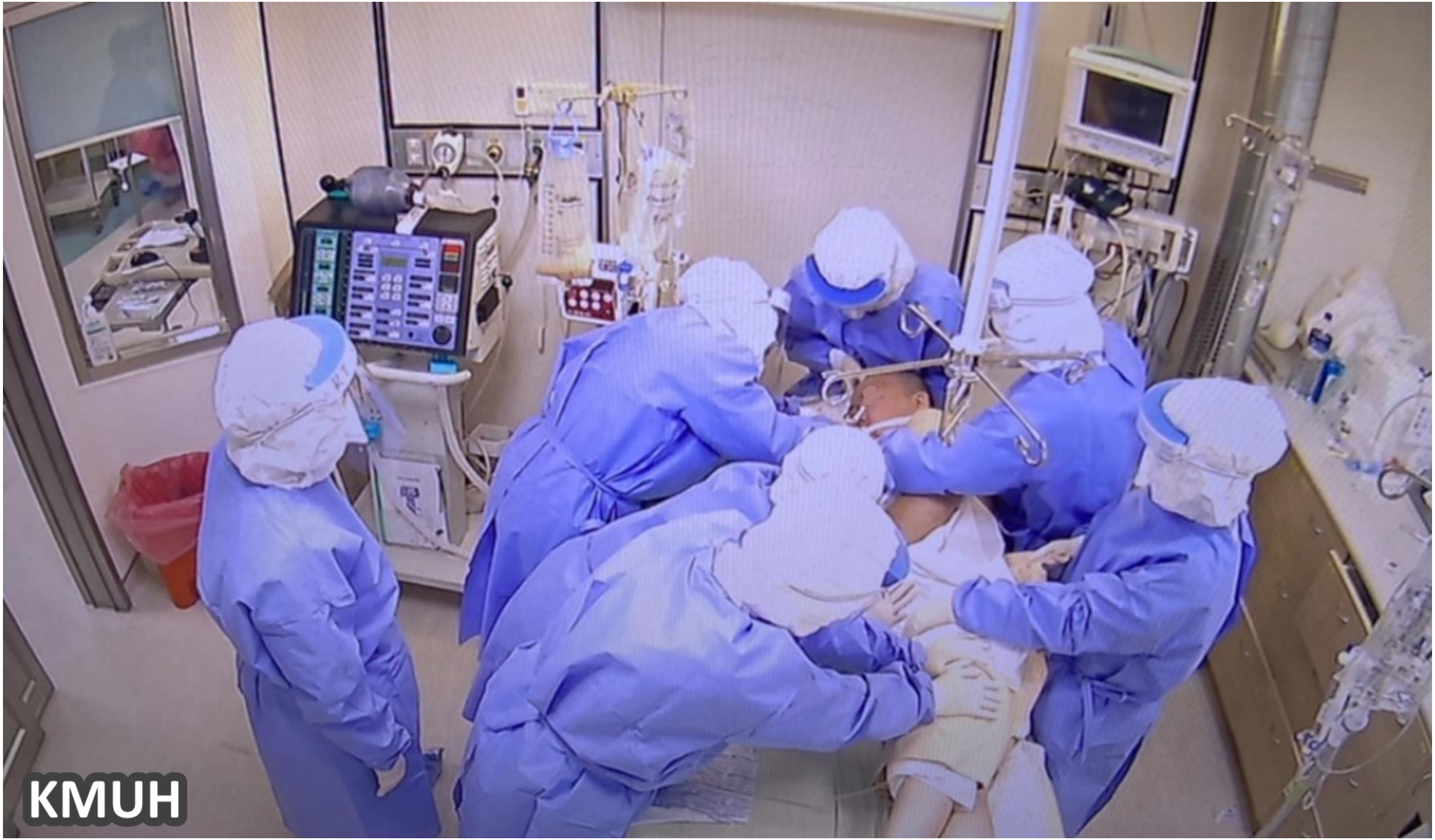
ARJO

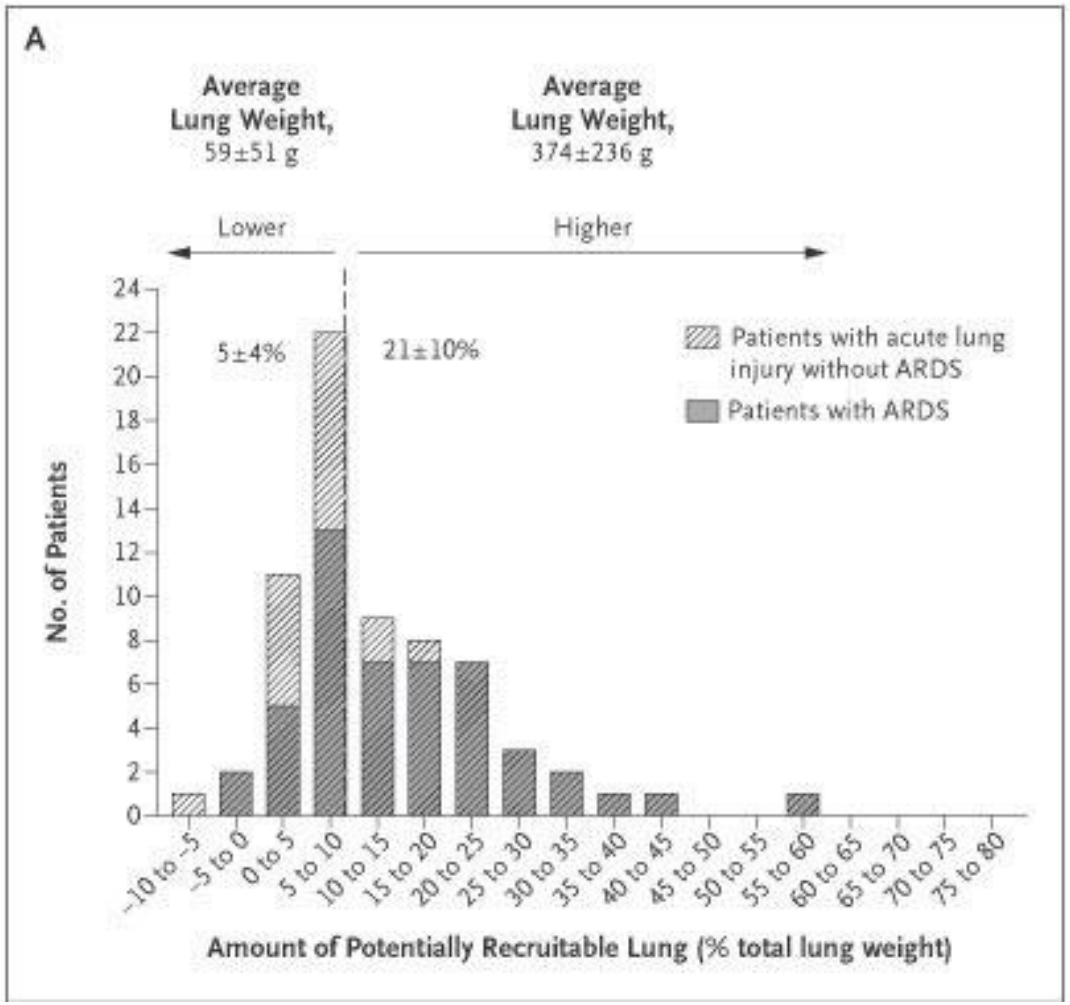


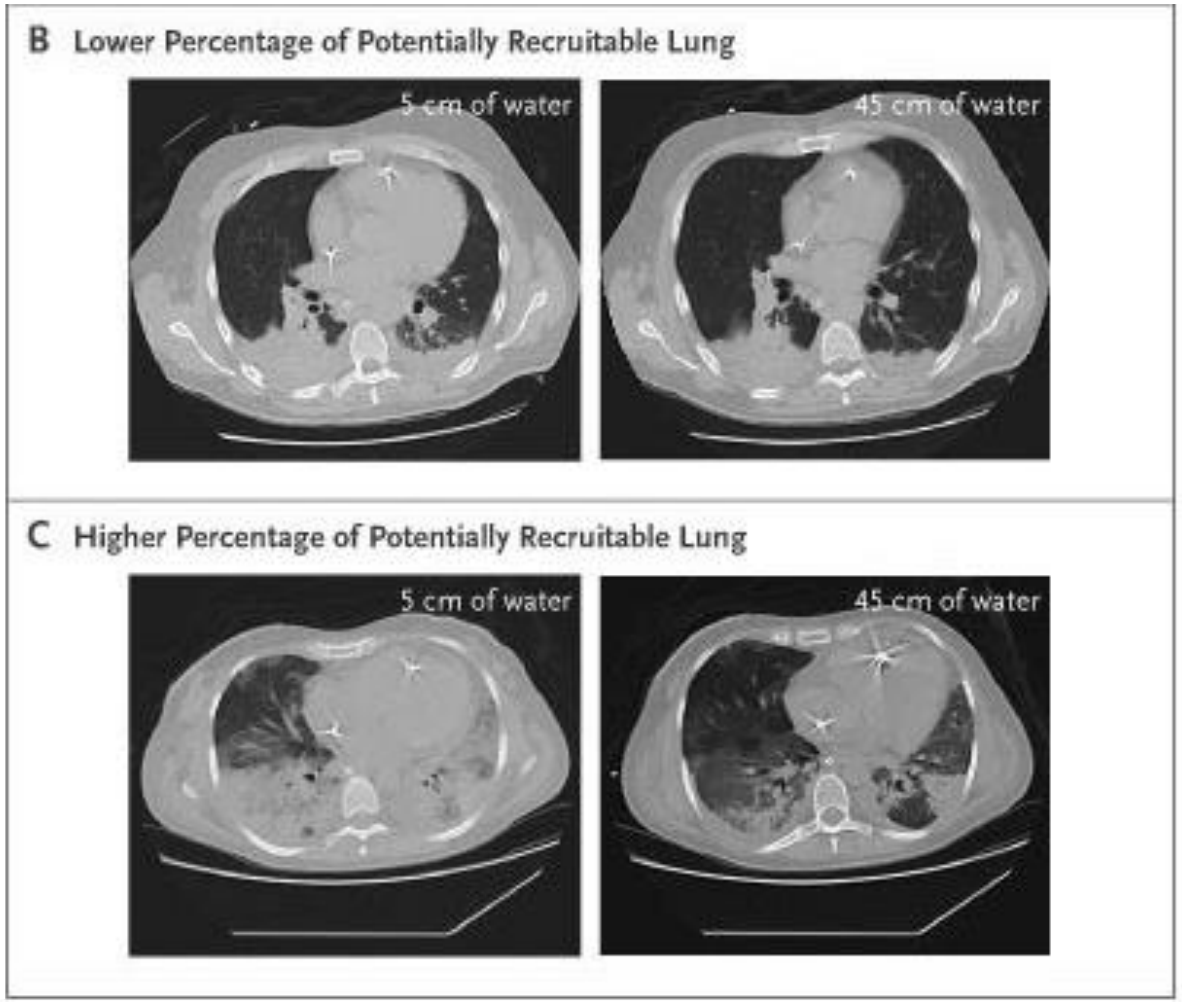


https://www.youtube.com/watch?v=x9AD3d6zBW8

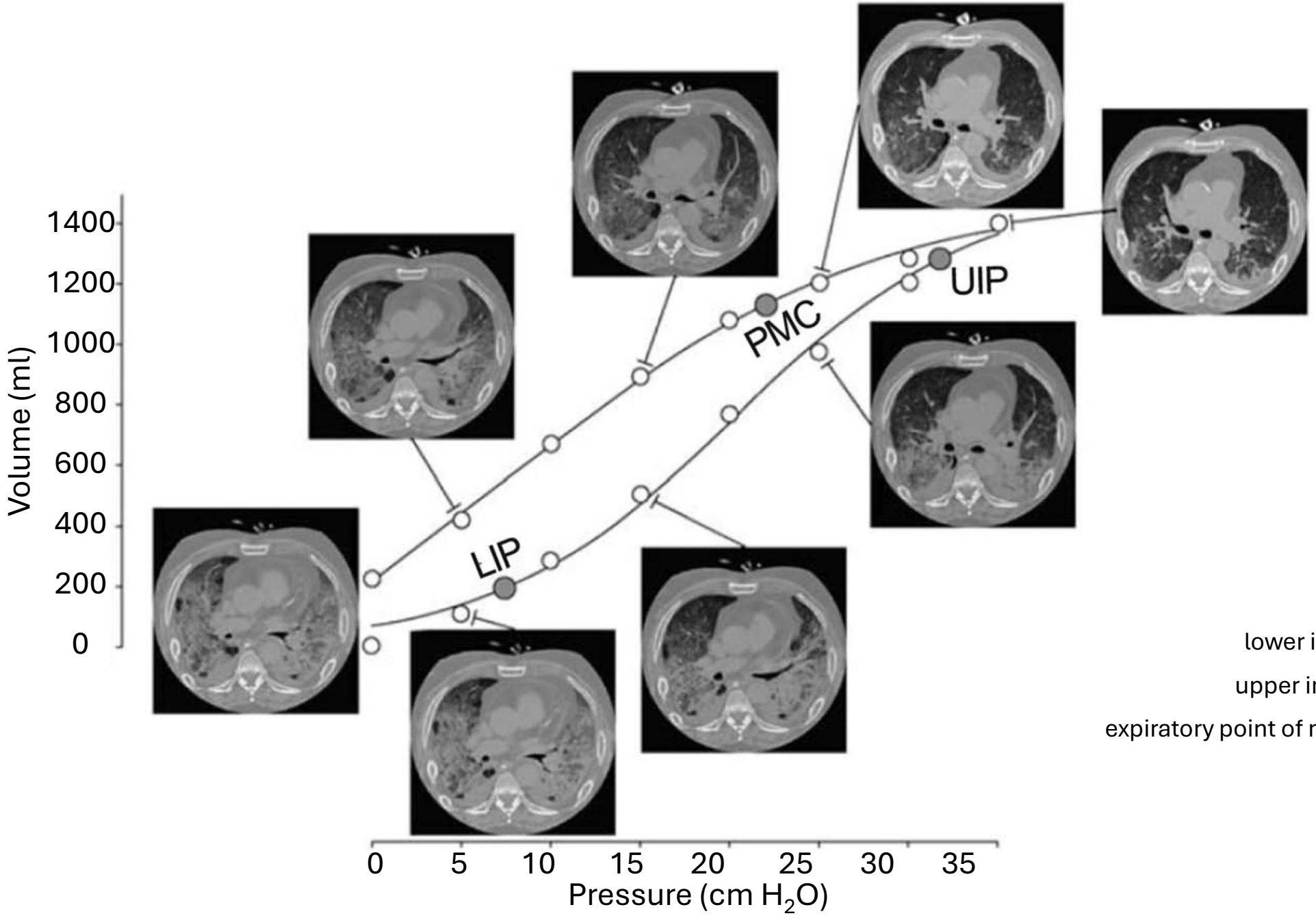
https://www.arjo.com/en-us/products/medical-beds/critical-


KMUH





Gattinoni, L. et al. N Engl J Med 2006;354:1775-1786

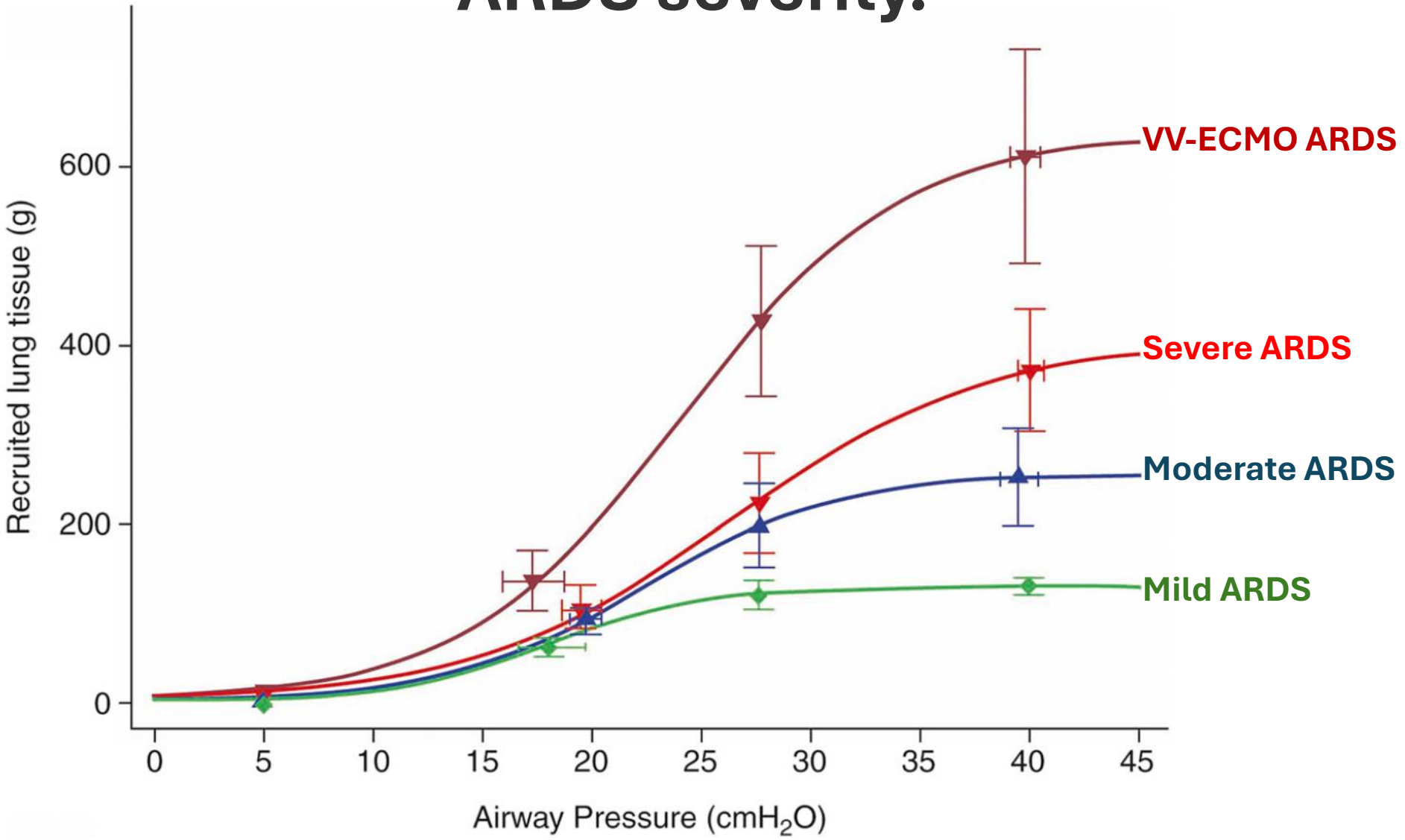


lower inflection point (LIP)

upper inflection point (UIP)

expiratory point of maximum curvature (PMC)

The amount of recruitable tissue increases with ARDS severity.



Zee and Gommers Critical Care (2019) 23:73

CONFERENCE REPORTS AND EXPERT PANEL

ESICM guidelines on acute respiratory distress syndrome: definition, phenotyping and respiratory support strategies

Ventilator Recruitment Maneuvers (RMs)

- **Definition:**

  Temporary increase in airway and transpulmonary pressure above tidal ventilation levels.

  Goal: Promote re-aeration of previously collapsed lung regions (lung recruitment).
- **Mechanism:**

  Pressure during RMs typically exceeds closing pressure, aiding in the reopening of collapsed lung units.
- **Benefits:**

  Increased End-Expiratory Lung Volume: Achieved after RM, potentially durable.

  Improved Gas Exchange: Enhances oxygenation and CO2 removal.

  Homogenization of Alveolar Distension: Promotes uniform lung expansion.

  Decreased Lung Stress and Strain: Reduces risk of ventilator-induced lung injury.
- **Considerations:**

  Variability in occurrence and durability of effects.

Intensive Care Med. 2023 Jun 16;49(7):727–759.

Risks of High-Pressure Maneuvers:

- **Over-Distension Complications:**
  - Barotrauma
  - Reduced venous return
  - Increased pulmonary vascular resistance
  - Right ventricular failure
  - Potential for hemodynamic collapse
- **Strategies for Performing RMs:**
- Variations in:
  - **Duration:** Length of the maneuver
  - **Pressure Target(s):** Levels of pressure applied
  - **Frequency:** How often RMs are performed
  - **Ventilator Maneuver:** Specific techniques used

Intensive Care Med. 2023 Jun 16;49(7):727–759.

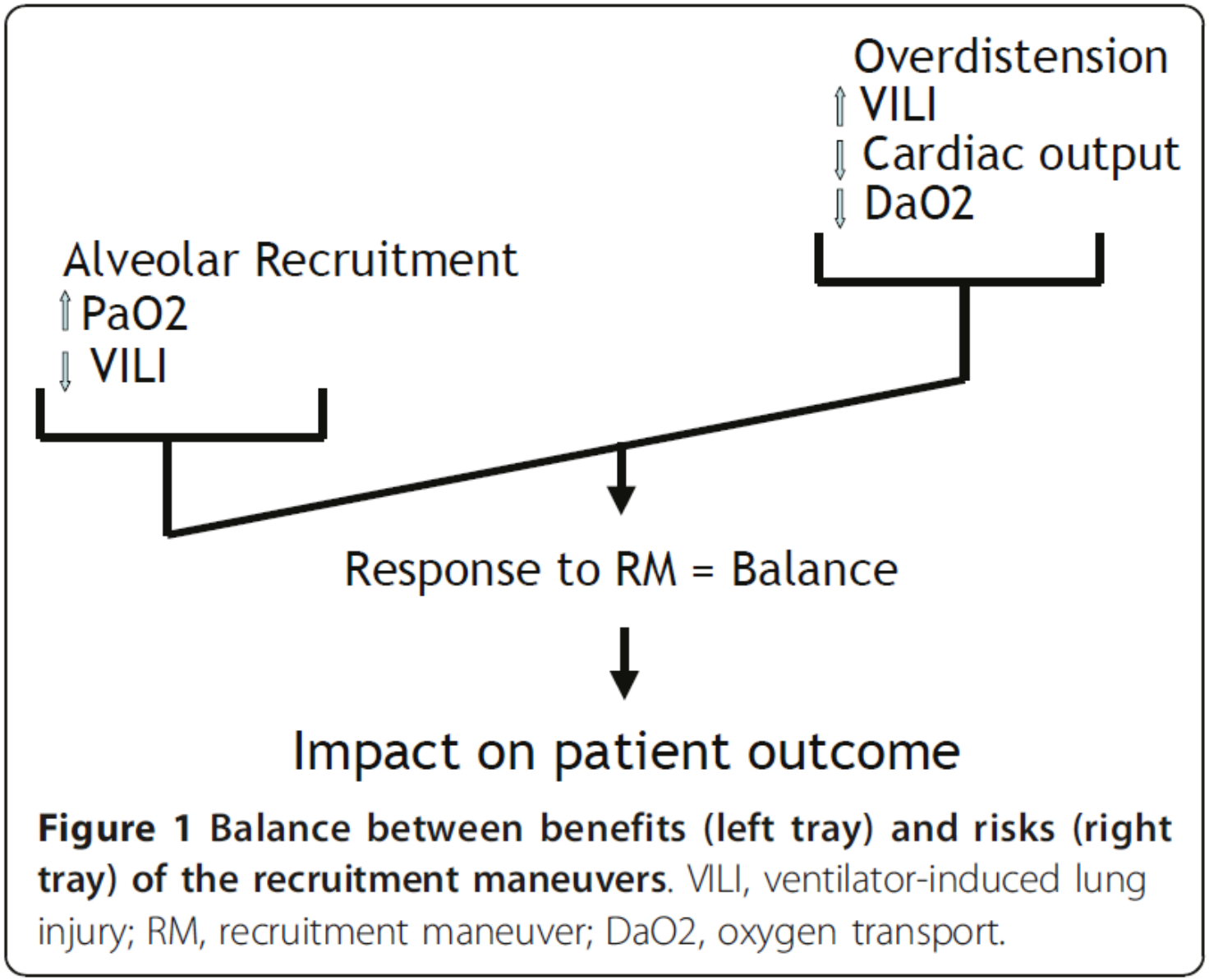


Figure 1 Balance between benefits (left tray) and risks (right tray) of the recruitment maneuvers. VILI, ventilator-induced lung injury; RM, recruitment maneuver; DaO2, oxygen transport.

Guerin et al. Annals of Intensive Care 2011, 1:9

Electrical Impedance tomography

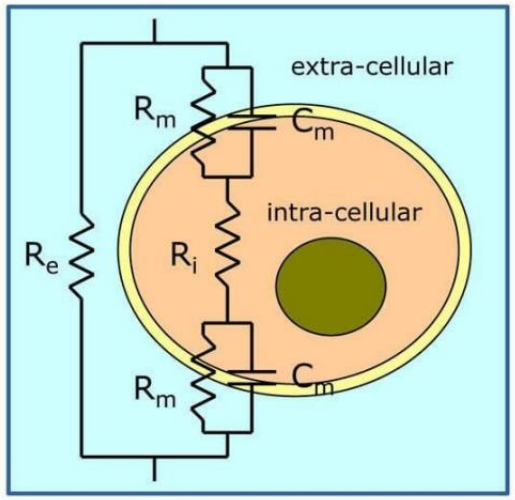


Fig.1: The equivalent electrical circuit model for tissues.

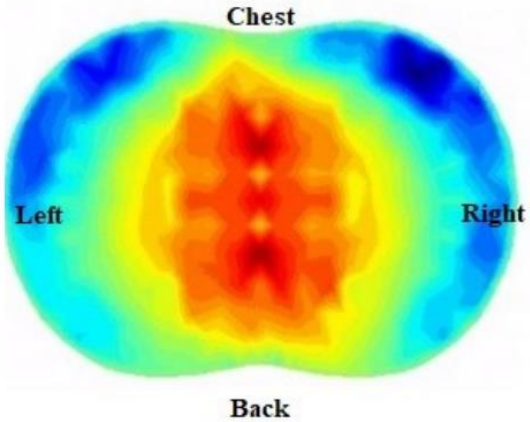


Fig. 3: Chest image reconstruction by EIT [21].

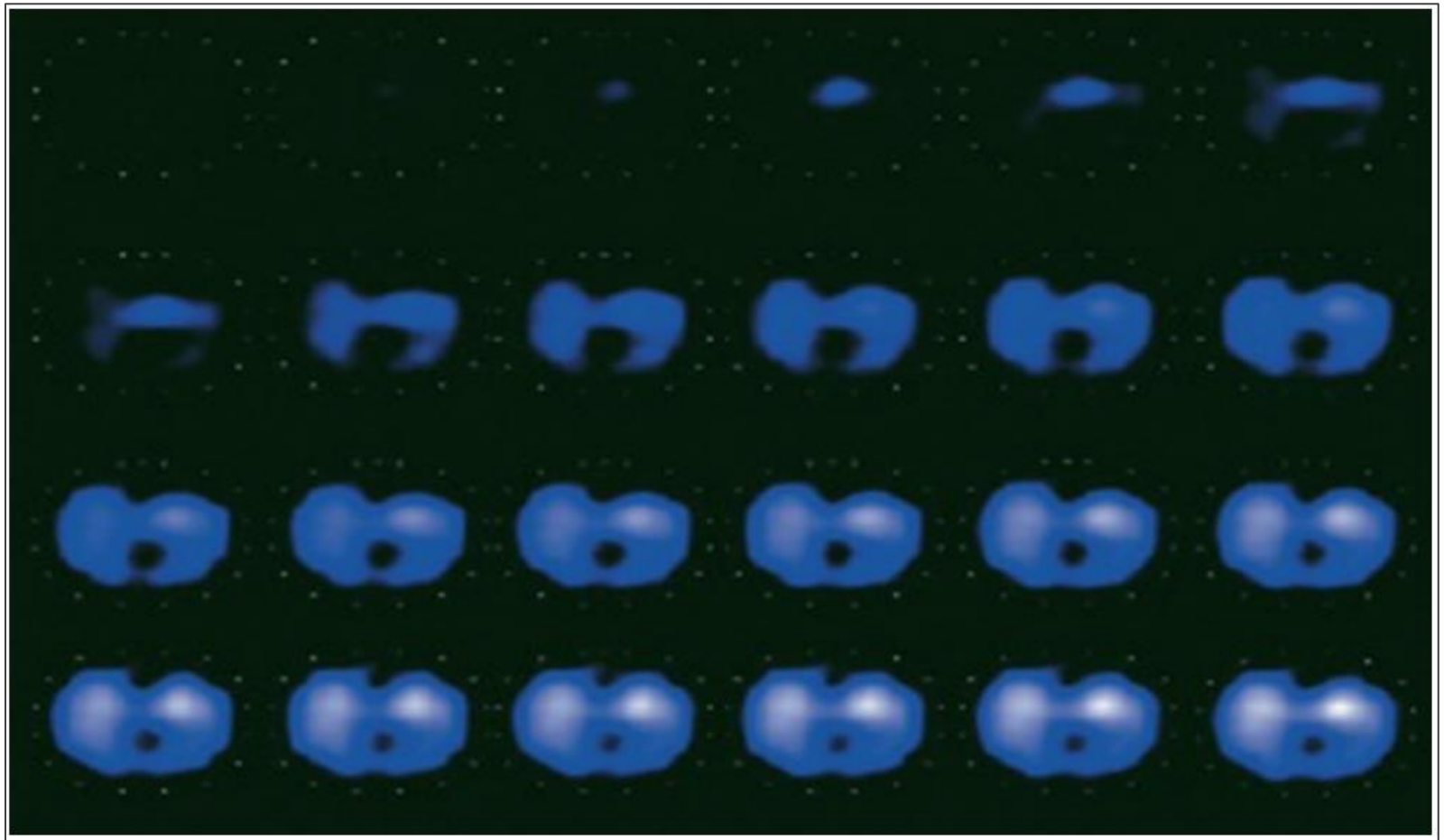


Fig. 6: Series of dynamic images showing air filling during inspiration by the PulmoVista500 system [81].

Mansouri et al.: Electrical impedance tomography. J Electr Bioimp, 12, 50-62,

History of EIT - Applied potential tomography

Definition and Principle

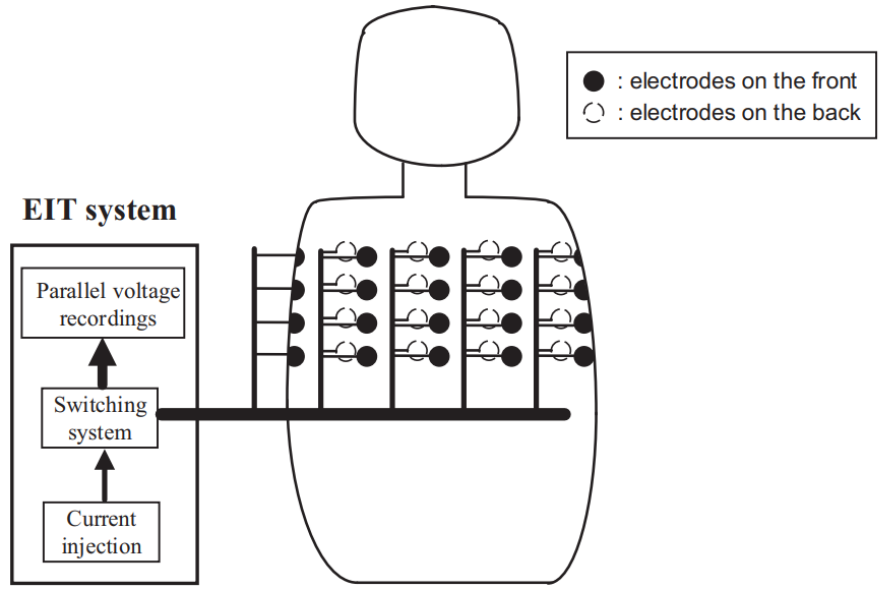
•APT is a novel imaging technique designed to detect **changes in the electrical resistivity distribution** within the human body.
•These changes reflect physiological activities such as **respiration, cardiac cycles, or fluid redistribution**.

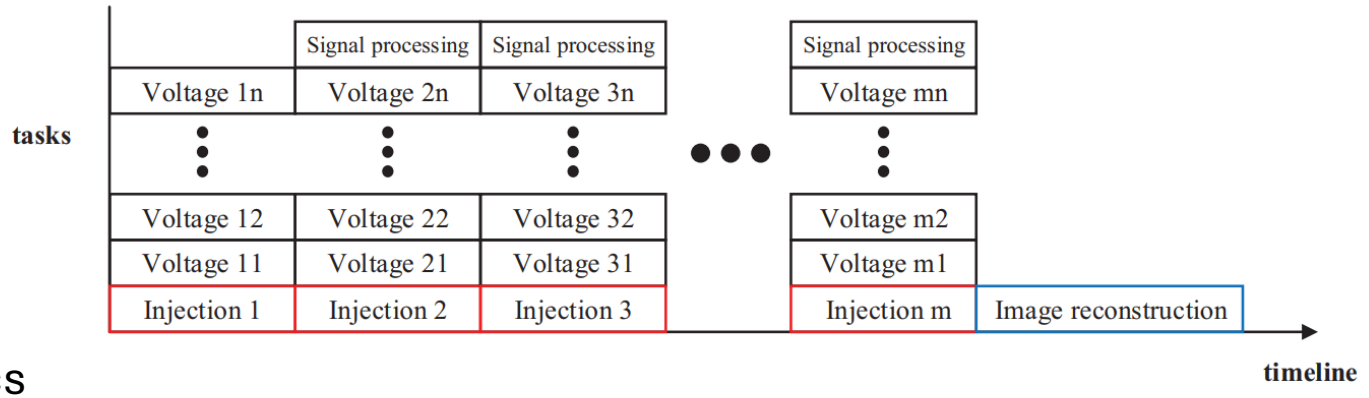
Physiological Applications

•**Respiration:** Variations in lung air volume cause measurable resistivity changes.
•**Cardiac Cycle:** Blood flow within the thorax alters electrical conductivity during each heartbeat.
•**Fluid Redistribution:** Under simulated weightlessness, body fluid shifts produce observable impedance variations.

J Br Interplanet Soc. 1989 Aug;42(7):391-3.

EIT system recording voltage in parallel





Medical Engineering & Physics
Volume 84, October 2020, Pages 36-50

Non-invasive real time lung monitoring—the upcoming future?

基本概念

- EIT 是一種 **非侵入性、無輻射、可即時影像化的肺通氣監測技術**。
- 利用電流注入胸壁電極測量電壓變化，重建胸腔內的電導（或阻抗）分布。

電極與測量方式

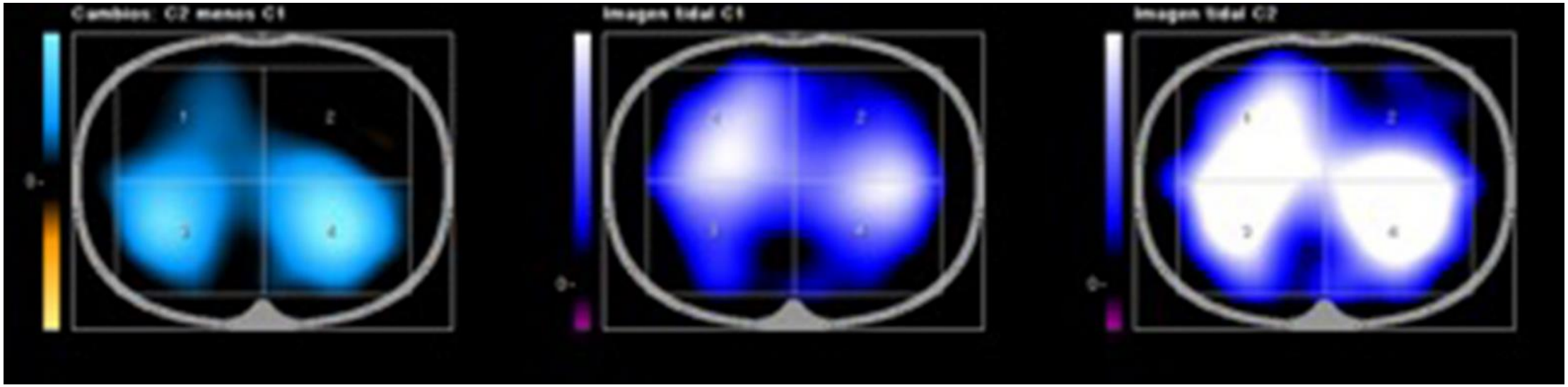
- 通常使用 **16 或 32 個電極** 的皮帶環繞胸廓（約第 4–5 肋間）。
- 小電流以兩電極注入，其餘電極量測電壓；逐對切換，共形成 **208 組量測值（frames）**。
- 每秒可重建約 **50 幅影像**，顯示胸腔阻抗變化。

生理意義

- **空氣量增加 → 阻抗上升（導電性下降）**。
- **血液或液體增加 → 阻抗下降（導電性上升）**。
- 因此能即時偵測肺內氣體含量、液體堆積或血流變化。

Ann Transl Med 2018;6(2):26

Non-invasive real time lung monitoring—the upcoming future?



Basal EIT PEEP 5-10 PEEP 10

Ann Transl Med 2018;6(2):26

Real-time effects of PEEP and tidal volume on regional ventilation and perfusion in experimental lung injury

Experimental Subjects

- A total of **11 piglets** were studied: **4 healthy controls** and **7 with lung injury** induced by repeated saline lung lavages.
  Due to one cardiovascular event, **10 animals completed the experiment** and were included in the final analysis.

Ventilation Settings

- Mechanical ventilation was applied using **three tidal volumes (VT)** of **7, 10, and 15 mL/kg**,
  and **four levels of positive end-expiratory pressure (PEEP)**: **5, 8, 10, and 12 cmH_2O**.
  All **12 combinations** of VT and PEEP were tested in **randomized order** for each animal.

Electrical Impedance Tomography (EIT) Monitoring

- Each pig had **32 electrodes** evenly placed around the thoracic circumference to record impedance changes within the lung. The lungs were divided into **three gravity-dependent regions of interest (ROIs)**: **nondependent**, **middle**, and **dependent** regions.
- Ventilation maps were obtained from **changes in air content**, while perfusion maps were derived by injecting **10 mL of 10% NaCl** as a conductive contrast agent during an **end-expiratory breath-hold**. The resulting impedance changes were analyzed to **estimate regional pulmonary blood flow**.

Borges et al. Intensive Care Medicine Experimental (2020) 8:10

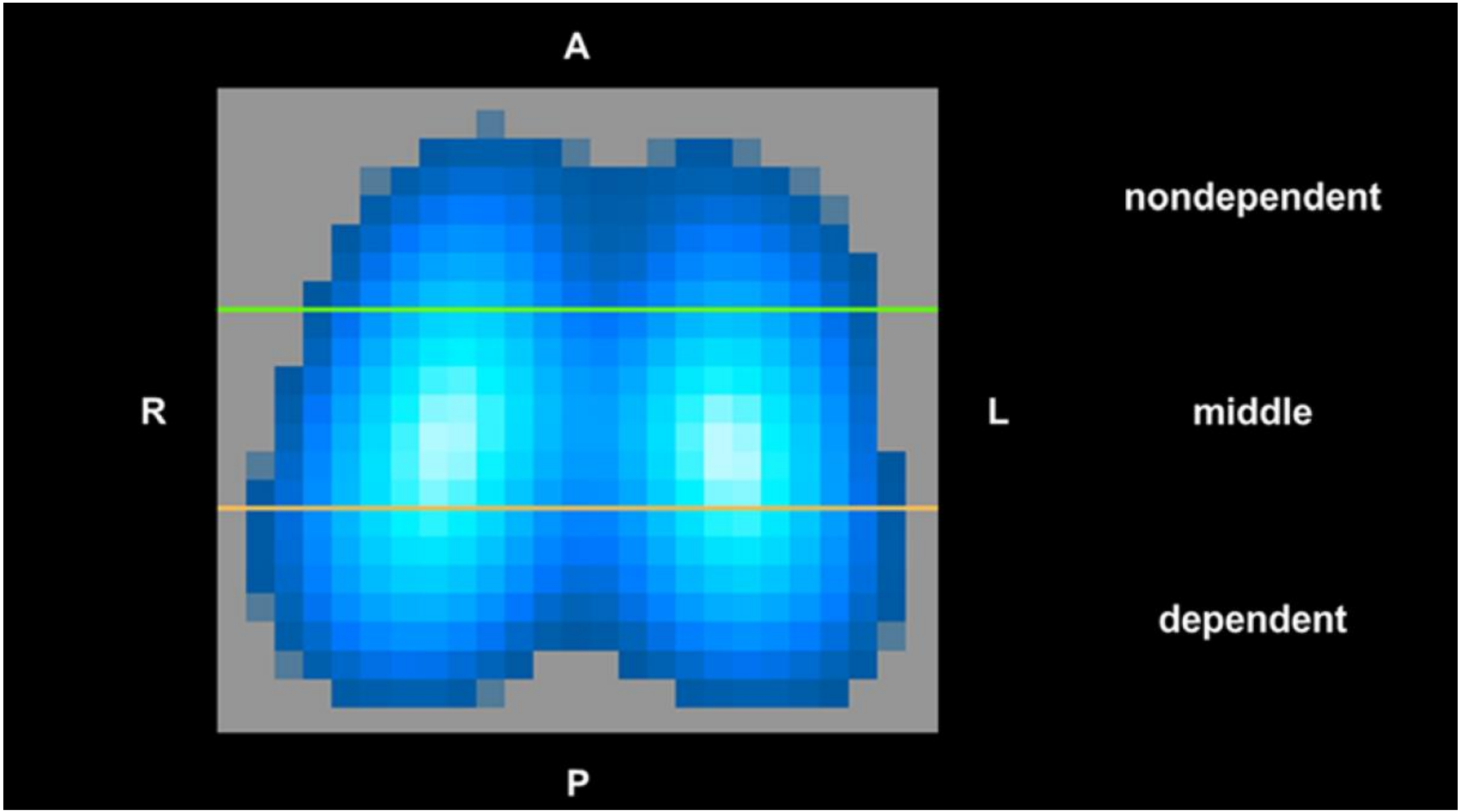
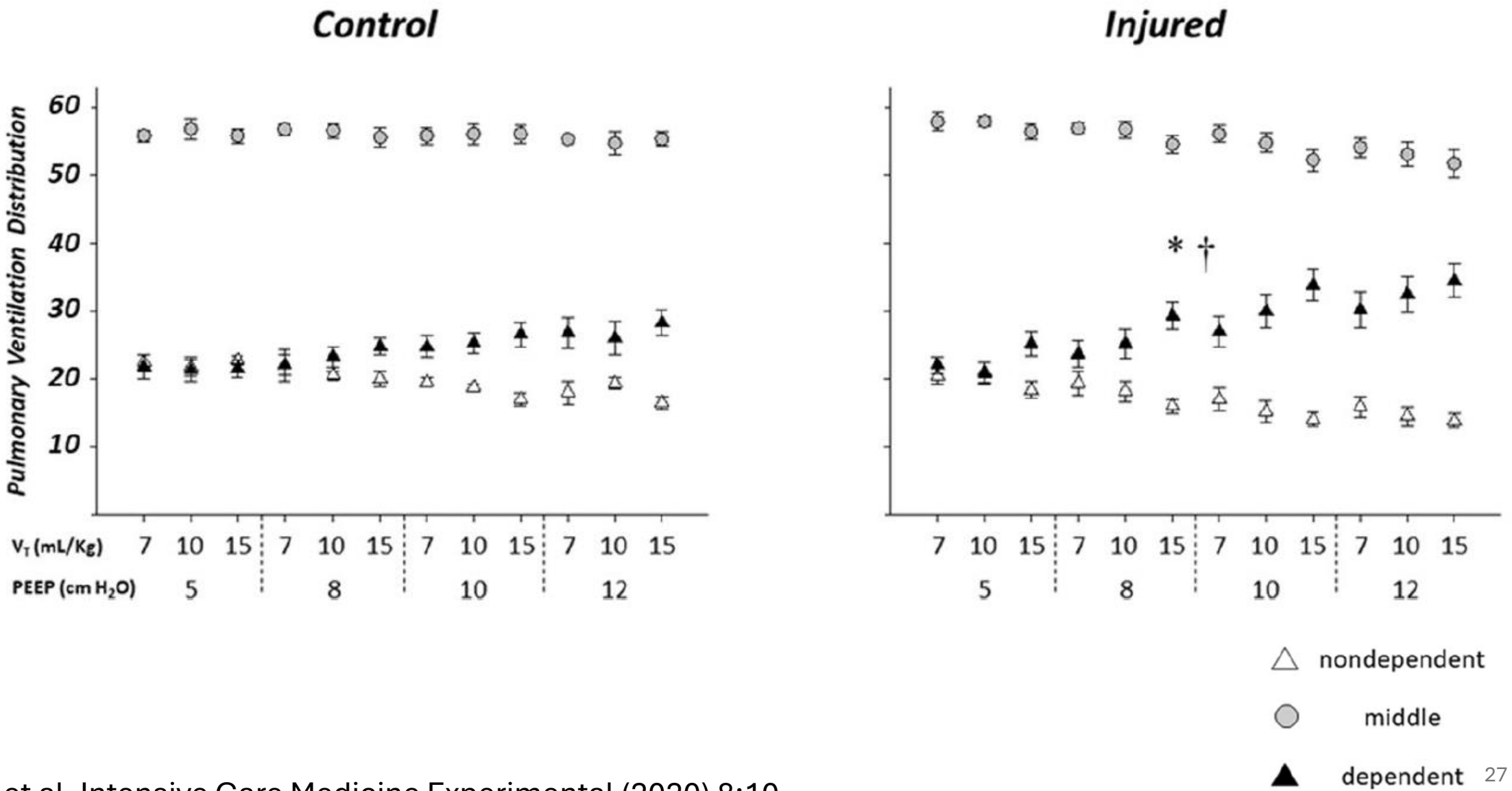

A
R
L
P
nondependent
middle
dependent

Table 1 Cardiopulmonary parameters

Parameter	Control				Injured						Control	Injured
	C1	C2	C3	C4	I1	I2	I3	I4	I5	I6	Mean (SD)	Mean (SD)
Weight (kg)	30	33	30	33	30	28	29	33	31	31	31 (2)	30 (2)
Lavage volume (L)	0	0	0	0	4	5	2	4	9	2	0 (0)	4 (3)
P/F ratio (mmHg)	287	384	441	373	158	206	153	104	164	143	371 (64)	154 (33)*
ABP (mmHg)	65	78	89	79	68	95	97	97	75	62	78 (10)	82 (16)
PAP (mmHg)	20	27	14	20	34	27	27	20	32	34	20 (5)	29 (6) #
CVP (mmHg)	6	11	11	6	13	8	11	6	8	12	9 (3)	10 (3)
HR (bpm)	75	87	82	143	97	105	98	107	107	93	97 (31)	101 (6)
CO (L/min)	1.9	4.0	3.0	6.1	3.6	3.9	3.2	4.0	4.1	3.4	3.8 (1.8)	3.7 (0.4)

Borges et al. Intensive Care Medicine Experimental (2020) 8:10



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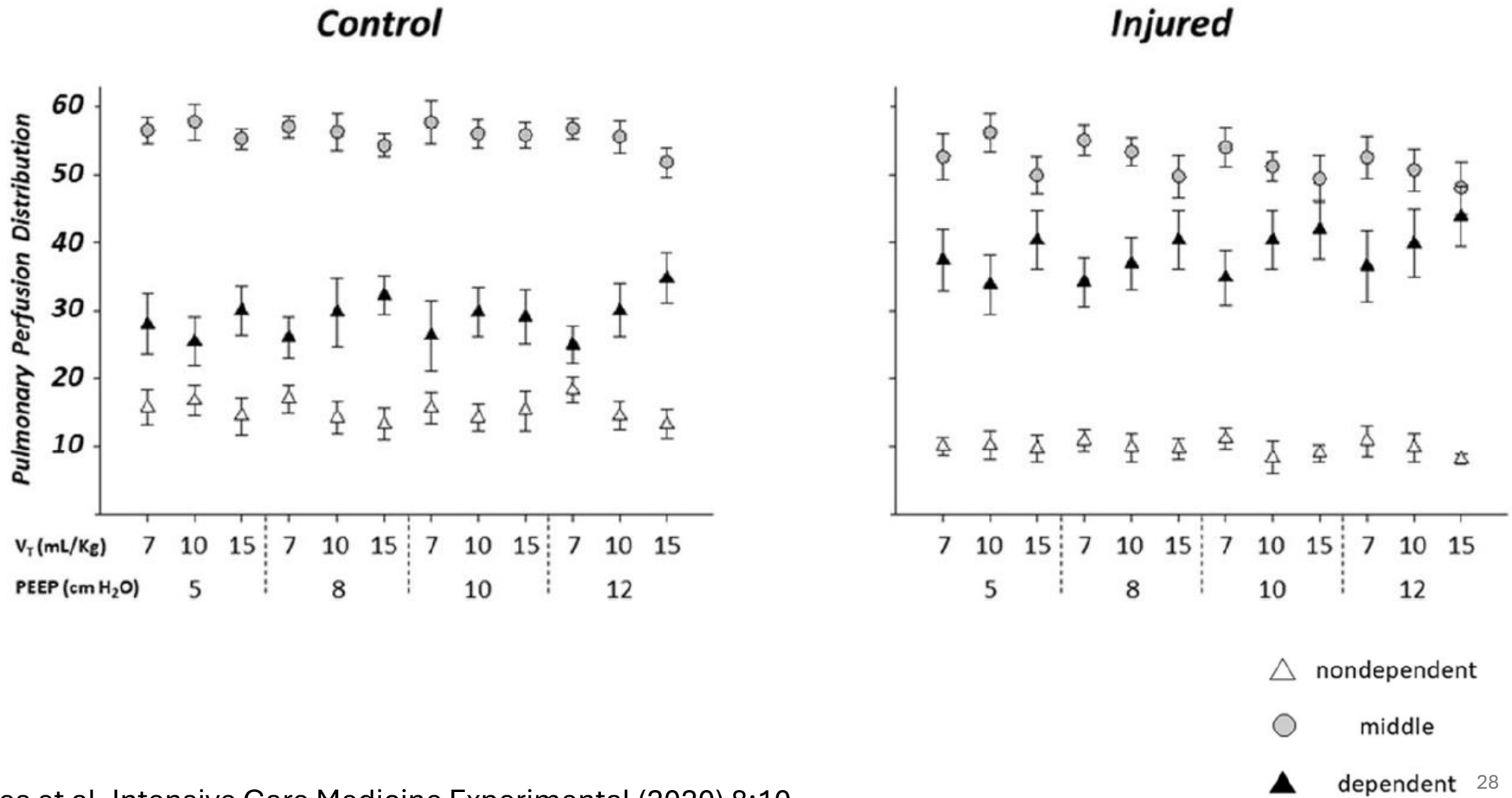
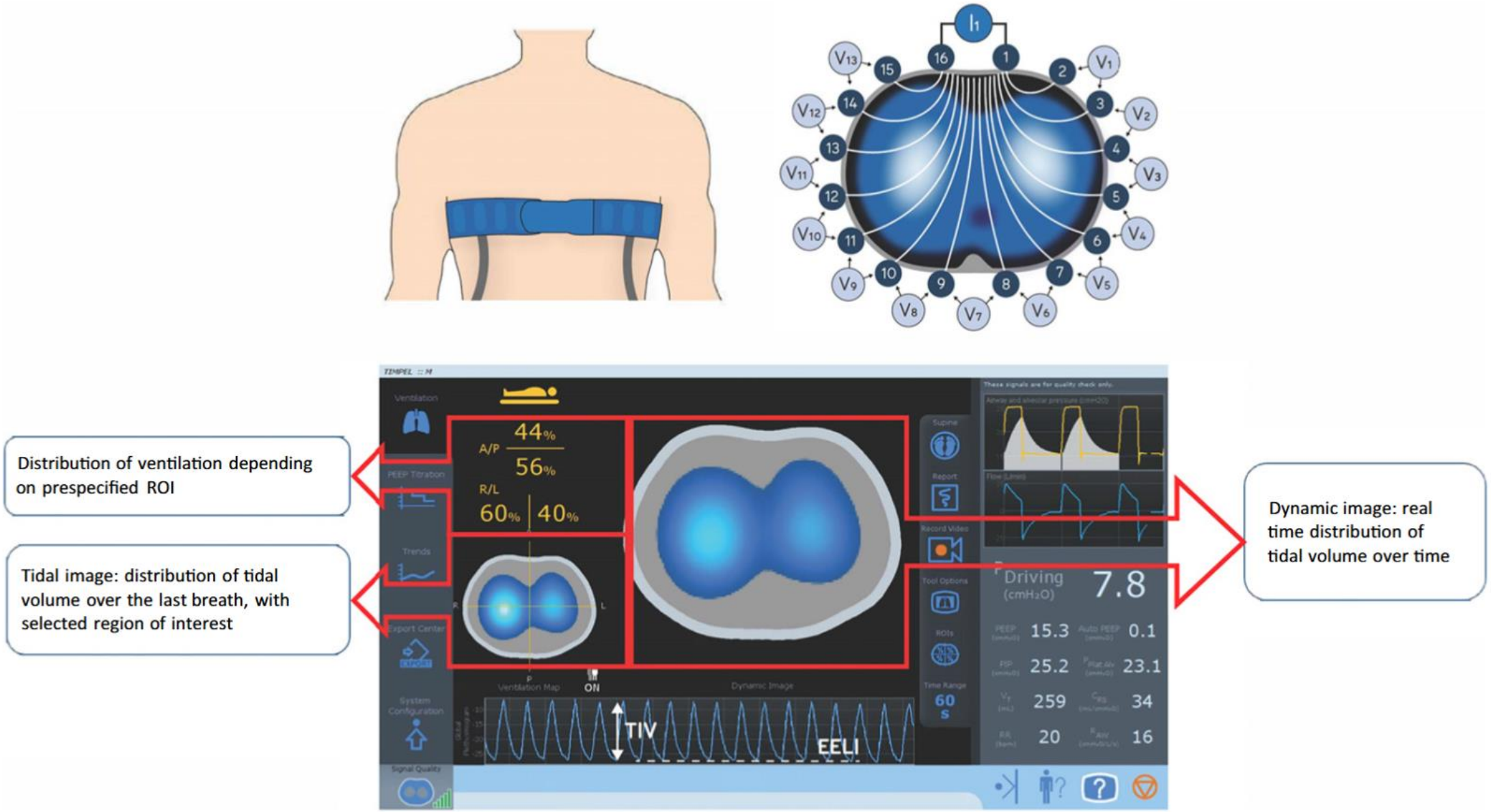


Borges et al. Intensive Care Medicine Experimental (2020) 8:10



American Journal of Respiratory and Critical Care Medicine Volume 209 Number 6 | March 15 2024

Table 1. Definition, Clinical Application, and Limitations of the Most Commonly Used EIT Indices in Patients with Hypoxemic Respiratory Failure

EIT Indices	Definition	Potential Applications	Limits
TIV (tidal impedance variation)	Variation of impedance values between end of inspiration and end of expiration (amplitude of plethysmogram signal)	• Reflects global and regional relative distribution of V_T in lungs during ventilation • Contributes to identification of pleural effusion, pneumothorax, endotracheal tube malposition, pendelluft	• Cannot be used for detailed anatomic diagnosis • Only relative distribution of V_T
EELI (end-expiratory lung volume)	Regional lung impedance at end of expiration	• EELI changes are correlated with EELV variation • Reflects lung recruitment/ derecruitment • Contributes to identification of pneumothorax	• Affected by factors other than lung volume (inflatable mattress, fluid infusion)
Global inhomogeneity index	Sum of absolute differences between median TIV and each pixel TIV normalized to sum of each pixel TIV	• Reflects heterogeneity of ventilation	• Does not reflect local distribution of TIV • Does not take into account overdistension, collapse, or any other pathological situation

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Table 1. Definition, Clinical Application, and Limitations of the Most Commonly Used EIT Indices in Patients with Hypoxemic Respiratory Failure

EIT Indices	Definition	Potential Applications	Limits
Overdistension and collapse estimation	Estimation of relative local compliance loss presented as percentage of collapse and overdistension during decremental PEEP trial	• Selection of PEEP level that jointly minimizes collapse and overdistension • Applicable even on venovenous ECMO when V_T is very low	• Assumes that ΔP on ventilator is reliable surrogate of regional ΔP • Depends on highest and lowest values of PEEP applied during PEEP trial
Regional ventilation delay	Time between start of inspiration and aeration of lung regions	• Identify recruitable lung regions and cyclic opening/closing phenomenon • Could be used to identify best PEEP level with most homogenized tidal inflation	• Requires a slow inflation maneuver with constant flow • Depends on defined threshold • Does not detect not-recruitable or overdistended regions
Center of ventilation Dorsal fraction of ventilation	Describes geometrical center of ventilation Describes percentage of V_T distributed in dorsal region	• Reflects global ventilation homogeneity to guide and monitor impact of mechanical ventilation management or adjunct therapies (i.e., prone positioning) • Identification of adverse events (e.g., malpositioning of endotracheal tube or development of pneumothorax)	• Reflects ventilation shifts but not their origin • Imprecise interpretation of ventilation distribution (ventilation on one side can be compensated by other side). • Setting PEEP aiming for >50% dorsal distribution could imply overdistension of whole lung

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Table 2. Summary of Recent Clinical Trials Evaluating the Outcomes of an EIT-based PEEP in Patients with ARDS

Population	Severity of the Population	Mean PEEP in the EIT group	Mean PEEP in the control group	Results
24 patients with ARDS vs. 31 historical patients (26)	APACHE II score 23.5	Based on overdistension and collapse: 18 cm H_2O	2 cm H_2O above inflection point of pressure–volume curve: 14 cm H_2O	- Higher compliance in EIT-based PEEP group: 26 vs. 20 ml/cm H_2O - No difference in clinical outcomes
117 patients with ARDS (83)	19.7% severe ARDS, 45.3% moderate ARDS, APACHE II score 19	Based on overdistension and collapse: 8 cm H_2O	Based on PEEP/$F_{I_{O_2}}$ table: 8 cm H_2O	- Nonsignificant 28-d mortality in EIT group: 21% vs. 27% - ICU length of stay: 13 vs. 10 d - Ventilator-free days: 14 vs 23 d
87 patients with ARDS (81)	75.9% severe ARDS, inclusion ⩽24 h after intubation	Based on overdistension and collapse: 16.2 cm H_2O	Based on pressure–volume curve: 17.4 cm H_2O	- Lower hospital mortality in EIT group: 44.4% vs 69.0% - Lower ΔP in EIT group: 10.9 vs. 12.4 cm H_2O
12 patients with ARDS with a cross-over protocol (84)	$Pa_{O_2}/F_{I_{O_2}}$, 130; MV duration at inclusion, 0.6 d; SAPS II, 38	EIT-selected PEEP was lower: mean difference of change, −2 cm H_2O		- Lower mechanical power in EIT group: 11.42 J/min, with lower ΔP and higher static respiratory system compliance

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Table 3. Main Advantages and Limitations of EIT and Future Improvements to Address Limitations

Main Advantages	Main Limitations	Direct Impact on Clinical Practice	Potential Future Improvements
• Real-time monitoring of lung ventilation	• Low spatial resolution	• EIT cannot be used for precise anatomic diagnosis	• Technological improvement and/or increase in number of electrodes on belt
• Evaluation of regional compliance before and after therapeutic procedures (e.g., recruitment)	• Most sensitive to detect electrical impedance changes occurring in plane of electrode belt	• EIT analysis cannot be extrapolated to lung part outside visualized area • EELV cannot be precisely inferred from EELI	• Further studies on potential benefit of combining apical EIT analysis with conventional one
• Visualization and quantification of overdistension and collapse • Identification of pathological situations (inhomogeneity, Pendelluft effect)	• Performance, relevance, and reference values of EIT indices still lacking	• Performance/relevance of available EIT indices to assess optimal PEEP have not been compared • Normal ranges of EIT indices unknown and may vary between patients	• Best EIT indices for each purpose need to be identified in patients with ARDS • "Normal ranges" should be accurately evaluated

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Table 3. Main Advantages and Limitations of EIT and Future Improvements to Address Limitations

Main Advantages	Main Limitations	Direct Impact on Clinical Practice	Potential Future Improvements
• EIT can be coupled with ventilator for further physiological analysis	• Lung perfusion assessment insufficiently developed	• Most EIT devices still do not perform lung perfusion analysis • Evaluation currently requires apnea and hypertonic saline bolus	• Integration of lung perfusion module in all EIT devices. • Promising method for lung perfusion without saline bolus should be further investigated
• Noninvasive continuous bedside monitoring	• Unknown clinical benefit of daily EIT-guided mechanical ventilation strategy	• Clinical impacts of ventilation strategy guided by EIT remain unknown	• Few clinical trials are ongoing (NCT04247477, NCT03793842, NCT03112512) to assess potential benefit of EIT-guided mechanical ventilation on outcomes in patients with ARDS

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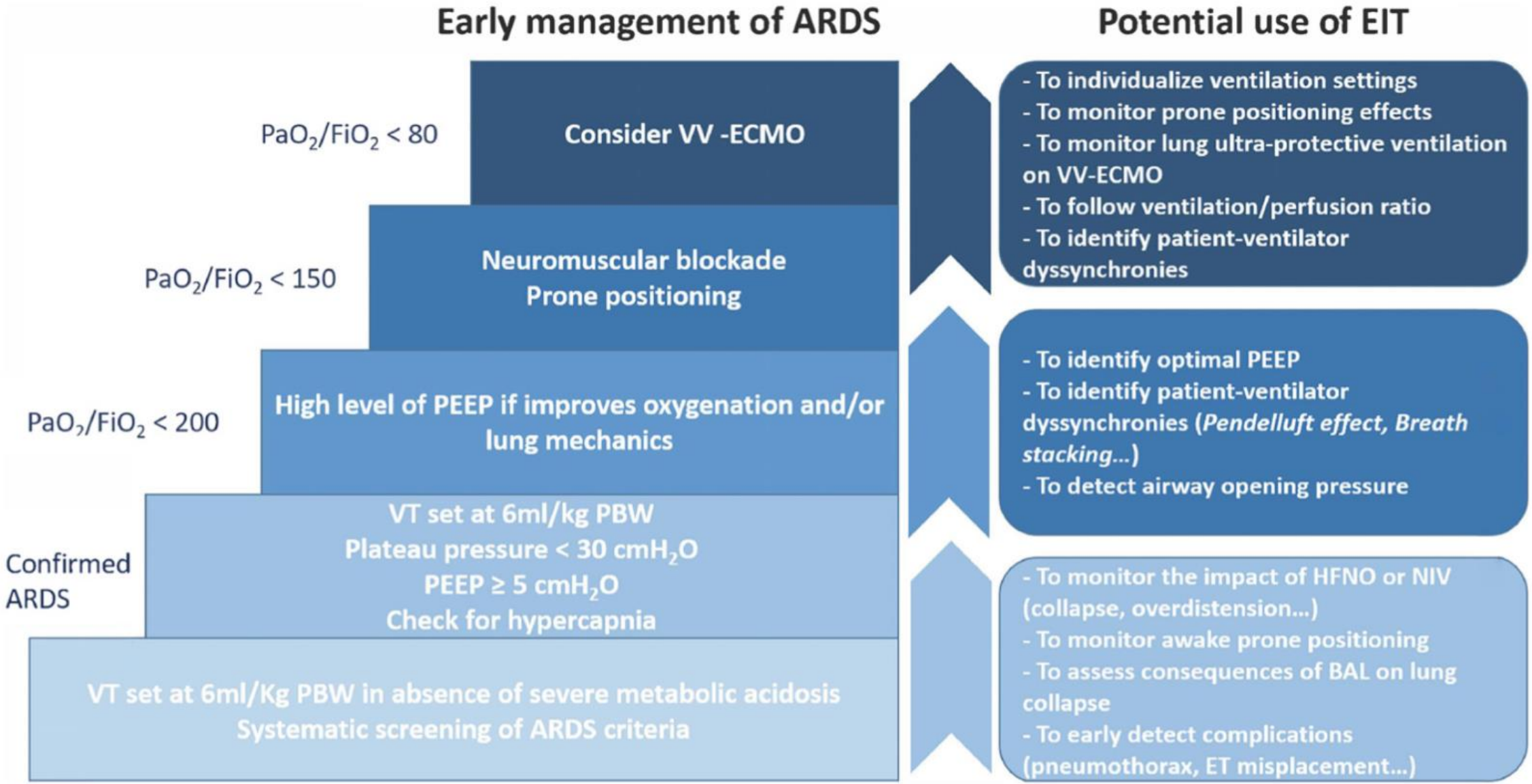

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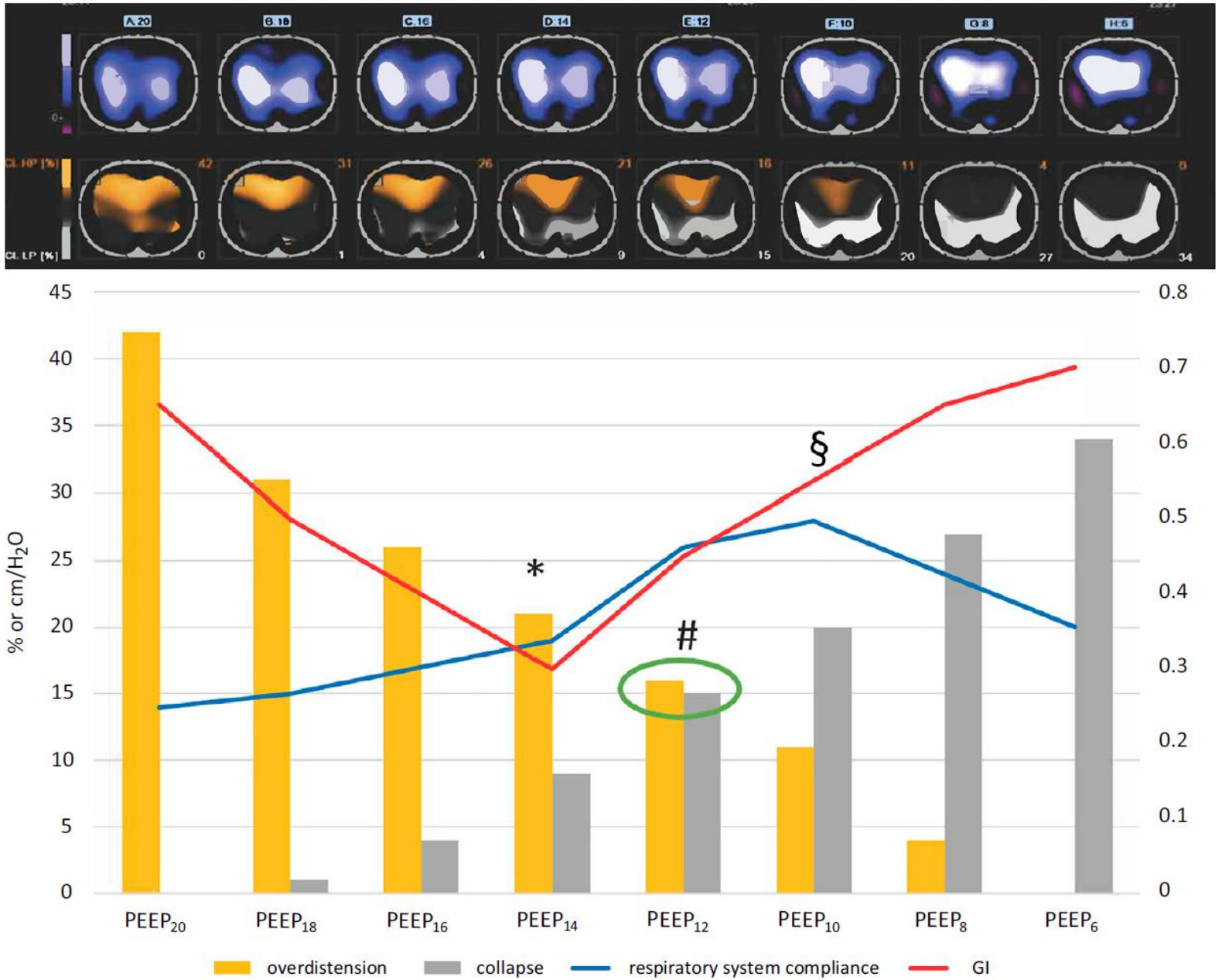

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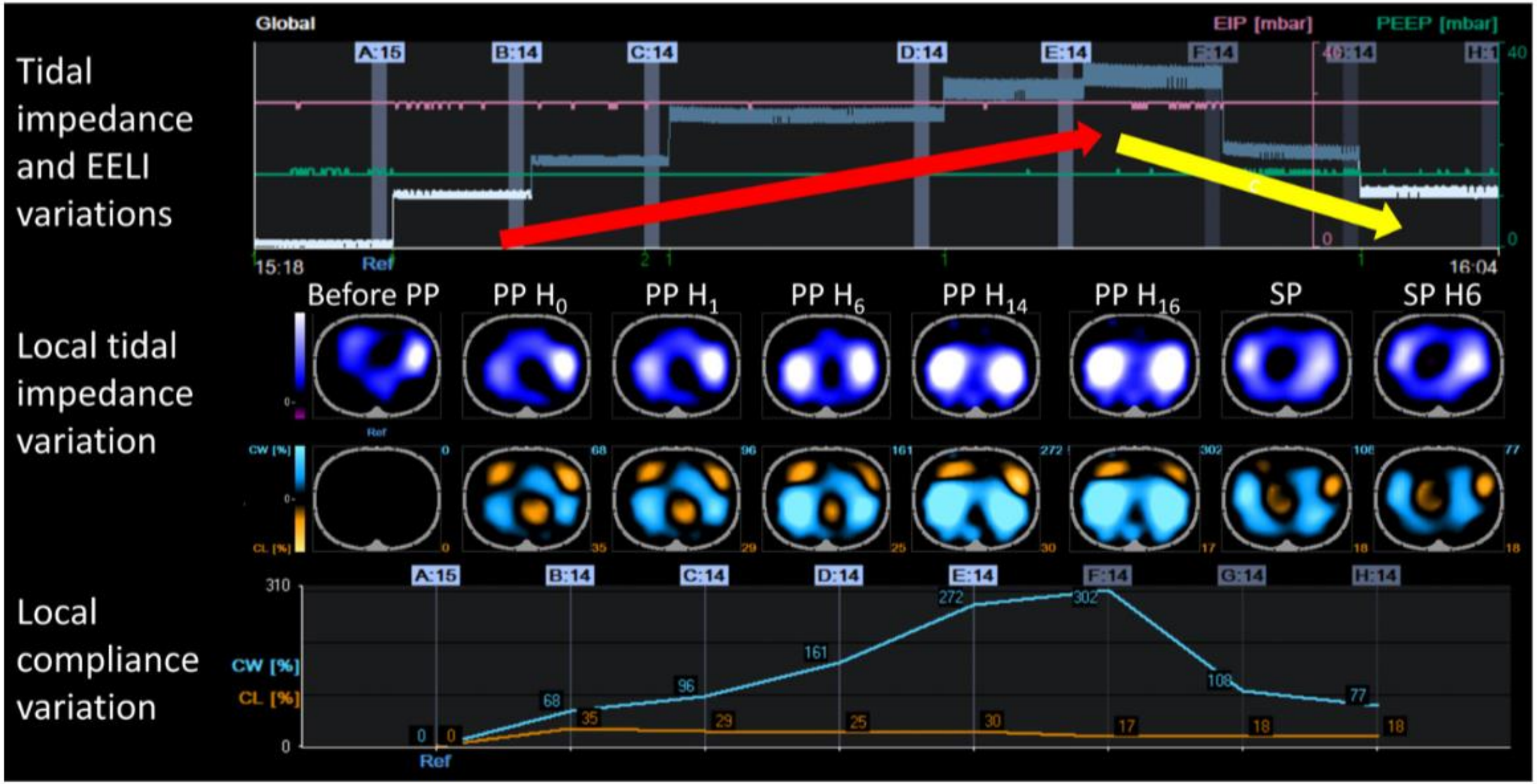

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Step 1. Setup and Calibration

- Place **16–32 electrodes** around the thorax (4th–5th intercostal space).
- Ensure good **skin contact**; avoid bandages or subcutaneous emphysema.
- Keep patient position stable to reduce motion artifacts.
- Calibrate baseline end-expiratory lung impedance (EELI).

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Step 2. Baseline Monitoring

- Observe **tidal image (TIV)** and **end-expiratory impedance (EELI)** in real time.
- Identify regions of:
  - Hypoventilation or collapse.
  - Overdistension or pneumothorax.
  - Tube malposition or regional derecruitment after suctioning/BAL.

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Step 3. PEEP Titration using EIT

- **Goal:** Find the compromise between alveolar recruitment and overdistension.

1. Perform a **decremental PEEP trial** (keep other settings constant).
2. For each PEEP level, calculate:
    1. Regional compliance changes.
    2. Percentage of overdistension vs. collapse.
3. Plot both curves → Choose the **intersection point** as *optimal PEEP* (≈ +2 cmH_2O transpulmonary pressure).
4. Confirm with improved dorsal ventilation and reduced heterogeneity.

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Step 4. Adjust Tidal Volume (VT)

- Compare **regional compliance** before and after halving driving pressure.
  - ↑ Compliance → Overdistension → Decrease VT.
  - ↓ Compliance → Collapse → Consider higher PEEP.
- Target: Better oxygenation + lower regional ventilation delay.

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Step 5. Positioning Strategies

- **Prone position:** Improves dorsal ventilation and compliance.
- **Lateral position:** May promote dorsal recruitment without high pressure.
- Monitor EELI & TIV to detect derecruitment during repositioning.

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Step 6. Weaning & Spontaneous Breathing Trial

- Use EIT to track changes in:
  - **Global Inhomogeneity Index (GI)** – rising GI predicts SBT failure.
  - **EELI** – drop indicates derecruitment.
- Early warning of regional instability and failed extubation risk.

GI = 各像素 TIV 與全肺中位數 TIV 的絕對差總和/全肺所有像素 TIV 的總和。
結果反映「通氣分布的離散程度」。

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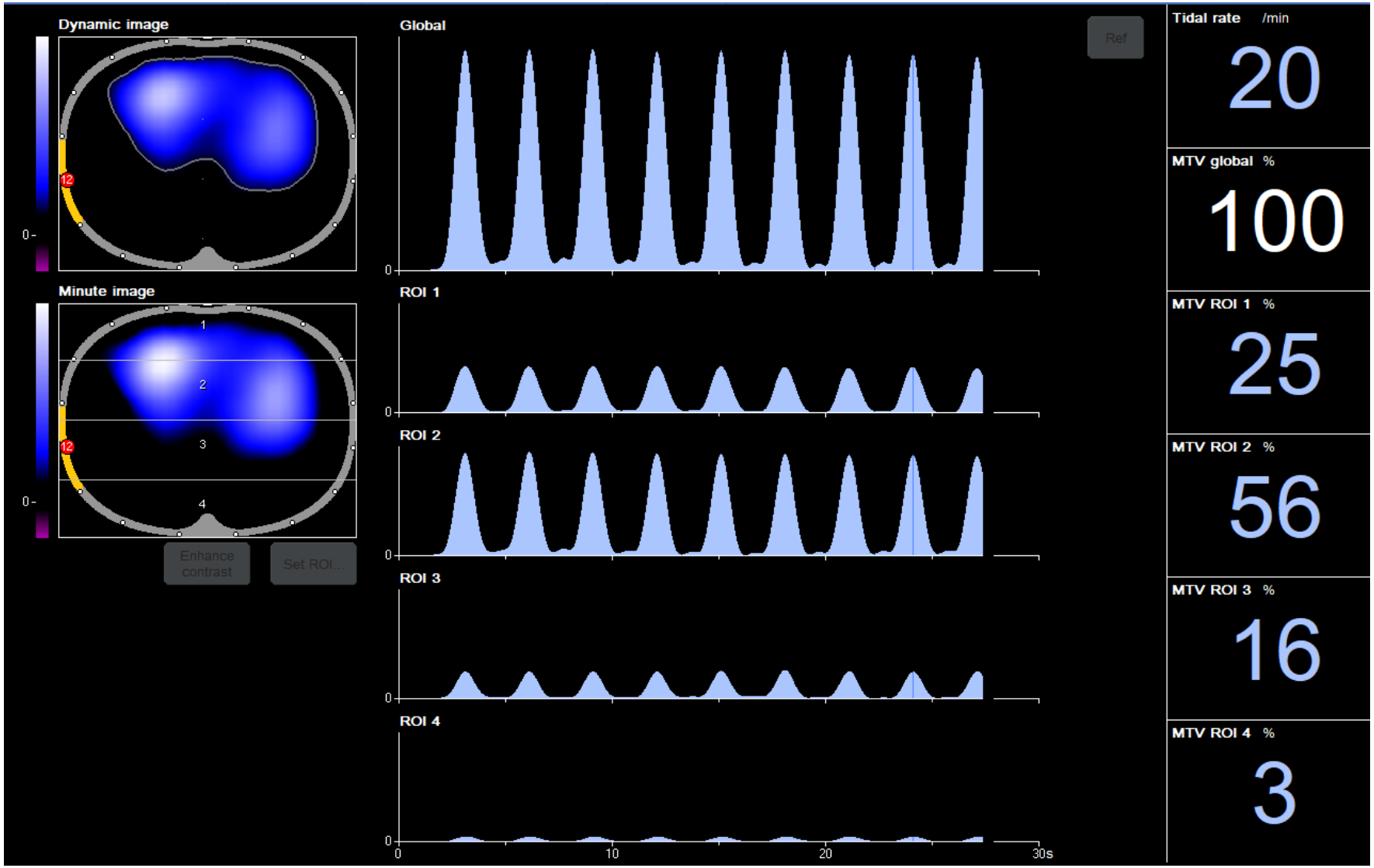
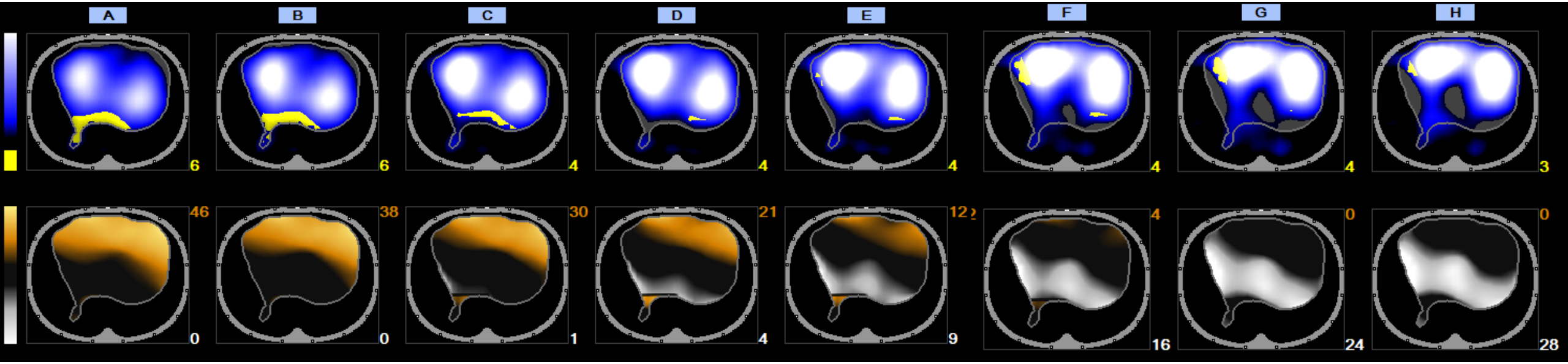
Day 1

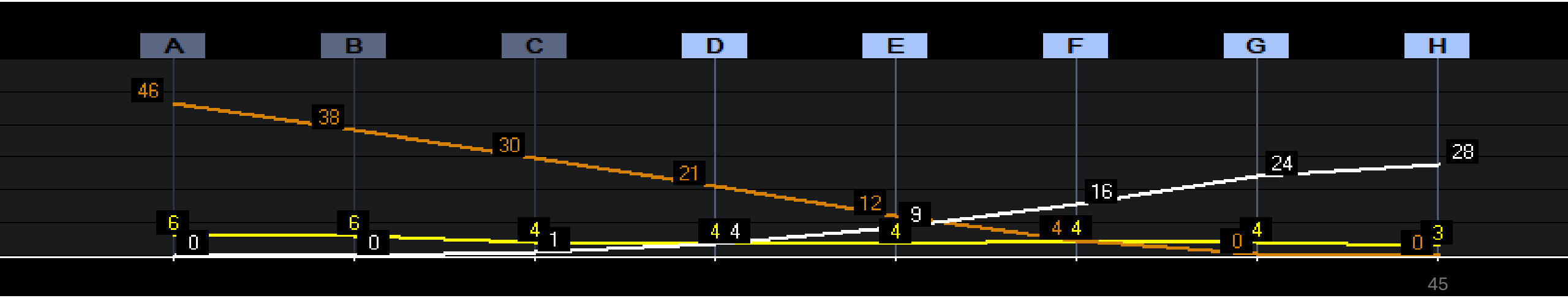


- Dorsal part atelectasis (+) under PEEP 14.
- RM was approached with 2 steps incremental PEEP until PIP 40 cmH_2O.
- Decremental PEEP trial then started with 2 cmH_2O stepwise until PEEP 12.

PEEP

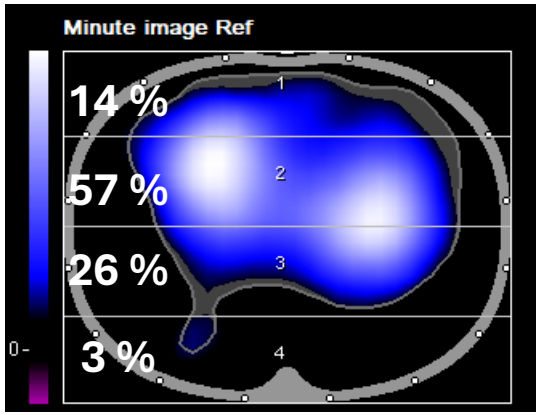
26 24 22 20 18 16 14 12



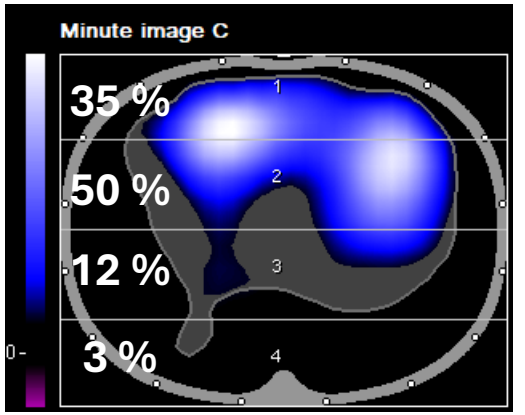


Day 1 – analysis result

PEEP 26

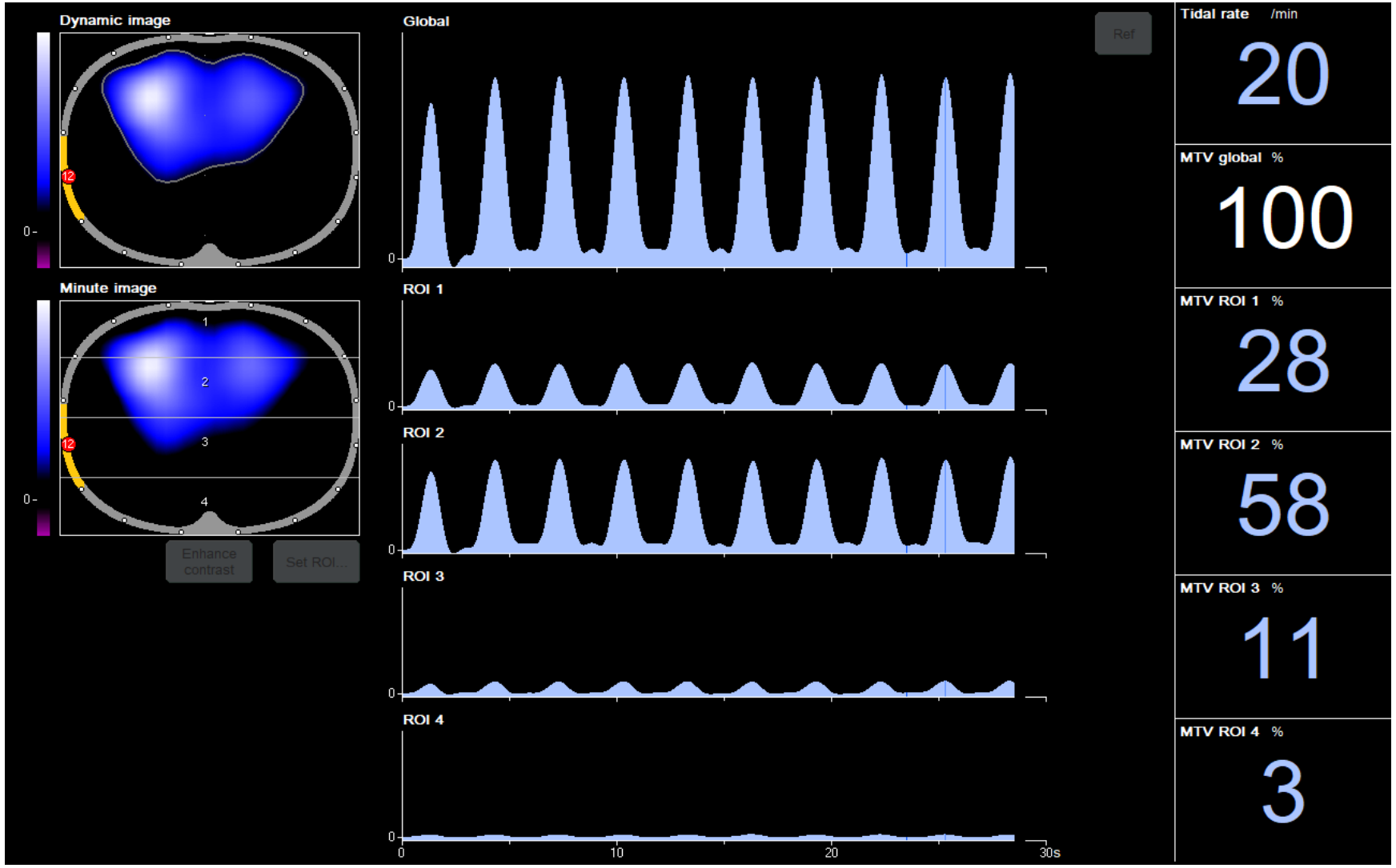


PEEP 12



- Ventilation of ROI 4 (most dorsal part) remains low even at highest PEEP.
- ROI 3 is recruitable (12 → 26 %) but overdistension is noted over ROI 1 (by decreasing ventilation from 35 to 14%).
- Optimal PEEP (balance overdistension & collapse) is closed to 18 but with ECMO in place, PEEP was set at 14 based on minimal overdistension strategy.
- Interestingly, shearing force could be seen over high PEEP indicates further recruitment possibility by using higher PEEP.

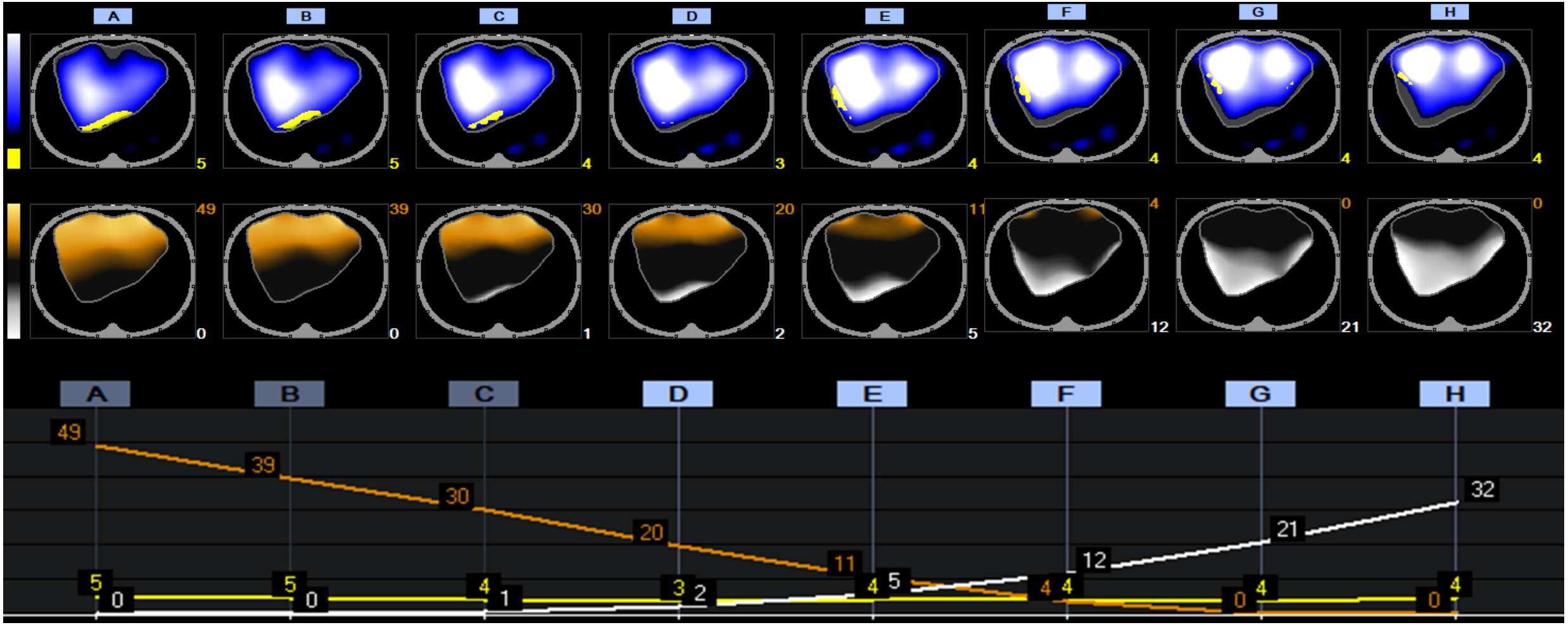
Day 2



- Similar image as compared to yesterday under PEEP 14.
- RM was approached with 2 steps incremental PEEP until PIP 40 cmH_2O.
- Decremental PEEP trial then started with 2 cmH_2O stepwise until PEEP 10.

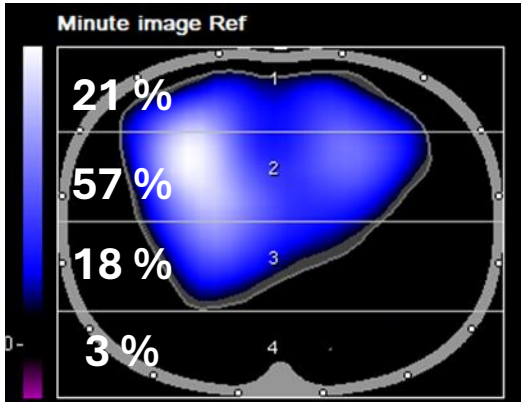
PEEP

24 22 20 18 16 14 12 10

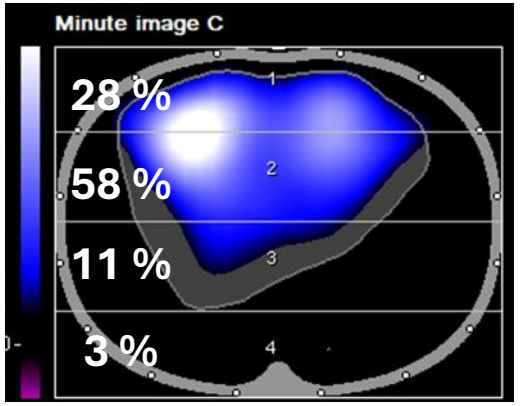


Day 2 – analysis result

PEEP 24



PEEP 10



- Same as yesterday, ventilation of ROI 4 (most dorsal part) is not responsible to RM.
- ROI 3 is recruitable (18 → 11 %) but overdistension is noted over ROI 1 (by decreasing ventilation from 28 to 21%). Both minor changes as compared to yesterday.
- Optimal PEEP (balance overdistension & collapse) is reduced to 15 and both 14 or 12 are suitable for minimal overdistension strategy.
- Still, shearing force could be seen over high PEEP same as yesterday.

EIT-omics

不是只看 1–2 個 EIT 指標，而是同時把通氣、灌流（以脈動訊號作 proxy）、以及 V′/Q 匹配等 180 個變數一起分析，再用階層式分群（AGNES，Ward′s linkage）把病人在不同 PEEP 下的狀態分出「生理亞型」。目標是找出呼吸驅動/努力（P0.1、ΔPes）較高、可能較容易 P-SILI 的族群，並觀察 PEEP 調整能否「消弭差異」

	PEEPlow				
	ALL (*n* = 30)	**UNMATCHED (*n* = 15)**	**MISMATCHED (*n* = 9)**	**INHOMOG. VENTILATION (*n* = 6)**	***p*-value**
age (years)	64 ± 14	59 ± 15	68 ± 12	71 ± 12	0.178
gender (male / female)	23 / 7 (77% / 13%)	12 / 3 (80% / 20%)	7 / 2 (78% / 22%)	4 / 2 (67% / 33%)	0.805
BMI (kg/m^2)	28 ± 5	28 ± 6	27 ± 3	27 ± 5	0.944
P/F (mmHg)	205 ± 55	198 ± 58	202 ± 43	228 ± 66	0.515
PaCO2 (mmHg)	45 ± 6	47 ± 5	43 ± 7	43 ± 6	0.239
pH	7.44 ± 0.04	7.43 ± 0.04	7.44 ± 0.06	7.43 ± 0.03	0.914
Ventilatory Ratio	1.69 ± 0.46	1.70 ± 0.49	1.58 ± 0.29	1.81 ± 0.62	0.642
Vt/PBW (ml/kg)	7.88 ± 1.8	7.75 ± 1.46	8.57 ± 2.19	7.19 ± 1.94	0.333
Pulmonary ARDS	22 (73%)	12 (80%)	7 (77.78%)	3 (50%)	0.350
Infectious ARDS	22 (73%)	11 (73.33%)	8 (88.89%)	3 (50%)	0.249
	PEEPintermediate				
	ALL (*n* = 30)	**UNMATCHED (*n* = 7)**	**MISMATCHED (*n* = 11)**	**INHOMOG. VENTILATION (*n* = 12)**	***p*-value**
age (years)	64 ± 14	63 ± 18	66 ± 8	63 ± 17	0.887
gender (male / female)	23 / 7 (77% / 13%)	5 / 2 (71% / 29%)	10 / 1 (91% / 9%)	8 / 4 (67% / 33%)	0.363
BMI (kg/m^2)	26.64 (24.61–30.86)	26 (25–29)	27 (26–31)	27 (23–31)	0.638
P/F (mmHg)	205 ± 55	227 ± 50	178 ± 47	217 ± 58	0.110
PaCO2 (mmHg)	45 ± 6	44 ± 5	46 ± 8	45 ± 5	0.751
pH	7.44 ± 0.04	7.43 ± 0.04	7.46 ± 0.04	7.41 ± 0.04	0.022
Ventilatory Ratio	1.61 (1.38–1.87)	1.48 (1.32–1.65)	2.00 (1.73–2.26)	1.46 (1.27–1.65)	0.017
Vt/PBW (ml/kg)	7.57 (6.66–8.54)	7.72 (6.8–8.07)	7.23 (6.74–8.3)	8.04 (6.52–9.9)	0.786
Pulmonary ARDS	22 (73%)	5 (71.43%)	10 (90.91%)	7 (58.33%)	0.209
Infectious ARDS	22 (73%)	5 (71.43%)	7 (63.64%)	10 (83.33%)	0.561
	PEEPhigh				
	ALL (*n* = 28)	**UNMATCHED (*n* = 6)**	**MISMATCHED (*n* = 15)**	**INHOMOG. VENTILATION (*n* = 7)**	***p*-value**
age (years)	64 ± 14	62 ± 19	64 ± 14	61 ± 11	0.910
gender (male / female)	23 / 7 (77% / 13%)	5 / 1 (83% / 17%)	13 / 2 (87% / 13%)	5 / 2 (71% / 29%)	0.683
BMI (kg/m^2)	26.64 (25.04–30.86)	26 (25–27)	26 (25–30)	29 (27–33)	0.411
P/F (mmHg)	205 ± 55	233 ± 51	199 ± 57	204 ± 58	0.473
PaCO2 (mmHg)	45 ± 6	44 ± 6	46 ± 7	43 ± 4	0.534
pH	7.44 ± 0.05	7.45 ± 0.04	7.45 ± 0.04	7.39 ± 0.05	0.015
Ventilatory Ratio	1.61 (1.38–1.93)	1.53 (1.40–1.69)	1.76 (1.47–2.17)	1.43 (1.30–1.65)	0.434
Vt/PBW (ml/kg)	7.57 (6.66–8.56)	7.78 (7.32–8.19)	6.87 (6.55–8.3)	8.51 (7.57–9.94)	0.251
Pulmonary ARDS	21 (75%)	3 (50%)	14 (93.33%)	4 (57.14%)	0.053
Infectious ARDS	21 (75%)	5 (83.33%)	11 (73.33%)	5 (71.43%)	0.864

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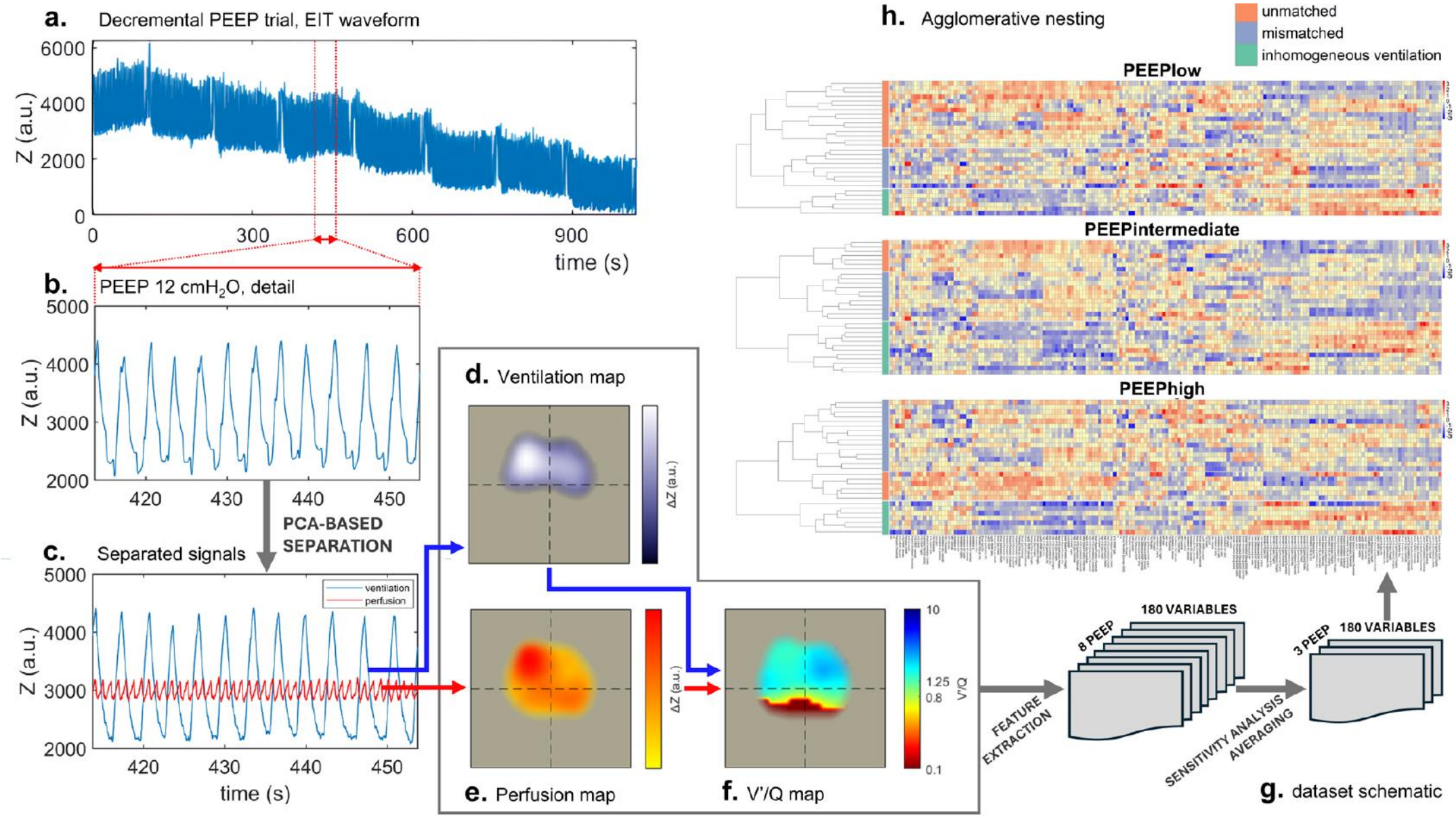

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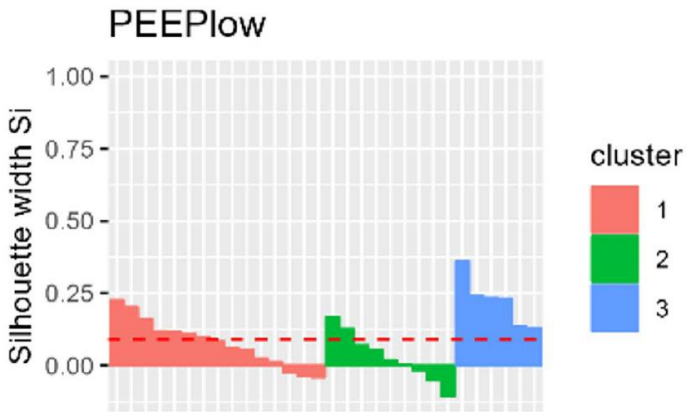

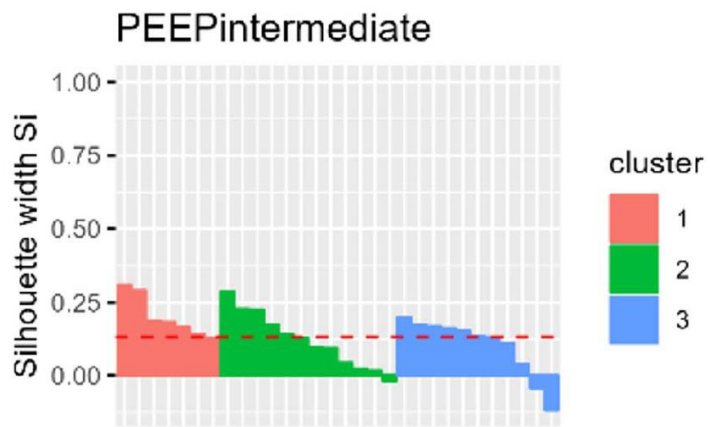

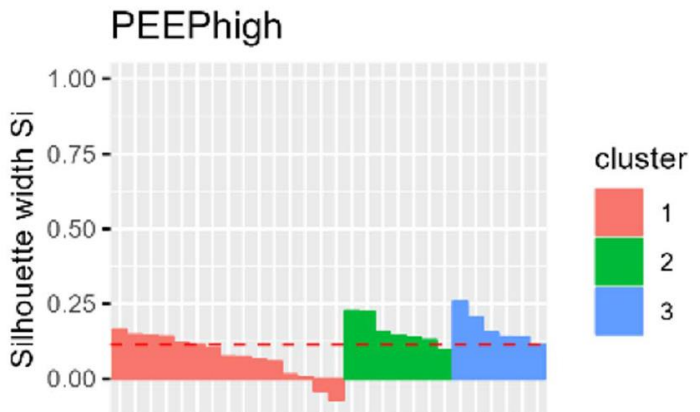

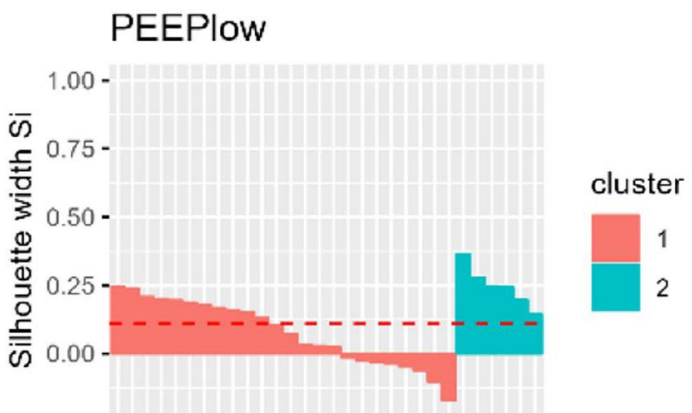

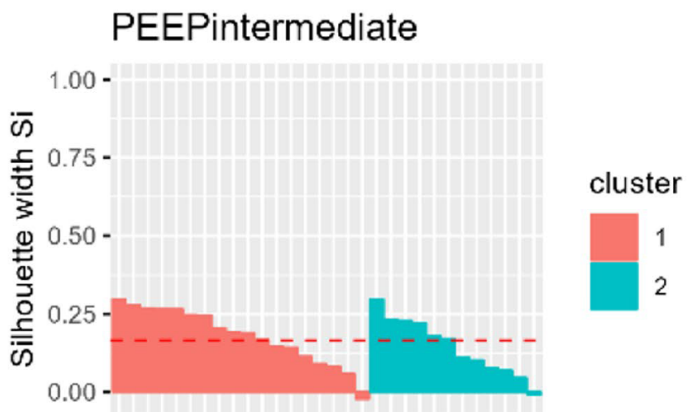

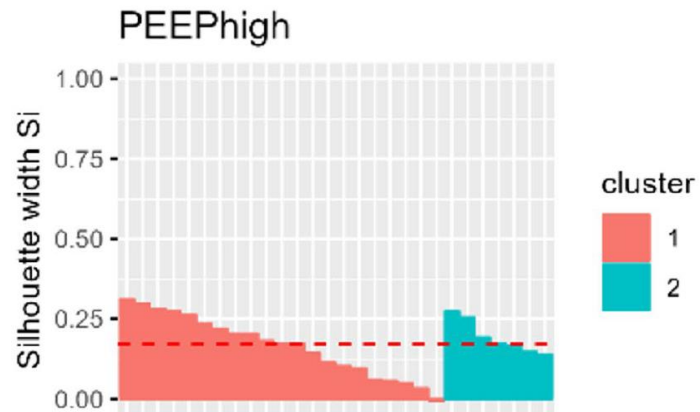

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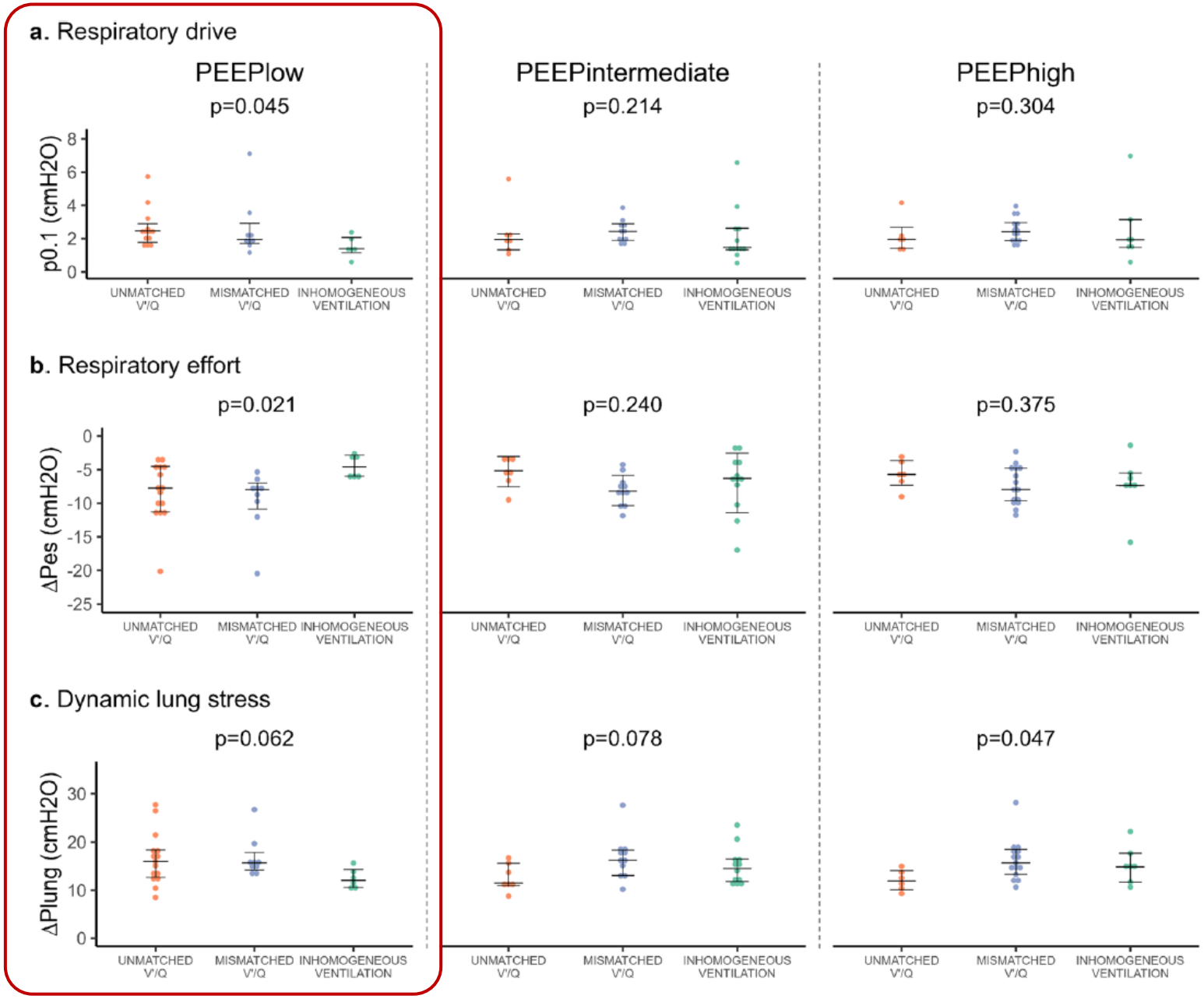

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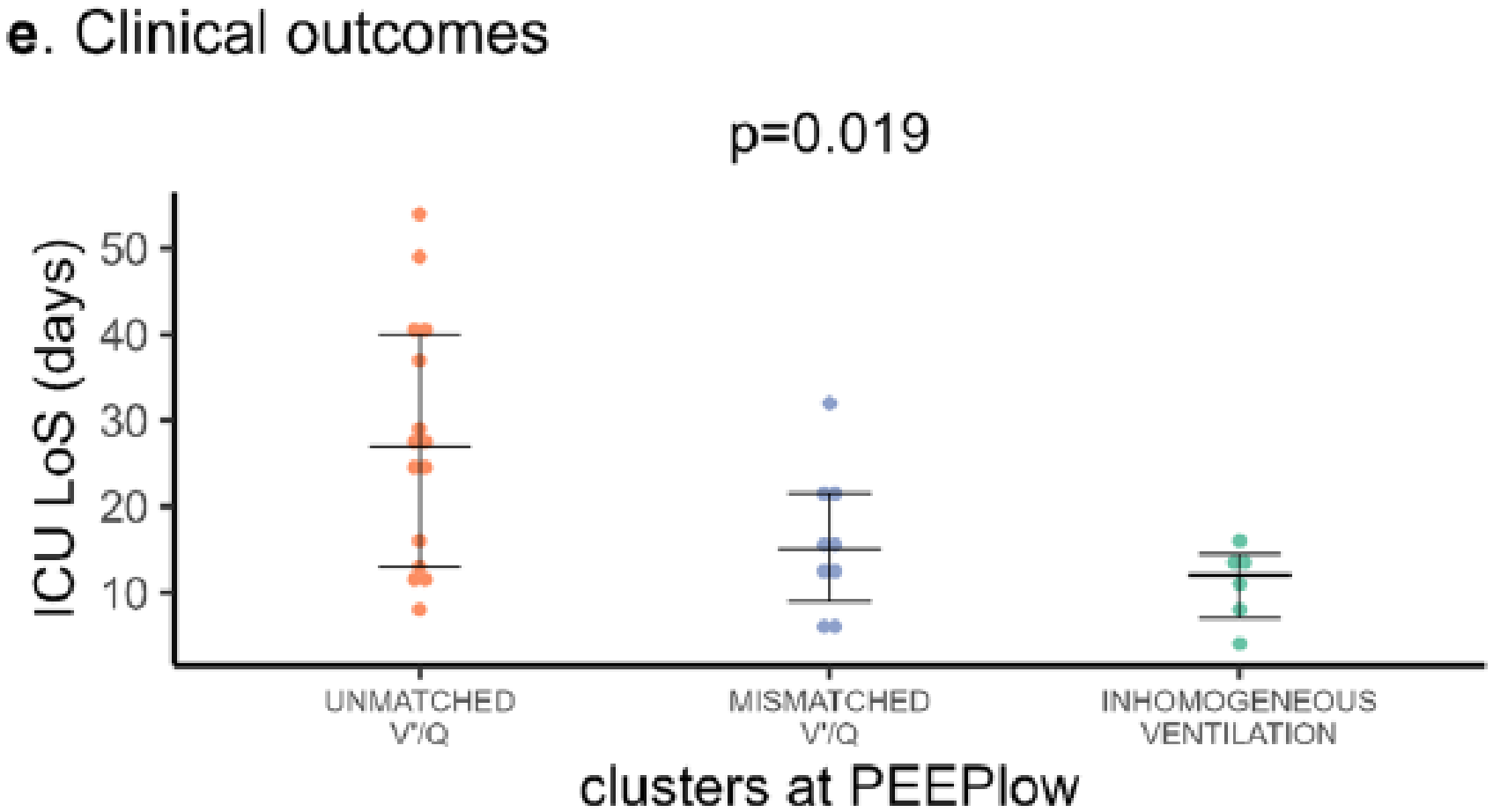

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Each EIT variable was tested for differences between clusters by bonferroni-corrected ANOVA/Kruskal-Wallis tests, significant features at $PEEP_{low}$ are here represented with their p-values and intra-class correlation coefficients (ICC)

f. Significant features

variable	unmatched	mismatched	inhomogeneous ventilation	Bonferroni-corrected p-value	ICC
Dead Space Fraction (%)	85 ± 7	61 ± 12	57 ± 8	**<0.001**	.80
High V'/Q [ventilation] (%)	72 ± 16	55 ± 14	31 ± 7	**0.003**	.71
Normal V'/Q [perfusion] (%)	16 ± 7	34 ± 7	31 ± 7	**0.001**	.75
Wasted Perfusion (%dorsal)	70 ± 15	38 ± 12	34 ± 19	**0.005**	.70

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Take home message

- EIT is an emerging **functional lung imaging tool** with great potential.
- EIT Provides **noninvasive, continuous bedside monitoring** of lung ventilation and perfusion dynamics.
- The main challenges lie in **perfusion measurement and clinical validation**.
- Future progress depends on **integrating ventilation–perfusion analysis, improving bedside usability, and generating solid clinical evidence.**

Thanks for your attention