Electrical Impedance Tomography in clinical practice, why, how and when?

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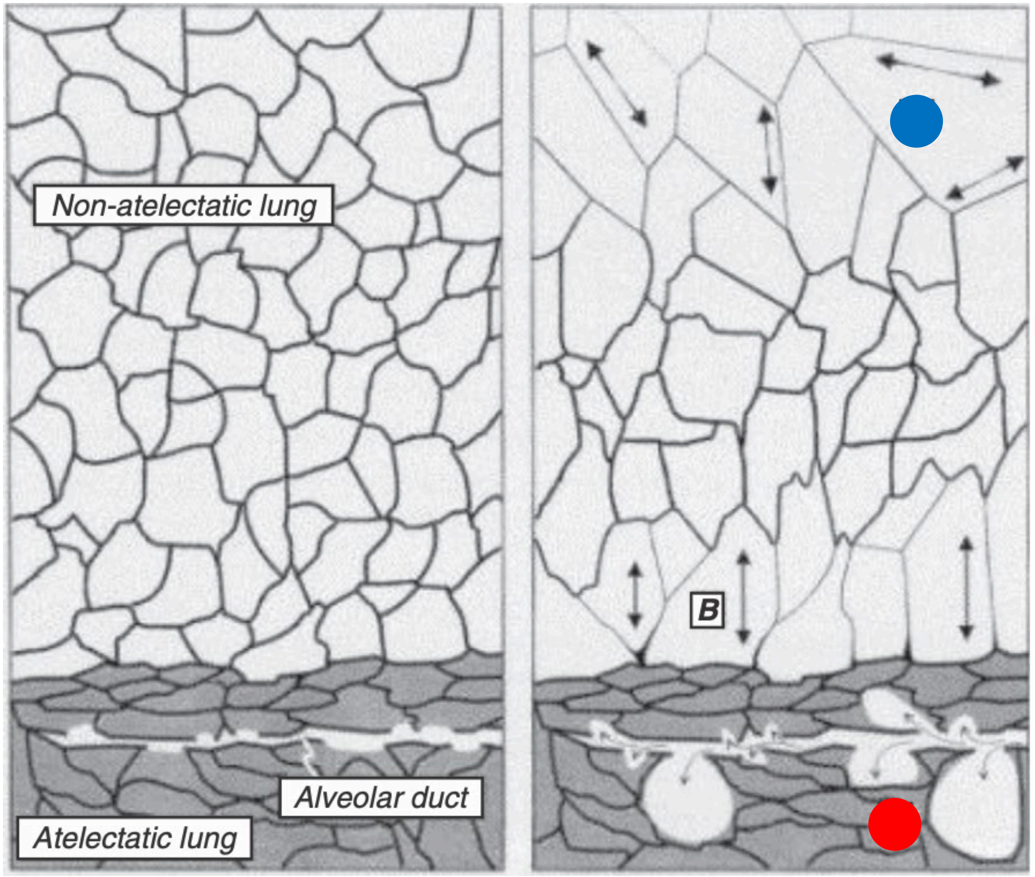
Aug 23, 2026 14:10-14:50

Outlines

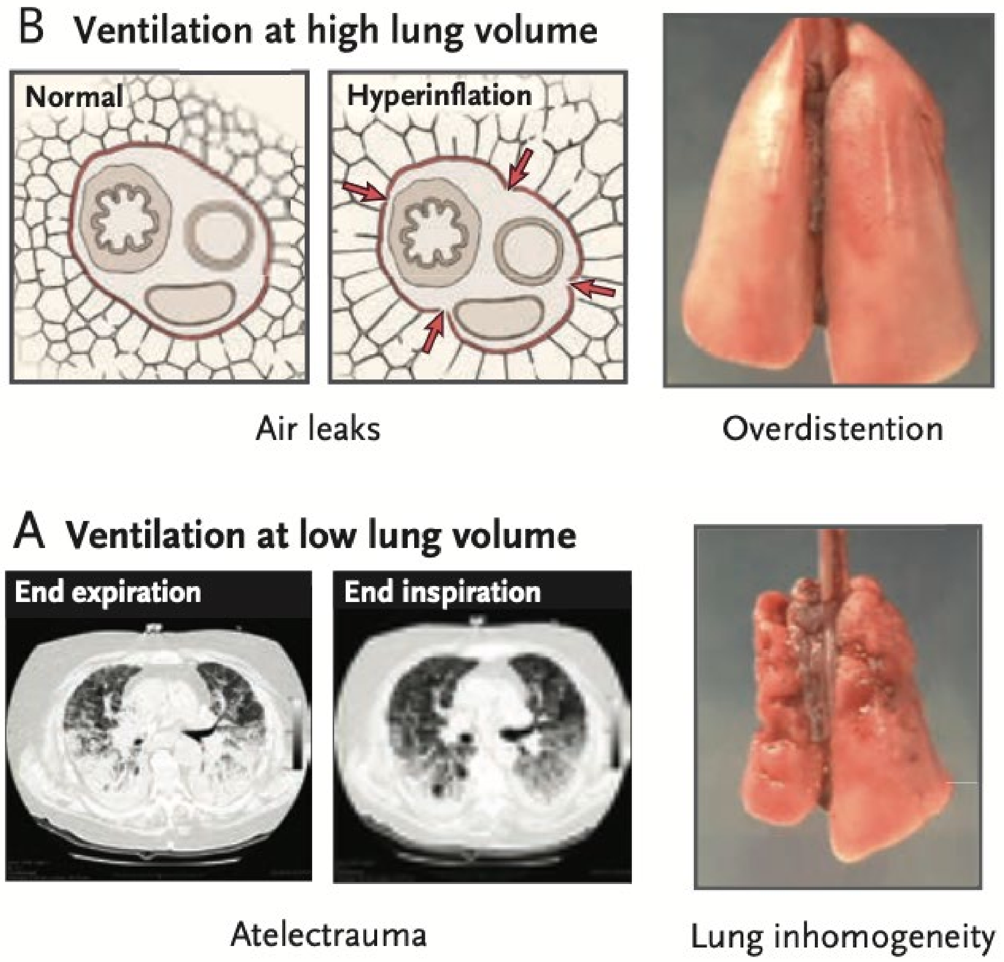
- Why? Unmet needs in hypoxemic respiratory failure and ARDS
- How? Introduction of electrical impedance tomography
- When? Clinical application of EIT

Ventilator-induced lung injury, VILI

Barotrauma & Volutrauma



Atelectrauma (repeated opening & closing)



Slutsky et al. NEJM. 2013 Nov 28;369(22):2126-36.
Sahetya et al. AJRCCM. 2017 Jun 1; 195(11): 1429–1438.

Global vs. regional respiratory mechanics

Global respiratory mechanics -
are only the tip of the iceberg

Regional phenomena -
remain undetected with conventional monitoring

Alveolar overdistension

Cyclic opening and closing

Regional lung collapse

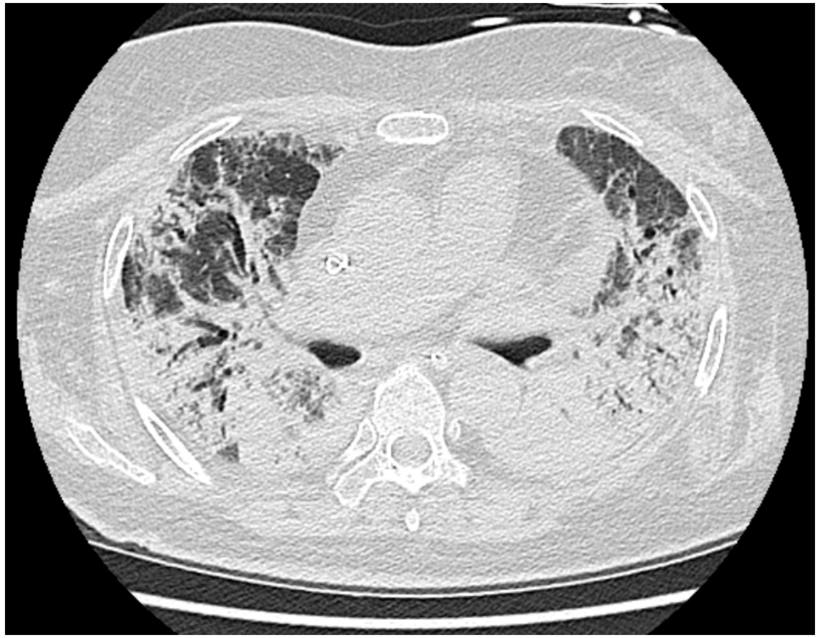
Same low TV (One size does not fit all)

PBW 60kg, TV 360ml

Compliance 36

Driving pressure 10

PBW 60kg, TV 360ml



Compliance 18

Driving pressure 20

ΔP=Vt/ Crs

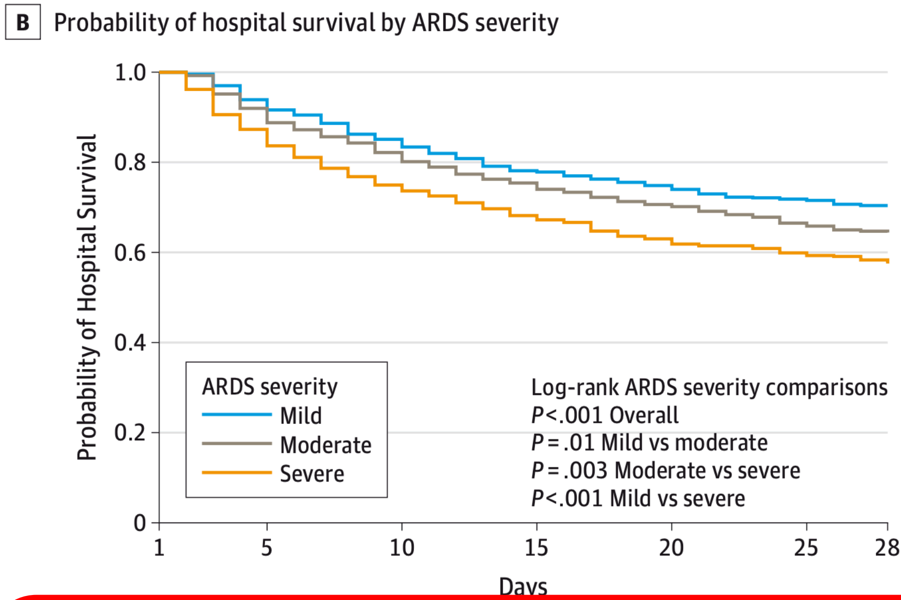
LUNG SAFE

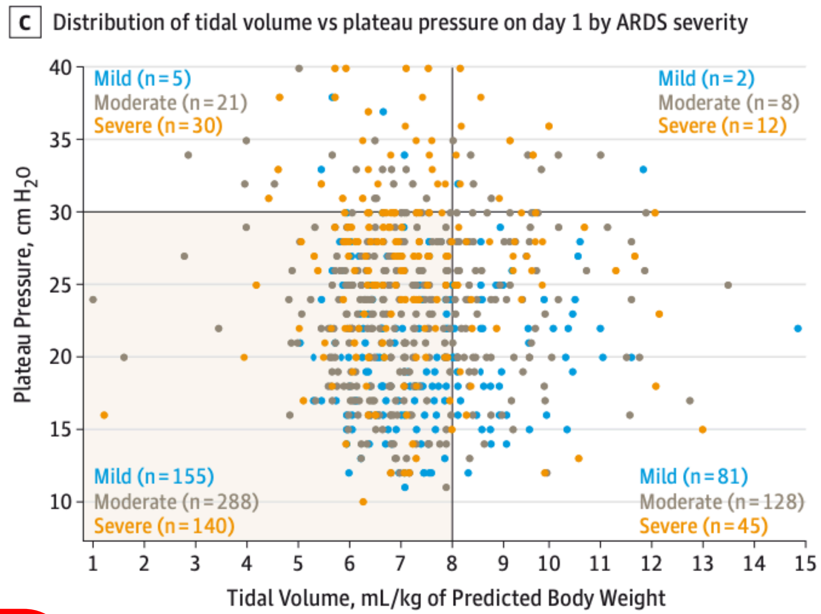
JAMA | Original Investigation | CARING FOR THE CRITICALLY ILL PATIENT

Epidemiology, Patterns of Care, and Mortality for Patients With Acute Respiratory Distress Syndrome in Intensive Care Units in 50 Countries

2014 winter
459 ICUs
29144 patients

The Large Observational Study to Understand the Global Impact of Severe Acute Respiratory Failure





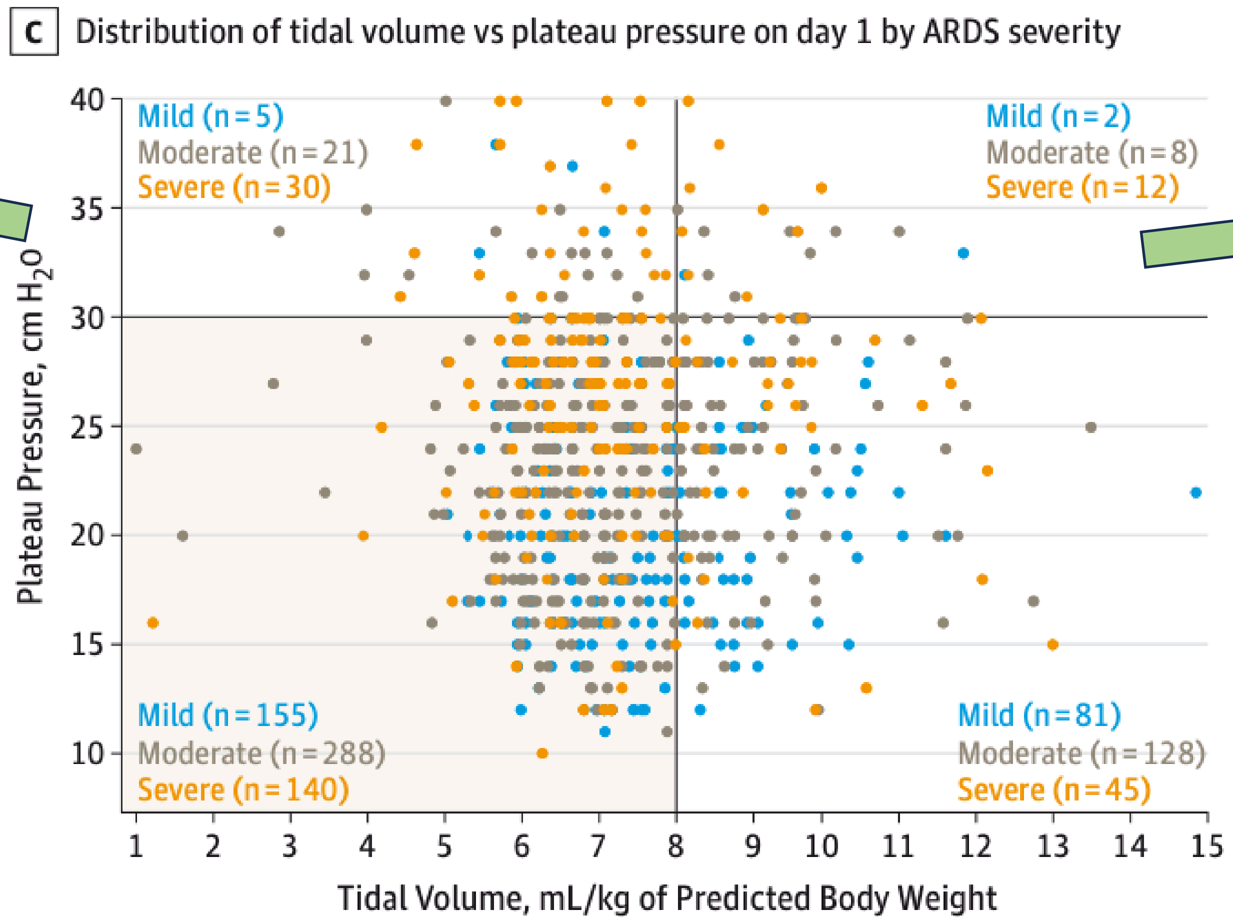
Hospital mortality
34.9% (95% CI, 31.4%-38.5%) for mild ARDS
40.3% (95% CI, 37.4%-43.3%) for moderate ARDS
46.1% (95% CI, 41.9%-50.4%) for severe ARDS

Two-thirds of the patients fell within the limits for *protective ventilation* (plateau pressure ≤ 30 cm H2O and TV ≤ 8 mL/kg of PBW) on Day 1

Bellani et al. JAMA. 2016 Feb 23;315(8):788-800.

High plateau pressure
Low TV

High plateau pressure
High TV



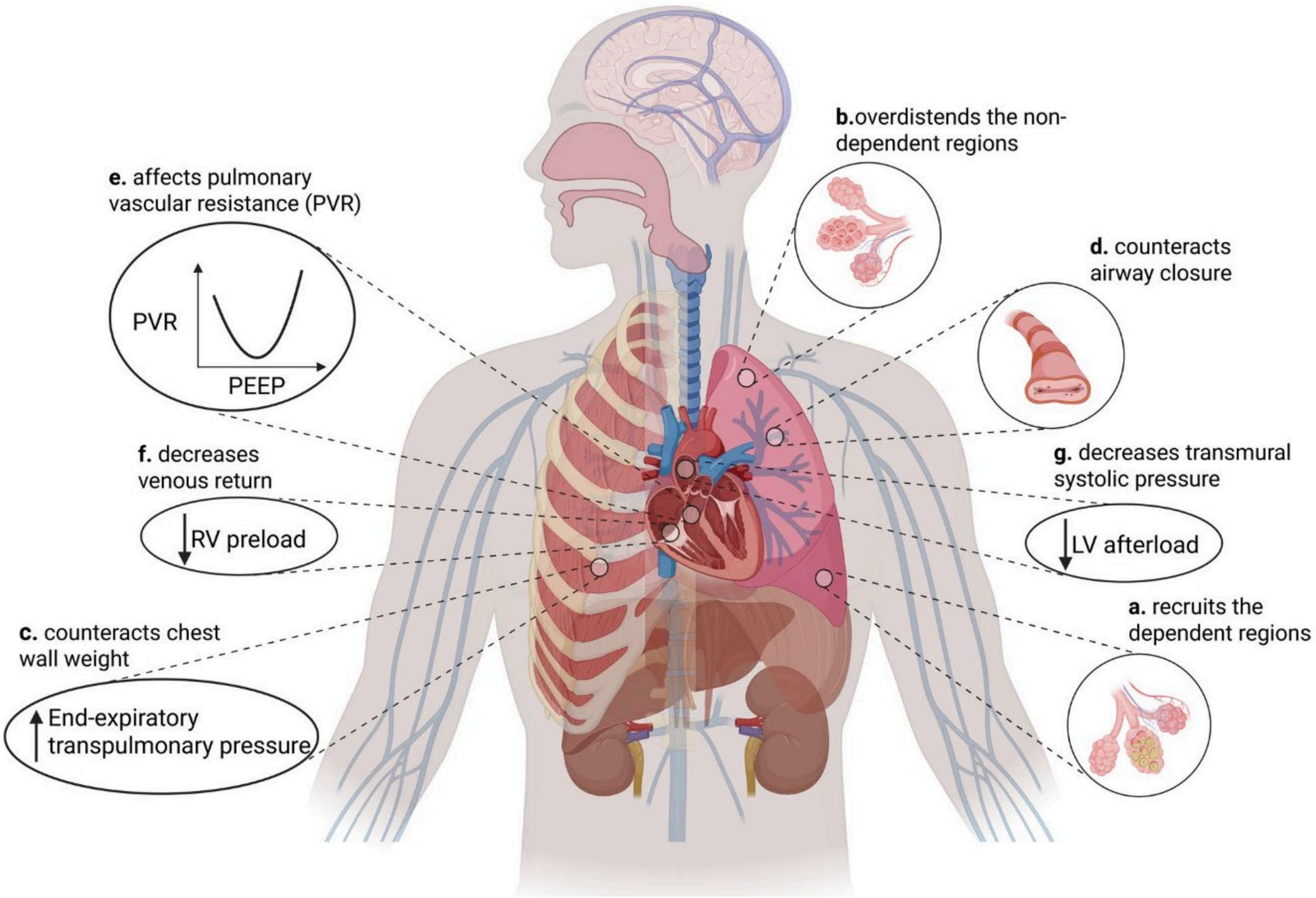
Only Two-thirds of the patients fell within the limits for *protective ventilation* (plateau pressure ≤ 30 cm H2O and TV ≤ 8 mL/kg of PBW) on Day 1

Bellani et al. JAMA. 2016 Feb 23;315(8):788-800.

ARDS remains high-mortality **“one-size” ventilation fails** in heterogeneous lungs

How can we lower driving pressure/plateau pressure while maintaining adequate oxygenation and ventilation?

ATS 2024		ESCIM 2023
Strong recommendation for	**Lung protective ventilation**	Strong recommendation for
Strong recommendation for	**Early prone positioning in mod-severe ARDS**	Strong recommendation for
Conditional recommendation in favor of	**VV-ECMO in severe ARDS**	Suggestion for
Conditional recommendation in favor of High PEEP vs. low PEEP in moderate to severe ARDS	**PEEP titration strategy**	No recommendation
Conditional recommendation in favor of	**Corticosteroids**	Do not address
Conditional recommendation in favor of use in moderate to severe ARDS	**Neuromuscular blockade**	Strongly recommendation against
Strongly recommendation against	**Prolonged recruitment maneuvers**	Strong recommendation against



Menga et al.Intensive Care Med. 2026 Mar;52(3):570-573.

Benefit and harms of **Individualized PEEP**

- ↑ EELV via recruitment + higher resting volume
- Mainly ↓ shunt via recruitment
- Prevents cyclic collapse if recruitable
- may trade collapse for overdistension
- Overdistension risk **Higher** if PEEP too high (esp. nondependent)

PEEP Titration tools

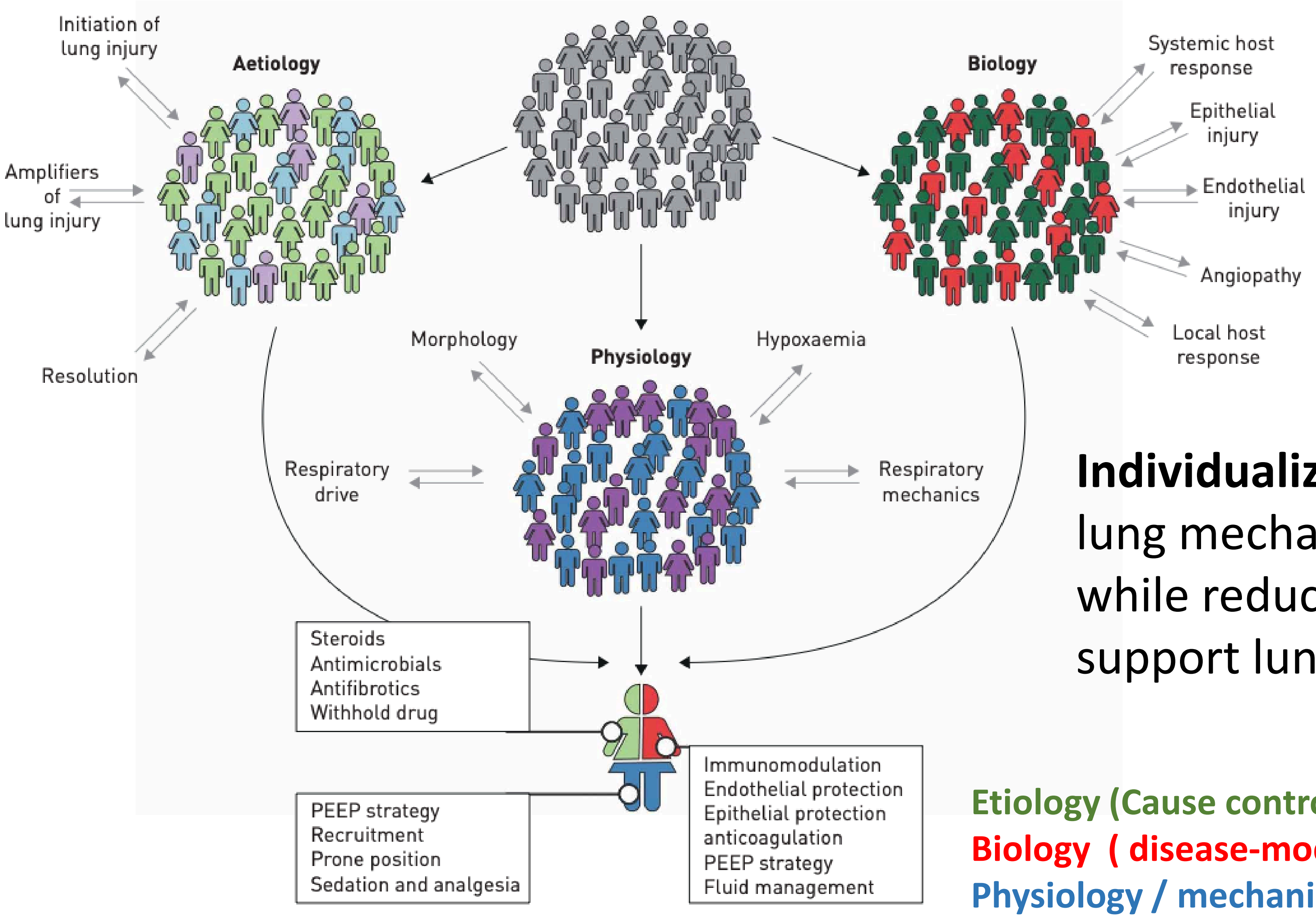
- Best Compliance (Sutter NEJM 1975)
- Pressure-Volume Curve (Matamis CHEST 1984)
- PEEP/FiO_2 Table (Alveoli NEJM 2004, LOVS JAMA 2008)
- Esophageal pressure (Talmor NEJM 2008, Grasso ICM 2012)
- Stress Index (Ranieri AJRCCM 1994)
- EELV measurements by automated nitrogen washout/washin technique
- Images (Ultrasound, EIT)

Lowering driving pressure by individualzing PEEP

Battaglinil et al. ICM 2024

Yehya et al. Ann Am Thorac Soc 2021

Precision medicine in ARDS



Individualized PEEP could optimize lung mechanics and oxygenation while reducing injurious stress to support lung protection

Etiology (Cause control)
Biology (disease-modifying)
Physiology / mechanics-focused supportive care

Bos et al. *Eur Respir Rev*. 2021 Feb 2;30(159):200317.

Need **bedside personalization of PEEP** (recruitment vs overdistension)

Global metrics(P/F ratio, Crs) may miss regional injury risk

But “optimal PEEP” differs by target (oxygenation, compliance, transpulmonary pressure, or EIT-derived regional balance)

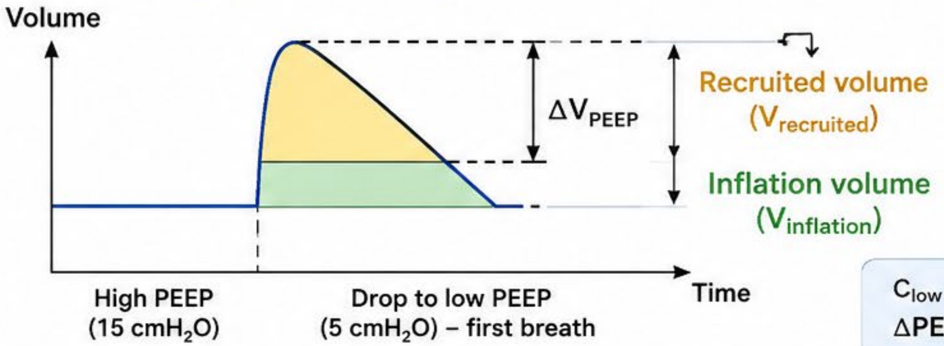
$PaO_2 : FiO_2$ 150 – 300 mmHg

Low PEEP–FiO_2 table (8–15 cmH_2O range)

FiO_2	≤ 0.5	0.5 – 0.6	0.7
PEEP (cmH_2O)	8	10	10 – 12

If PEEP > 10 cmH_2O,
check R:I ratio[b]

R:I ratio (PEEP 15 → 5)



$$R{:}I = \frac{V_{recruited}}{V_{inflation}}$$

$$V_{recruited} = \Delta V_{PEEP} - (C_{low} \times \Delta PEEP)$$

$$V_{inflation} = C_{low} \times \Delta PEEP$$

C_{low} = respiratory system compliance at low PEEP (e.g., PEEP 5)
$\Delta PEEP = PEEP_{high} - PEEP_{low}$ (e.g., 15 – 5 = 10 cmH_2O)

R:I > 0.5

Higher PEEP range is appropriate if:

- Vt ≤ 6 ml/kg PBW and
- Plat < 30 cmH_2O

High recruitability → more lung is opened by higher PEEP)
Consider higher PEEP range and EIT-guided titration

R:I ≤ 0.5

Lower PEEP range

Low recruitability → mostly inflation (overdistension risk)
Use lower PEEP range

a: PEEP in cmH_2O b: R:I ratio = Recruitment to Inflation ratio

Morris et al. Intensive Care Med. 2026 Jan;52(1):104-117.

$PaO_2 : FiO_2$ < 150 mmHg

Sedation (+/- NMBA) to apnoea

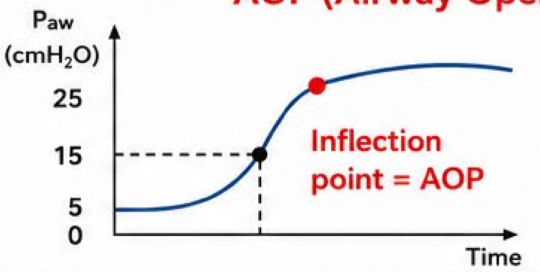
Consider **High-PEEP-FiO_2 table**[a] (14–20 cmH_2O range)

FiO_2	0.4	0.5 – 0.8	≥ 0.8
PEEP (cmH_2O)	14 – 16	16 – 20	20

Confirm PEEP > AOP

(PEEP ≥ 2 cmH_2O above AOP)[c]

AOP (Airway Opening Pressure)



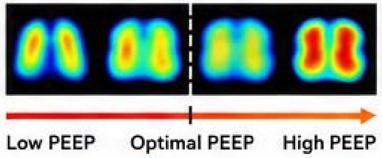
- Perform low-flow inflation (e.g., 5 L/min)
- Identify inflection on P_{aw}-time or P_{aw}-Volume curve
- Set PEEP ≥ AOP + 2 cmH_2O

Personalised PEEP strategy indicated,
choice based on available equipment, expertise and clinical priorities

Use additional tools as available

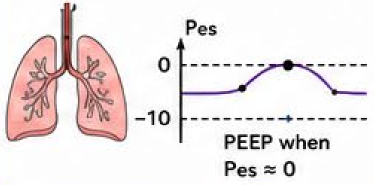
Electrical Impedance Tomography

PEEP to best balance recruitment vs overdistension (crossing point)[d]



Oesophageal Manometry

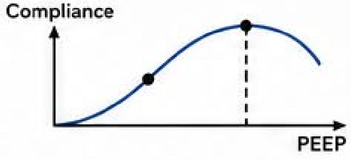
PEEP to match end-expiratory oesophageal pressure[e]



Respiratory Mechanics

PEEP to optimise compliance[f]

(lung protective)



Gas Exchange

PEEP to optimise

1. Oxygenation, or
2. Ventilatory Ratio[f]

(RV protective)

Outlines

- Why? Unmet needs in hypoxemic respiratory failure and ARDS
- How? Introduction of electrical impedance tomography
- When? Clinical application of EIT

Introduction to electrical impedance tomography (EIT)

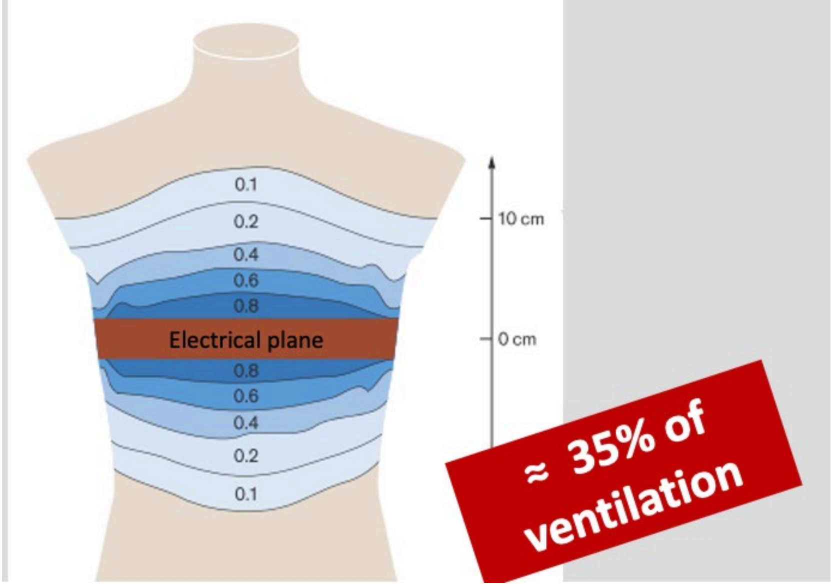
- As air moves in and out of the chest images are constructed from the measured voltages that change over time with ventilation.

- 4th-6th ICS

The Ohm's law

$$V = I \times R$$

Voltage Current Resistance

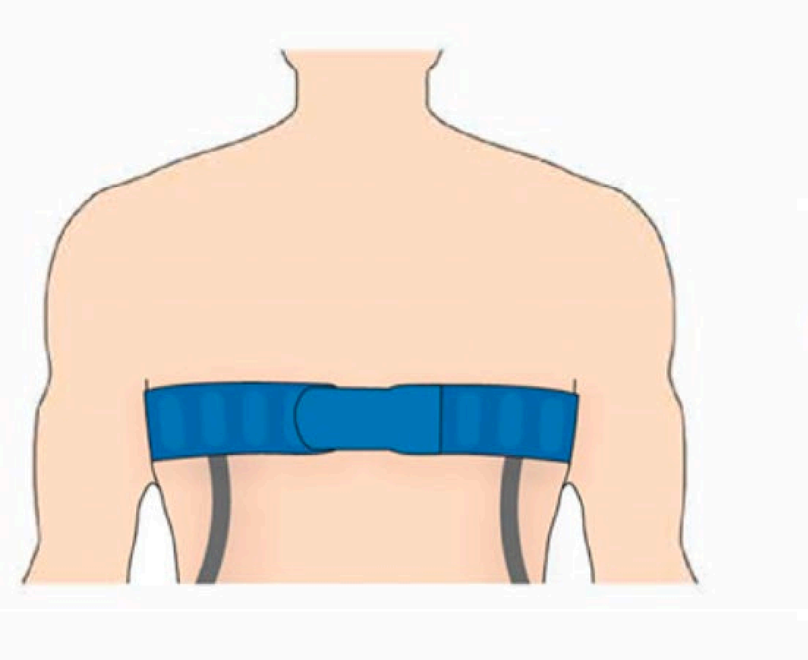


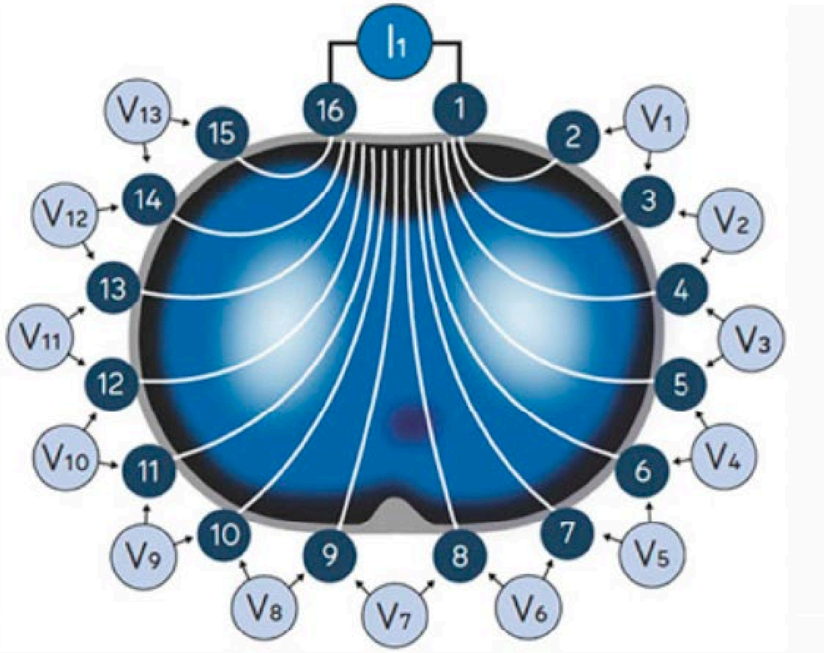
Bioimpedance (specific composition, e.g., lipids, water, electrolytes in the extracellular fluid)

Tissue	Impedance / Resistivity	
Blood		150 Ω * cm
Lung	Expiration	700 Ω * cm
	Inspiration	2400 Ω * cm
Fat		2000 – 2700 Ω * cm
Bones		16600 Ω * cm
Muscles	Longitudinal	125 Ω * cm
	Transversal	1800 Ω * cm
Heart muscles	Longitudinal	160 -575 Ω * cm
	Transversal	420 – 5200 Ω * cm

The principles of EIT

One pair of electrodes injects electrical current while remaining electrodes read voltages produced as a result of the distribution of current density inside thorax



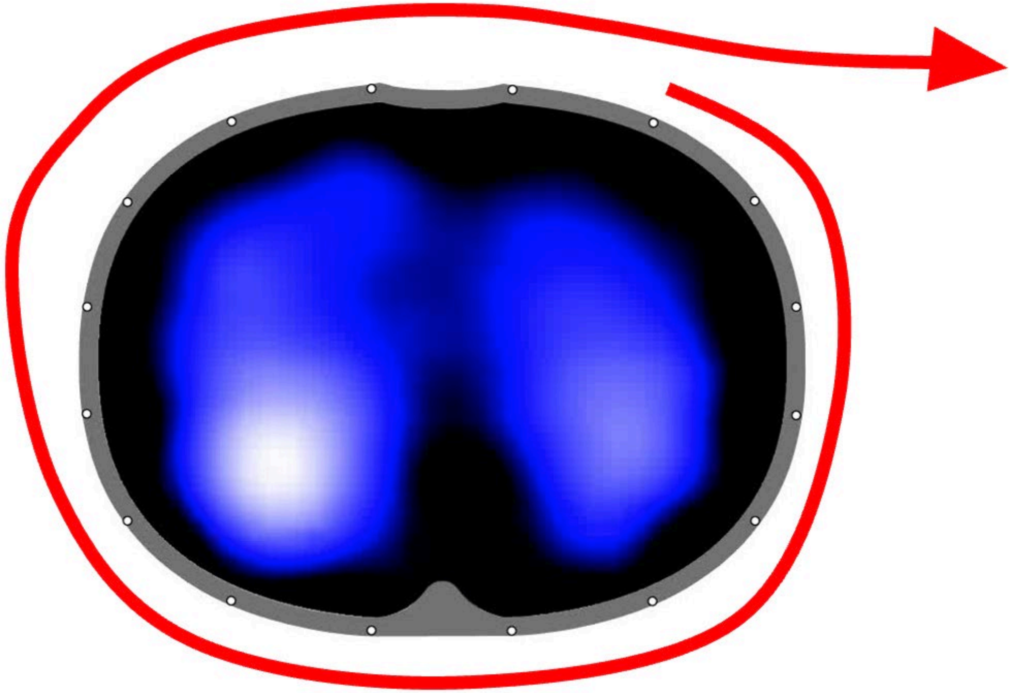


A frame = 16 x 13=208 values (reconstruct one cross-section image)

一個完整的 EIT measurement cycle 會得到 208 個 voltage measurements

Rotating voltage measurement

Resolution
= 32*32 = 1024 pixels

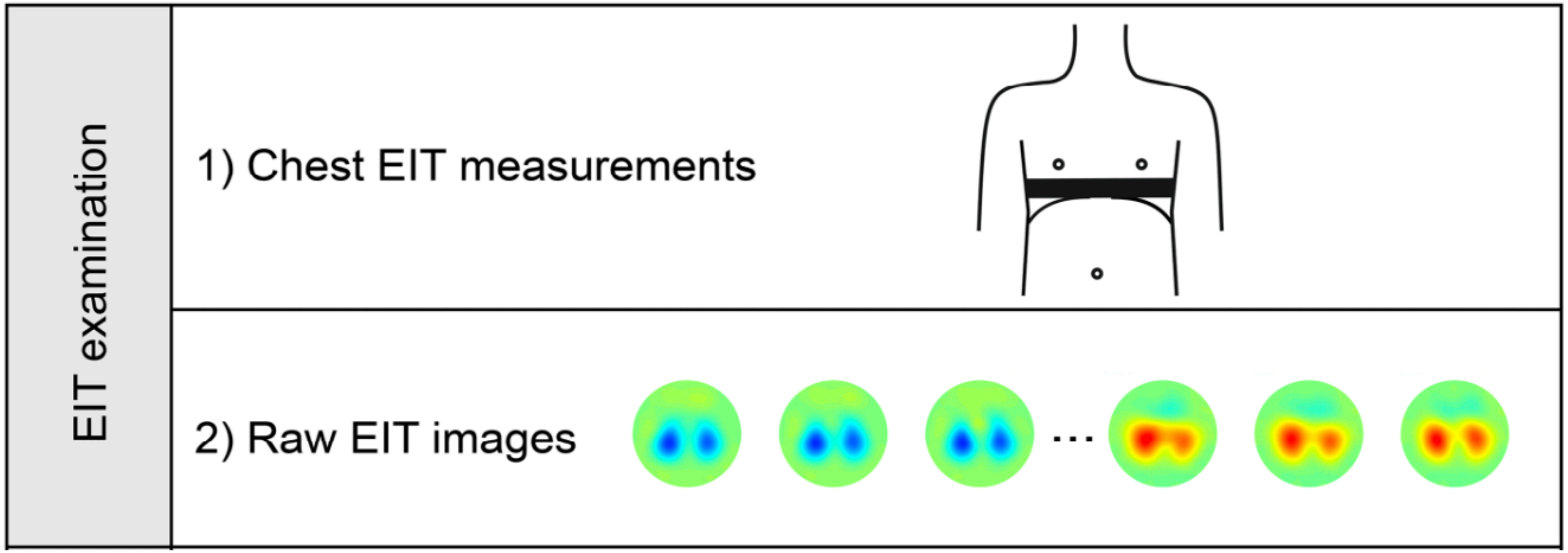


1 cycle per second
means 1 Hz

20 Hz is enough for any condition of conventional ventilation

40 Hz is recommended for patient receiving HFOV

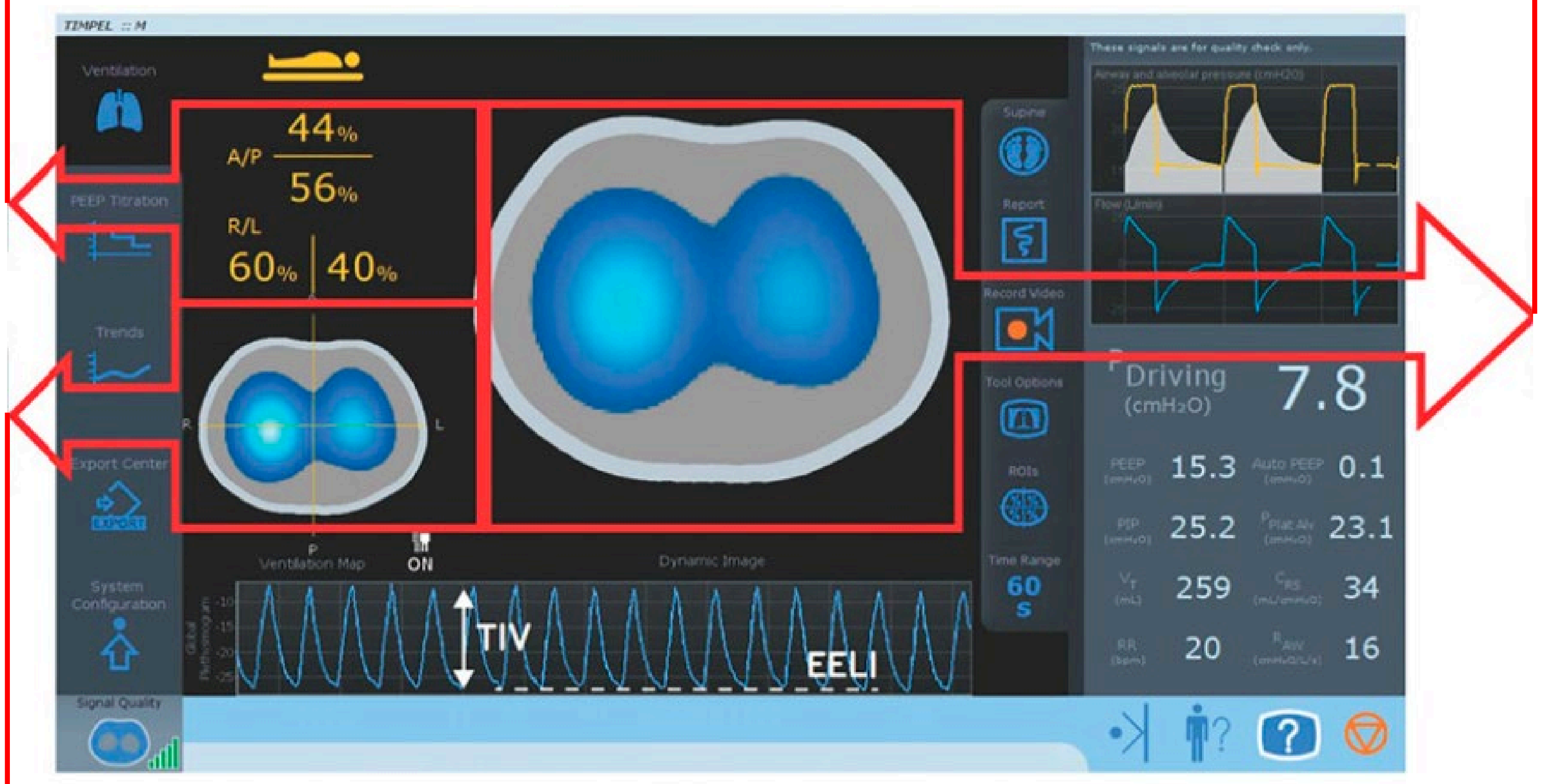
EIT examination



Frerichs et al. Thorax 2017;72:83–93

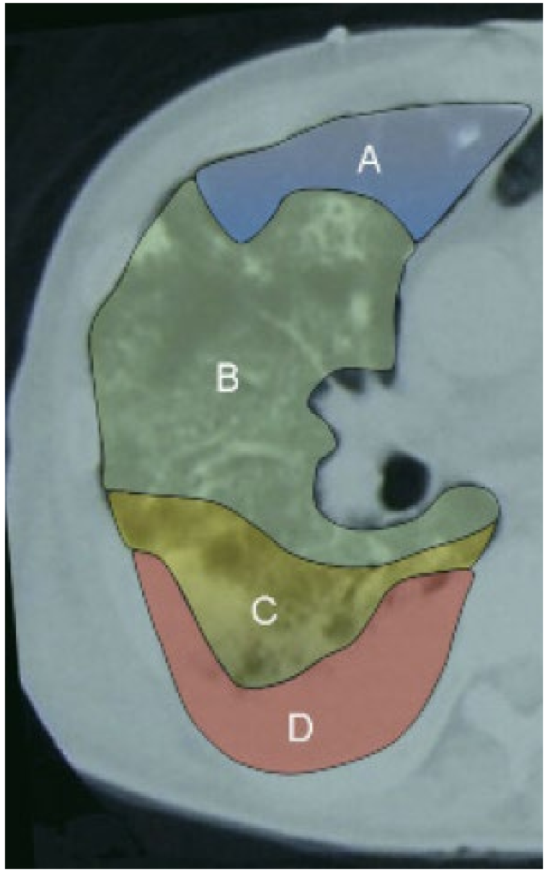
Distribution of ventilation depending on prespecified ROI

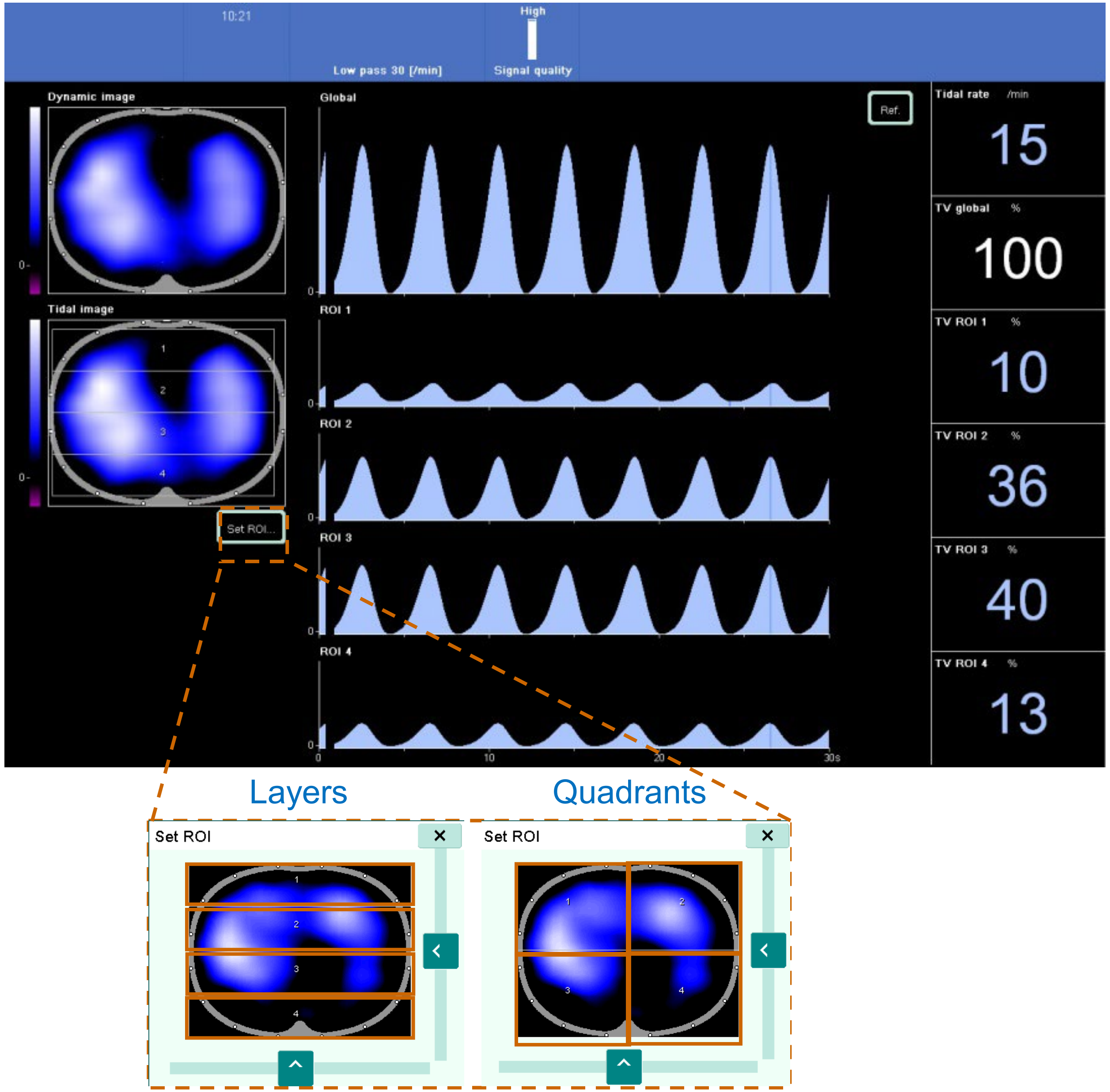
Dynamic image: real me distribution of tidal volume over time



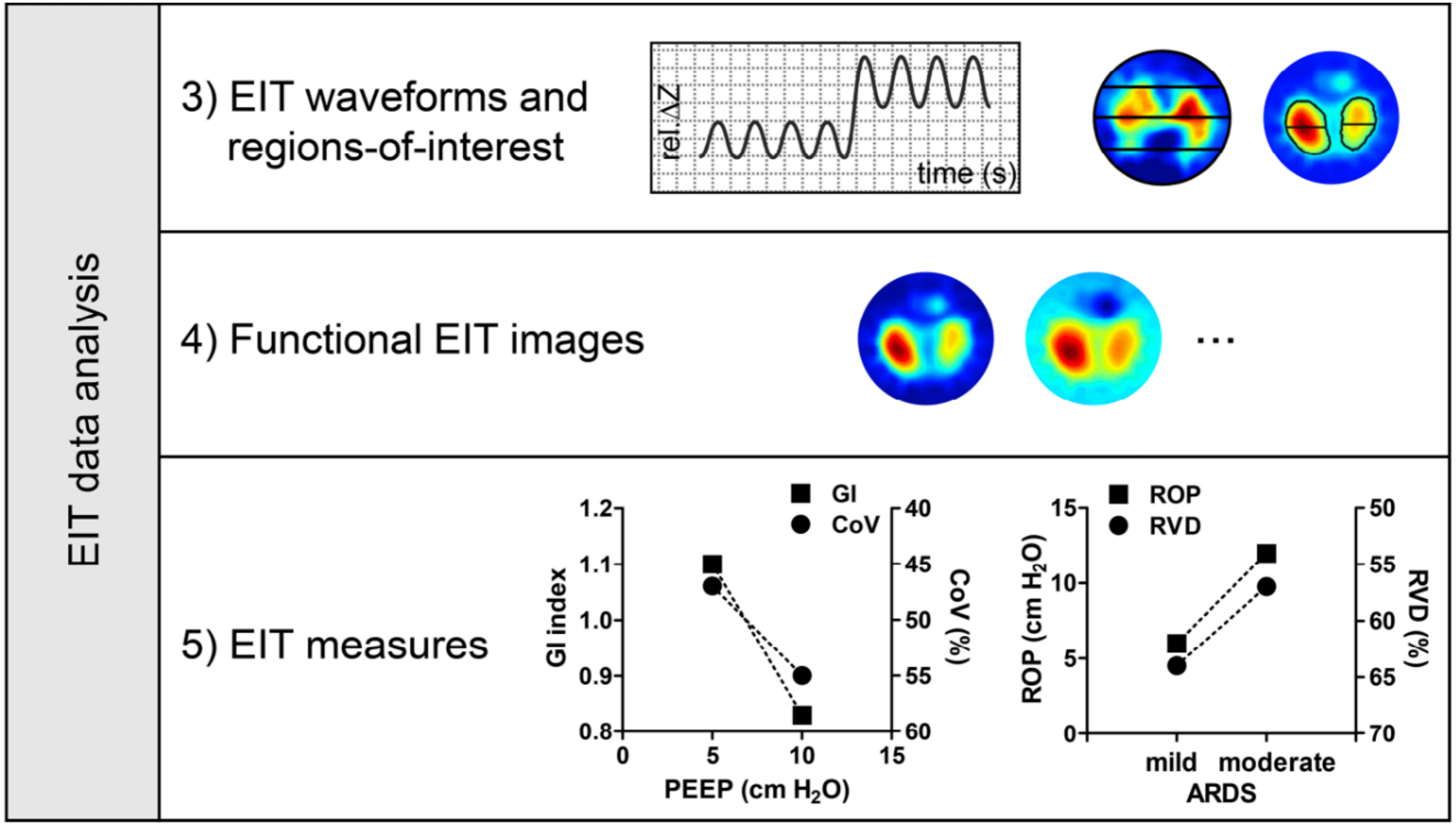
Tidal image: distribution of tidal volume over the last breath, with selected ROI

EIT-Global & regional impendence waveform

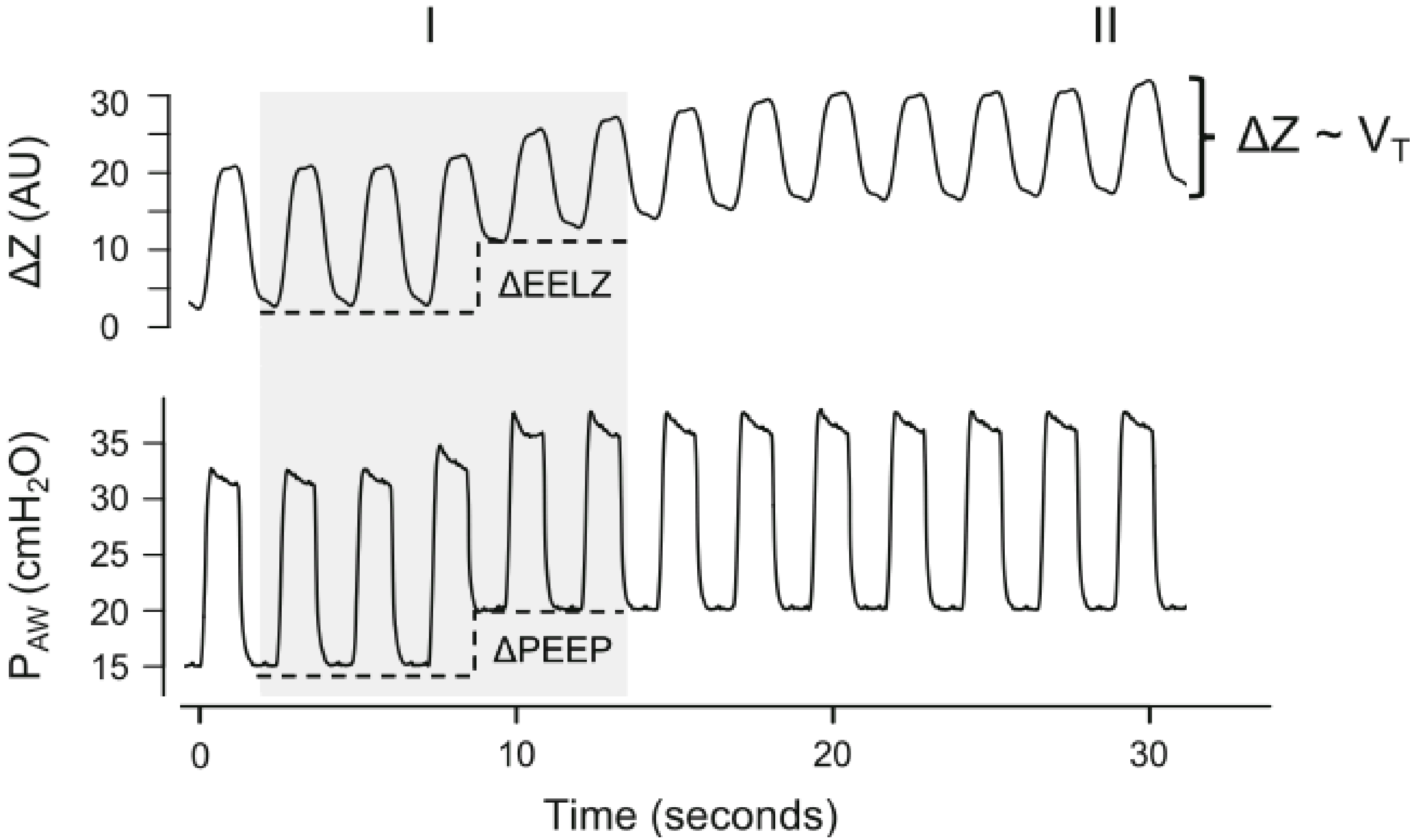




EIT analysis



Frerichs et al. Thorax 2017;72:83–93



- Ventilatory cyclical variation (ΔZ) tracks changes in tidal volume (VT)
- Increment in PEEP increased end-expiratory lung volume (ΔEELZ), a strong correlation between EELV and the EELZ (R^2 = 0.95)

Bachmann et al. Crit Care.2018 Oct 25;22(1):263.

Hinz et al. Intensive Care Med. 2003;29:37-43.

EIT Indices	Definition	Potential Applications
TIV	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
EELI	Regional lung impedance at end of expiration	• EELI changes are correlated with EELV variation • Reflects lung recruitment/ derecruitment • Contributes to identification of pneumothorax

Franchineau et al. AJRCCM. 2024 Mar 15;209(6):670-682.

EIT indices

- **Spatial** parameters
  - GI (Global Inhomogeneity Index)
  - CoV (Center of Ventilation)
  - Ventral–Dorsal Ratio / Difference
- **Temporal** parameters
  - RVD (Regional Ventilation Delay)
  - TSA(Temporal Skew of Aeration)

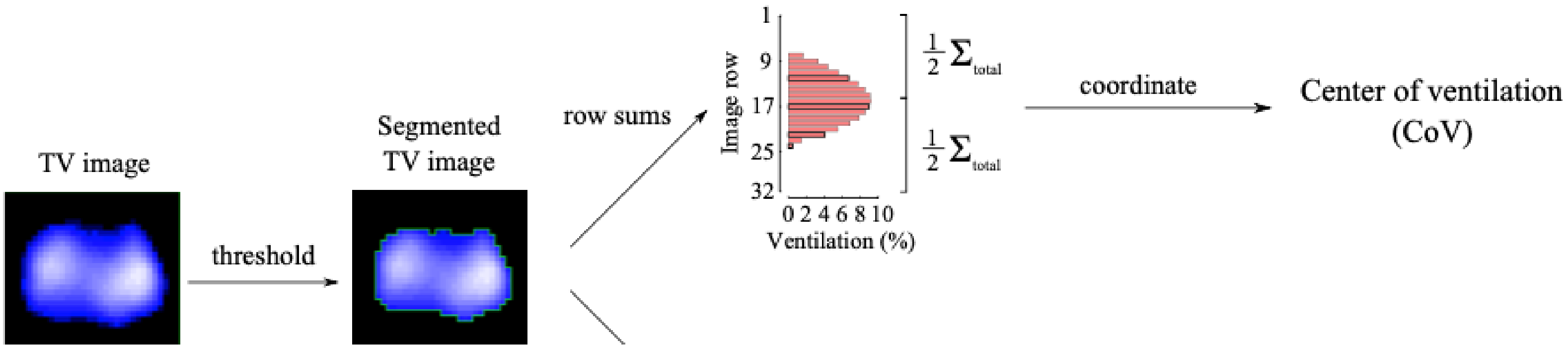
EIT Indices	Definition	Potential Applications
Global inhomogeneity index	Sum of absolute differences between median TIV and each pixel TIV normalized to sum of each pixel TIV	• Reflects heterogeneity of ventilation
Overdistension and collapse estimation	Estimation of relative local compliance loss presented 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
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
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)

Franchineau et al. AJRCCM. 2024 Mar 15;209(6):670-682.

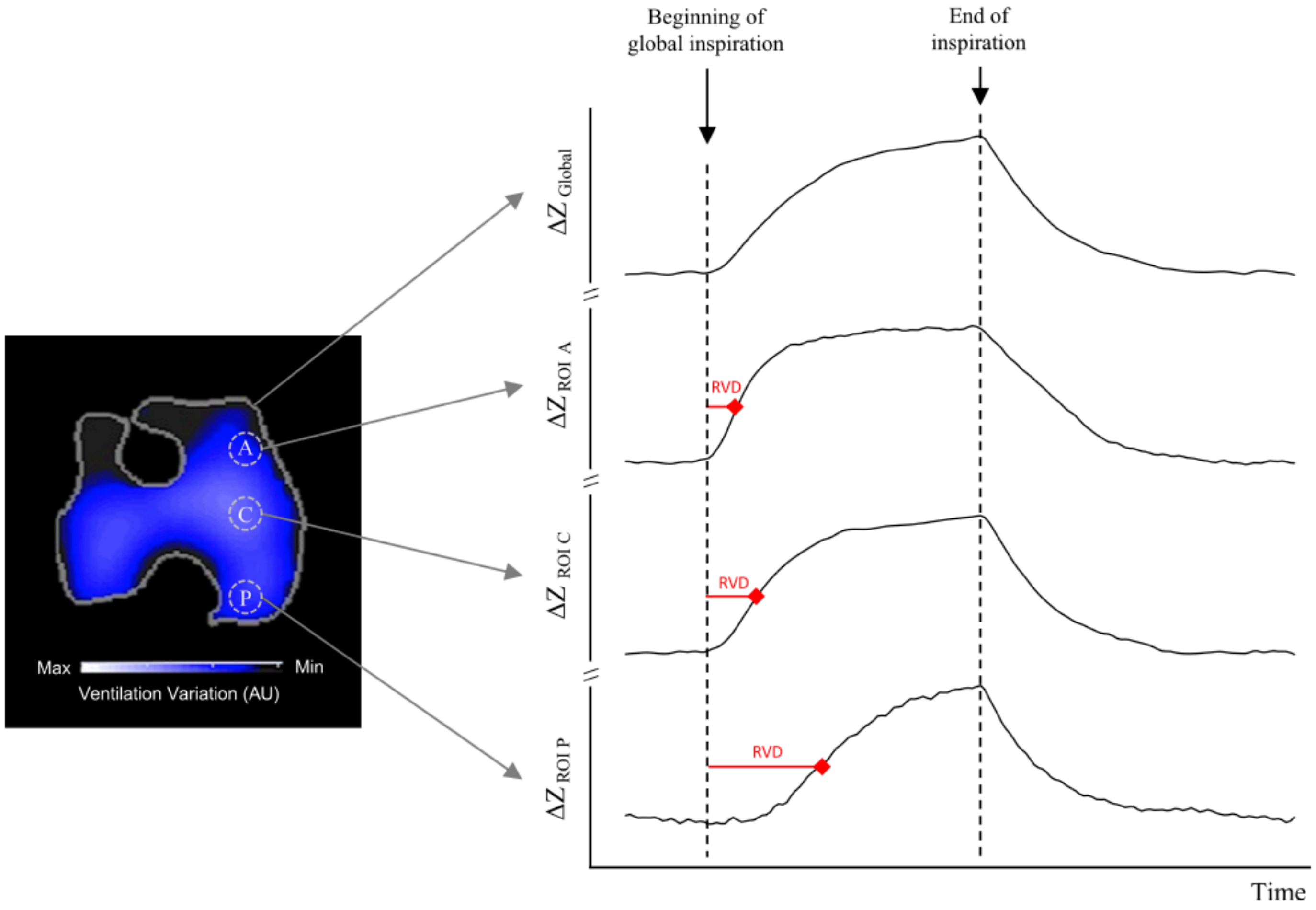
- Global inhomogeneity index: the sum of the impedance changes of each pixel with respect to its median (in absolute values), divided by the sum of the impedance values of each pixel (smaller index, more homogenous)

$$\mathrm{GI} = \sum_{x,y\in \mathrm{lung}} \left| DI_{xy} - \mathrm{median}\left(DI_{\mathrm{lung}}\right)\right| / \sum_{x,y\in \mathrm{lung}} DI_{xy}.$$

- Center of ventilation: geometric center of ventilation, describes the variations of the pulmonary ventilation distribution in the ventral–dorsal direction (0% ventral, 100% dorsal, 50% balanced distribution)

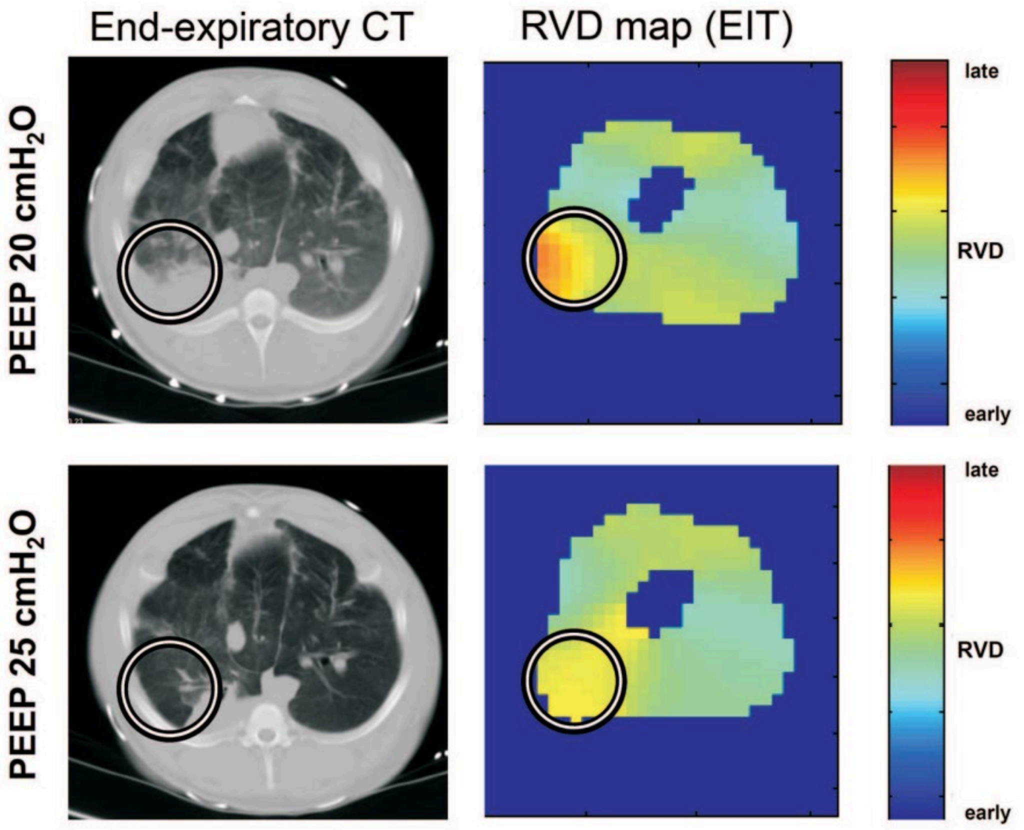


Regional Ventilation Delay (RVD)



Bachmann et al. Crit Care . 2018 Oct 25;22(1):263.

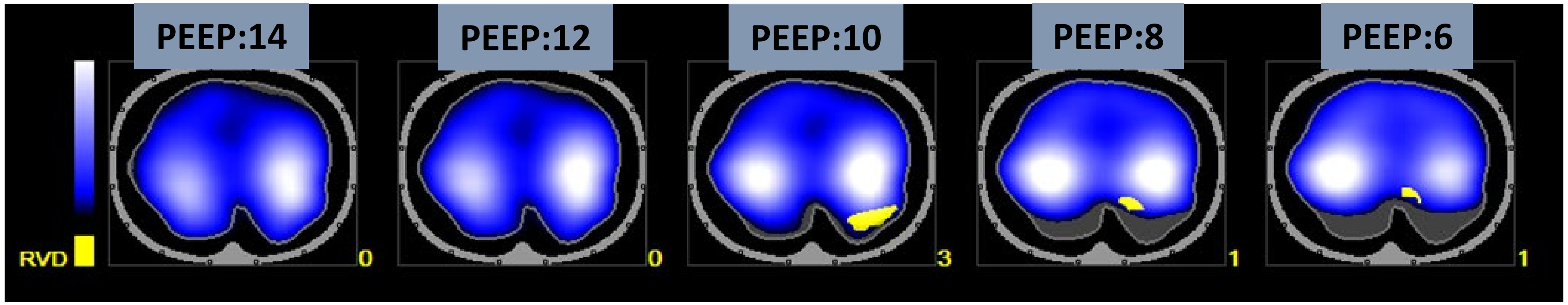
RVD inhomogeneity provides a good estimate of tidal recruitment



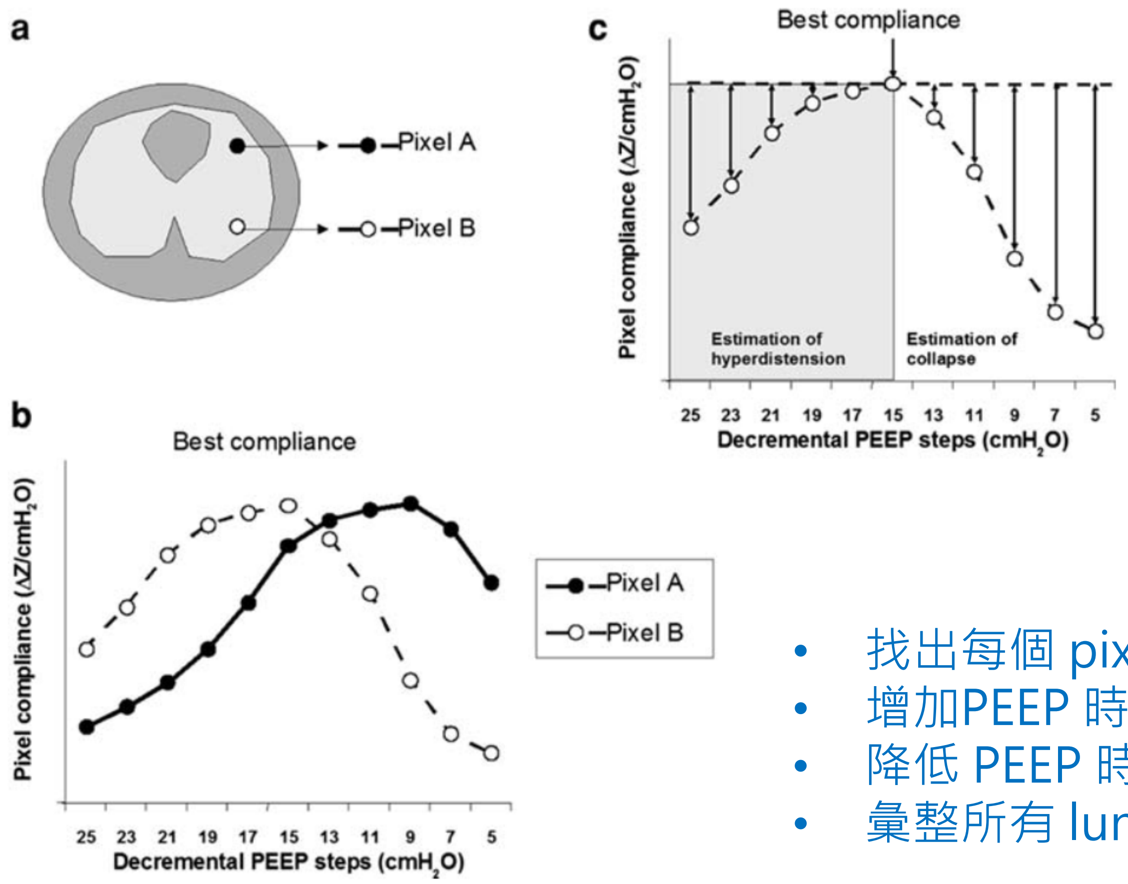
Muders et al. Crit Care Med 2012; 40:903–911.

Three types of patterns

	Inspiration	Expiration	Interpretation
Gray color	close	close	Remain collapse
Blue to white color	open	open	Remain open
Yellow color	open	close	Tidal recruitment



Single Pixel Compliance



$$\text{Hyperdistension}_{\text{pixel}}\ (\%) = \frac{(\text{Best compliance}_{\text{pixel}} - \text{Current compliance}_{\text{pixel}}) \times 100}{\text{Best compliance}_{\text{pixel}}}$$

$$\text{Collapse}_{\text{pixel}}\ (\%) = \frac{(\text{Best compliance}_{\text{pixel}} - \text{Current compliance}_{\text{pixel}}) \times 100}{\text{Best compliance}_{\text{pixel}}}$$

- 找出每個 pixel 的 best compliance
- 增加PEEP 時compliance下降 → **hyperdistension**
- 降低 PEEP 時compliance下降 → **collapse**
- 彙整所有 lung pixels → 計算**過度擴張與塌陷比例**

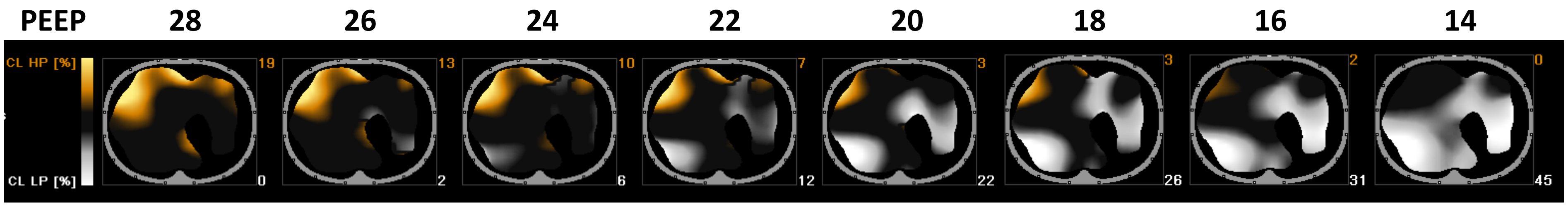
CL HP: Compliance loss towards higher PEEP levels (decrease in compliance)

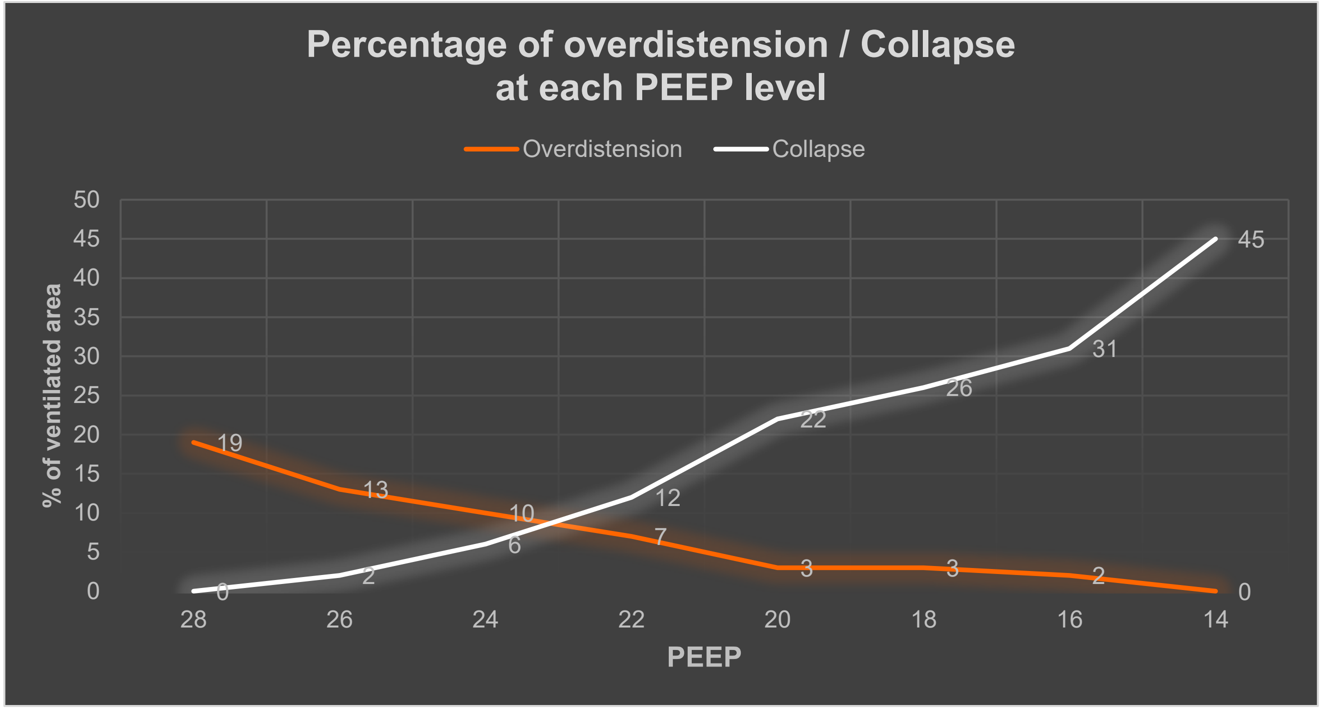
CL LP: Compliance loss towards lower PEEP levels (decrease in compliance)

→ Calculate the percentage of hyperdistention and collapse

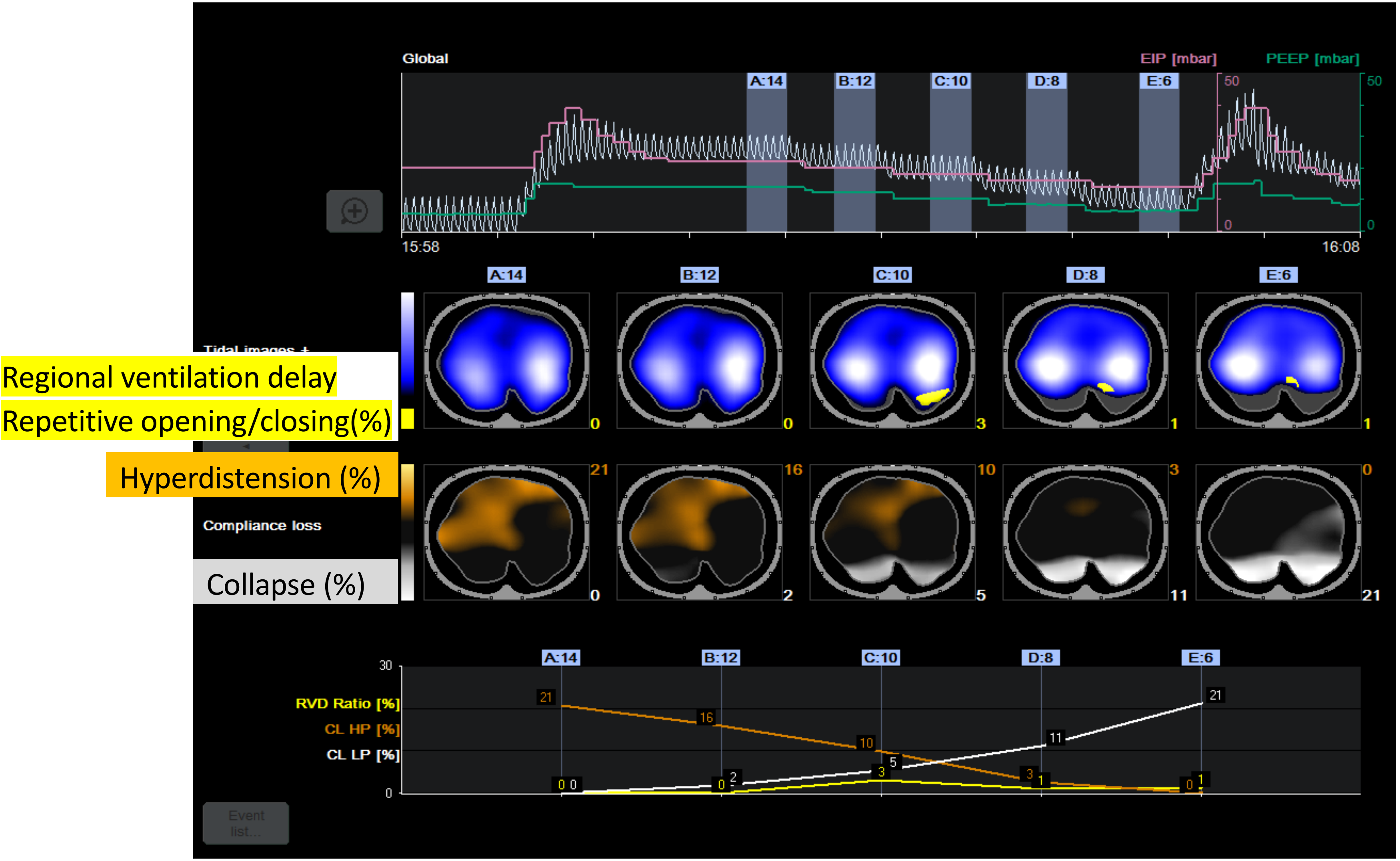
Costa et al. Intensive Care Med . 2009 Jun;35(6):1132-7.

Suggested PEEP: the balance of hyperdistention and collapse





Decremental PEEP Trial Analysis
(Detection of hyperdistention, collapse and optimal PEEP)



SYSTEMATIC REVIEW

Electrical impedance tomography-guided positive end-expiratory pressure titration in ARDS: a systematic review and meta-analysis

Nickjaree Songsangvorn[1,2], Yonghao Xu[1,3*], Cong Lu[1], Ori Rotstein[1,4], Laurent Brochard[1,5], Arthur S. Slutsky[1,5], Karen E. A. Burns[1,5] and Haibo Zhang[1,5,6,7*]

Thirteen studies :
3 RCT
10 non-randomized

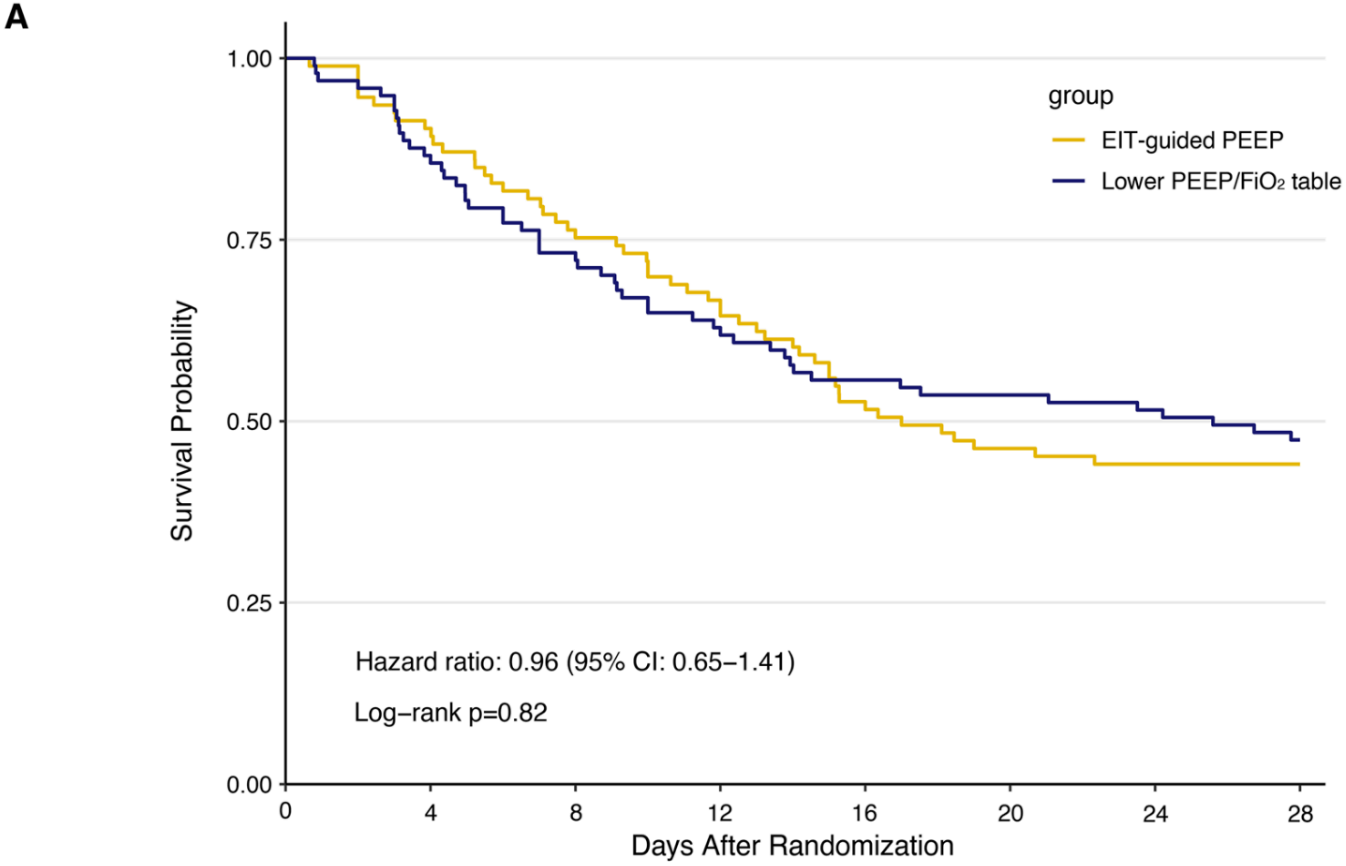
623 ARDS patients

- EIT-guided PEEP significantly
  - Improved lung compliance (n= 941, mean difference = 4.33),
  - Reduced mechanical power (n=148, mean difference = −1.99
  - Lowered driving pressure (n=903, mean difference = −1.20)
- A reduction in mortality rate (259 patients, relative risk = 0.64) was associated with modest improvements in compliance and driving pressure in three studies.

Songsangvorn et al. Intensive Care Med. 2024 May;50(5):617-631.

EIT-guided PEEP and mortality of ARDS patient (the EITVent RCT)

EIT group (n=93) vs. lower PEEP/FiO2 table group (n=97)

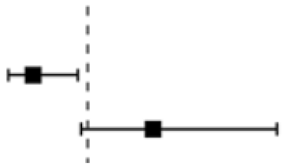


Number at Risk

EIT-guided PEEP	93	84	70	62	49	43	41	41
Lower PEEP/FiO₂ table	97	84	71	61	54	52	50	46

5 sites
Feb 2022 to June 2023
Early terminated for futility
Mortality: 52 patients (55.9%) vs 51 patient (52.6%)

R/I ratio		
≥ 0.5	16/45 (35.6)	27/45 (60.0)
< 0.5	30/41 (73.2)	24/47 (51.1)



0.01
0.49 (0.26–0.91)
1.61 (0.94–2.77)

decreased mortality in subgroup patients with higher lung recruitability

Yuan et al. Am J Respir Crit Care Med. 2026 Mar 1;212(3):440-451.

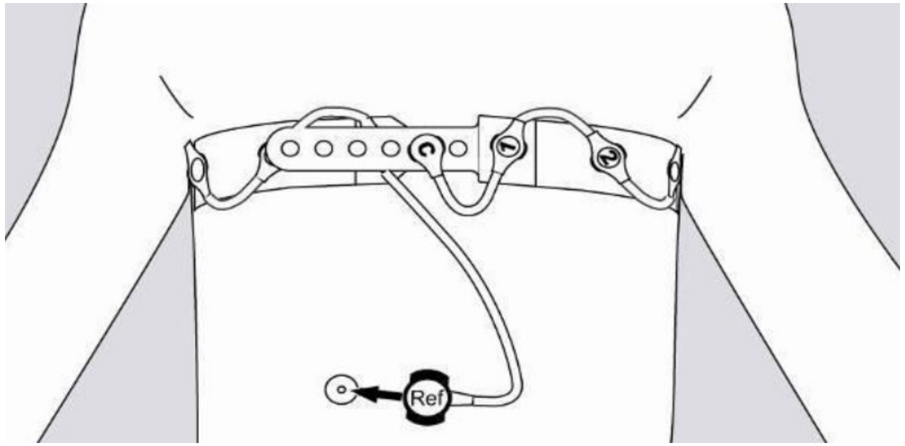
	Prone positioning	EIT	HFOT (Day 1)	HFOT (D2-)
診療項目及代碼	47104B 俯臥通氣治療	17024B 胸部電阻斷面造影	57030B 濕化高流量氧氣治療	57031B 濕化高流量氧氣治療
給付點數	5,114	3,883	6,000	1,937
生效起日	2022/3/1	2023/3/1	2024/4/1	2024/4/1

EIT 2023/3/1通過健保給付

- 編號：**17024B（3,833點）**
- 診療項目：**胸部電阻斷面造影**
- 註：（3,833點，醫學中心及區域醫院）
  - 適應症：入住加護病房，且為柏林定義中重度急性呼吸窘迫症候群病人（ICD-10-CM：J80）。
  - 限內科、外科、麻醉科、兒科、急診醫學科、神經科及神經外科專科醫師執行。
  - 須麻醉及呼吸治療師在場共同監作，隨時提供必要之緊急措施。
  - 執行本項至少需有十六個以上胸帶電極數，且執行本項時間至少六十分鐘，並應於申報時填寫執行起迄時間。
  - 需檢附「胸部電阻斷面造影報告」備查。
  - 每次住院以申報一次為原則，且至多申報二次，並應於病歷敘明查視執行之原因。

SOP_前置期

- **設備前測（3min）**：確認電源/校正線連接，完成校正流程
- **量測選皮帶（3min）**：量胸圍、選皮帶尺寸，檢查皮帶破損與彈性
- **固定連接**：病患電纜與皮帶織扣扣緊
- **備物與告知（3min）**：準備導電膠、貼片；告知檢查並褪上衣
- **醫師評估（6min）**：確認適應症、生命徵象穩定、無禁忌症
- **綁上胸帶（4min）**：胸帶電極以水/導電膠潤滑，固定於**第4–6肋間**



SOP_初期＆中期

- **開機校正**：機器自動校正約30秒後即可顯示影像
- **電極阻抗檢查（2 mins）**：確認電極區皮膚阻抗是否過高
- **改善接觸（1 min）**：必要時塗導電膠，確保電極貼合且訊號正常
- **設備連線（2 mins）**：EIT與呼吸器連線以擷取通氣訊號，完成介面/參數設定並確認輸入正常
- **肺部再擴張前準備（10 mins）**：呼吸器改 **Pressure control**；醫師調整鎮靜劑/肌肉鬆弛劑，確保平穩呼吸並記錄生理參數
- **Recruitment maneuvers（20 mins）**：做 **incremental + decremental trial**
- **步驟規則**：固定ΔP，逐步上調PEEP；每階停留2分鐘，穩定後再下一階
- **終點**：直到 **PIP 34 cmH_2O**

SOP_後期

- **測量結束，移除胸帶（4 mins）**：護理師 + 呼吸治療師協同取下胸帶
- **分離線材（2 mins）**：呼吸治療師將皮帶與插頭病患電纜分離
- **終期消毒（2 mins）**：以**2%克菌寧**擦拭皮帶，晾乾完成消毒
- **資料下載（1 min）**：下載影像與測量數據
- **醫師判讀（15 mins）**：綜合影像結果撰寫「胸部電阻斷面造影報告」
- **設備收尾（2 mins）**：解除與呼吸器連線，消毒紙巾擦拭機器表面
- **病患整理（6 mins）**：清潔胸廓並穿回病人服

Outlines

- Why? Unmet needs in hypoxemic respiratory failure and ARDS
- How? Introduction of electrical impedance tomography
- When? Clinical application of EIT

What EIT can show

- Individualize PEEP → **collapse/overdistension map**
- Ventral–dorsal shifts (prone/PEEP/SBT) → **CoV**, **V/D ratio**

- Heterogeneity risk → **GI index**
- Dyssynchrony / P-SILI risk → **pendelluft**, **RVD/TSA** (time-domain)
- Procedure-related derecruitment (suction/turning) → **EELI trend**, ROI ventilation loss

Potential use of EIT	P/ F ratio	Early management of ARDS
• Individualize ventilation settings • Monitor prone positioning effects • Monitor lung ultra-protective ventilation • Follow ventilation/perfusion ratio • Identify dyssynchronies	< 80	Consider VV-ECMO
• Identify optimal PEEP • Identify dyssynchronies (pendelluft effect, breath stacking) • Detect airway opening pressure	< 150	Neuromuscular blockade; prone positioning
	< 200	High level of PEEP if it improves oxygenation and/or lung mechanics
• Monitor impact of HFNO or NIV (collapse, overdistension) • monitor awake prone positioning • Assess consequences of BAL on lung collapse	Confirmed ARDS	VT 6 mL/kg PBW; plateau pressure < 30 cmH_2O; PEEP ≥ 5 cmH_2O; check for hypercapnia

Franchineau et al. JRCCM. 2024 Mar 15;209(6):670-682.

RECENT STUDIES ON CHEST ELECTRICAL IMPEDANCE TOMOGRAPHY

EXPERIMENTAL

- PEEP setting
- Unilateral, bilateral lung injury
- Ventilation mode
- Recruitment
- Body position
- AOP, atelectasis
- iNO efficacy
- $\dot{V}/Q$ match
- Lung perfusion, embolism
- Pendelluft
- Asynchrony

CLINICAL – ADULTS

1. Perioperative

Preoperative
- Ventilation pattern
- Complications

Intraoperative
- PEEP setting
- Atelectasis
- Sedation, anaesthesia effect
- Body position
- Single-lung ventilation
- Recruitment

Postoperative
- Phenotyping, PPC prediction

Outside OR
- Endoscopic procedures

2. ICU

- PEEP setting in different patients (ARDS, COVID-19, neurocritical)
- AOP
- APRV titration
- Lung perfusion
- $\dot{V}/Q$ match
- PEEP setting in assisted mode
- Pendelluft
- Weaning
- SBT prediction

CLINICAL – NEONATES/CHILDREN

1. Delivery room

- First breaths of life
- Form of delivery

2. Perioperative

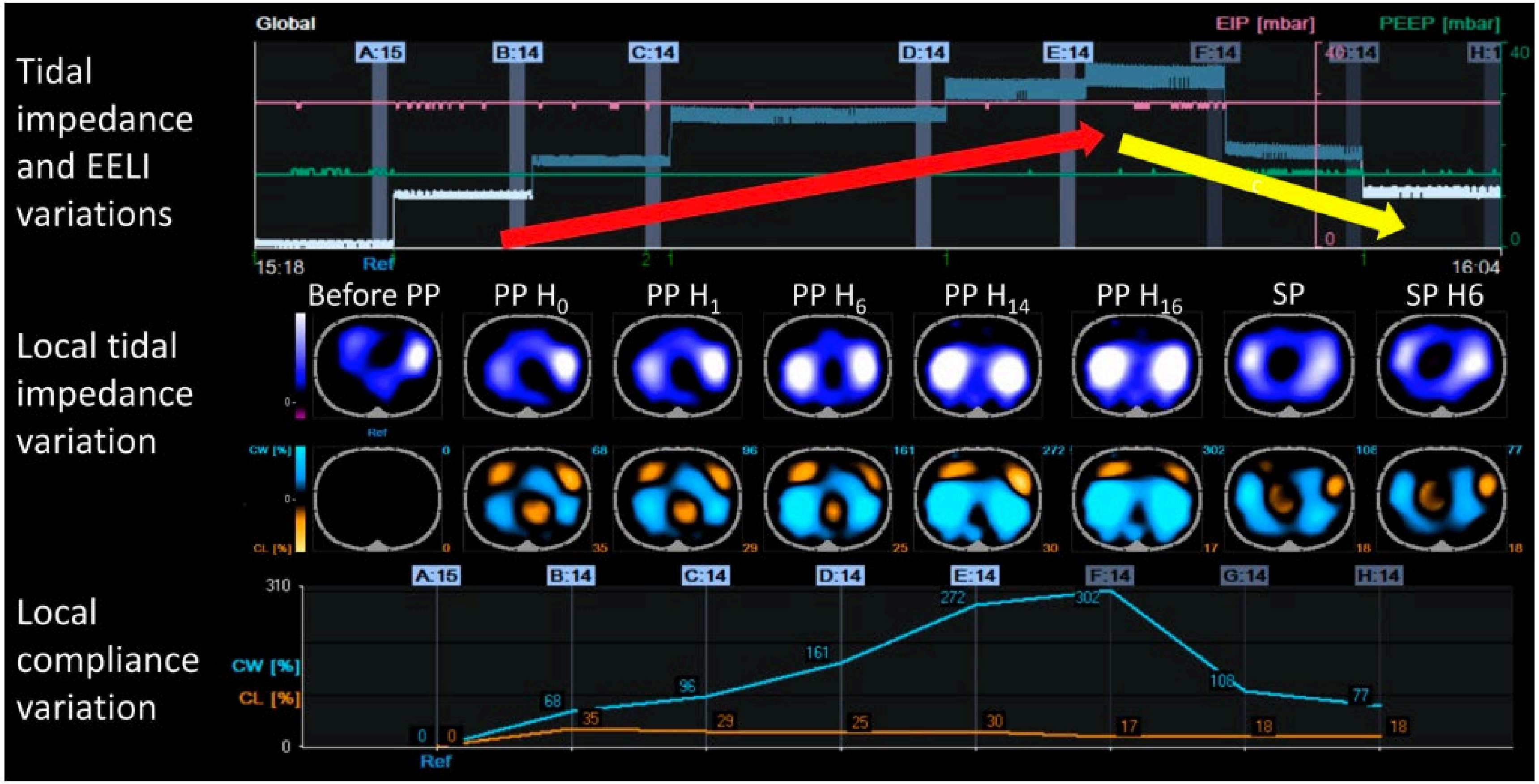
- Sedation, anaesthesia effect
- Extubation
- One-sided intubation
- Diaphragmatic hernia
- PEEP setting
- Body position

3. NICU/PICU

- Ventilation mode
- Physical therapy
- Non-invasive support
- Weaning
- Extubation
- Lower respiratory tract infection
- PEEP setting
- nARDS/pARDS

Frerichs et al. *Intensive Care Med Exp*. 2026 Jan 6;14(1):1.

Prone positioning monitored by EIT



The change of EELI and collapse parts

Franchineau et al. Am J Respir Crit Care Med. 2024 Mar 15;209(6):670-682.

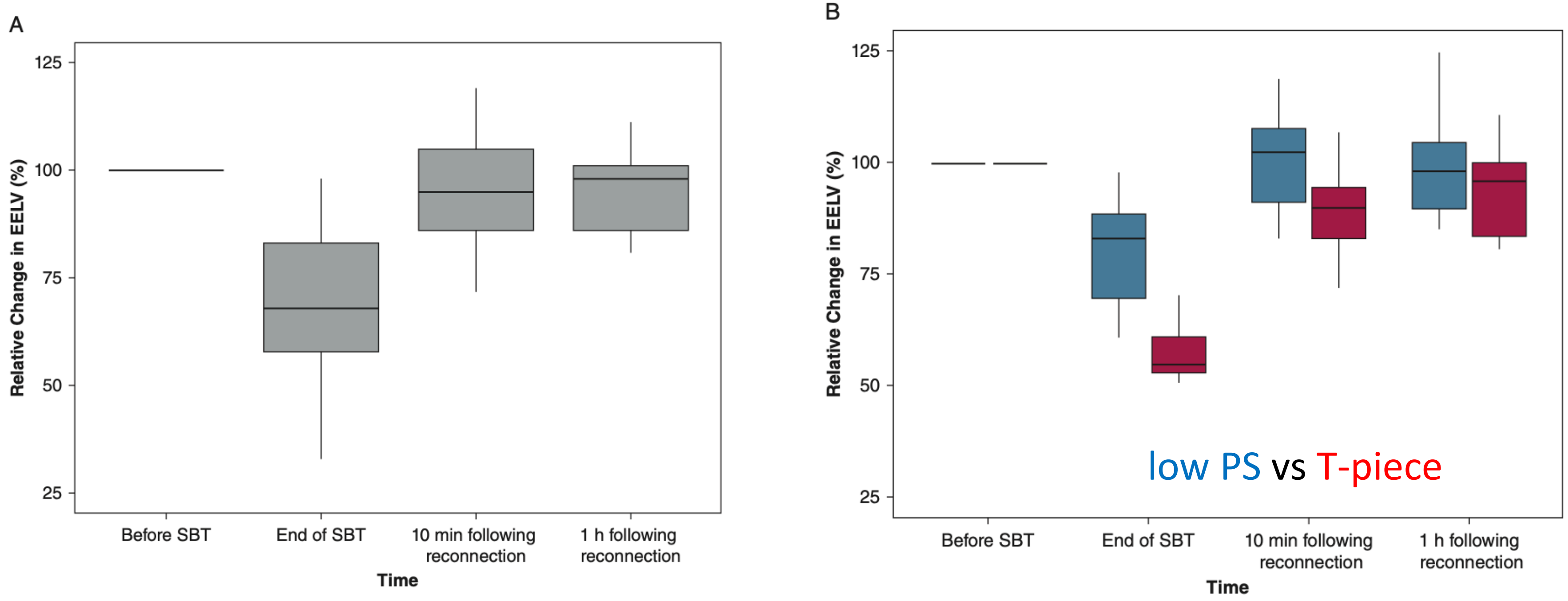
[**Critical Care** Original Research]

CHEST

Physiologic Effects of Reconnection to the Ventilator for 1 Hour Following a Successful Spontaneous Breathing Trial

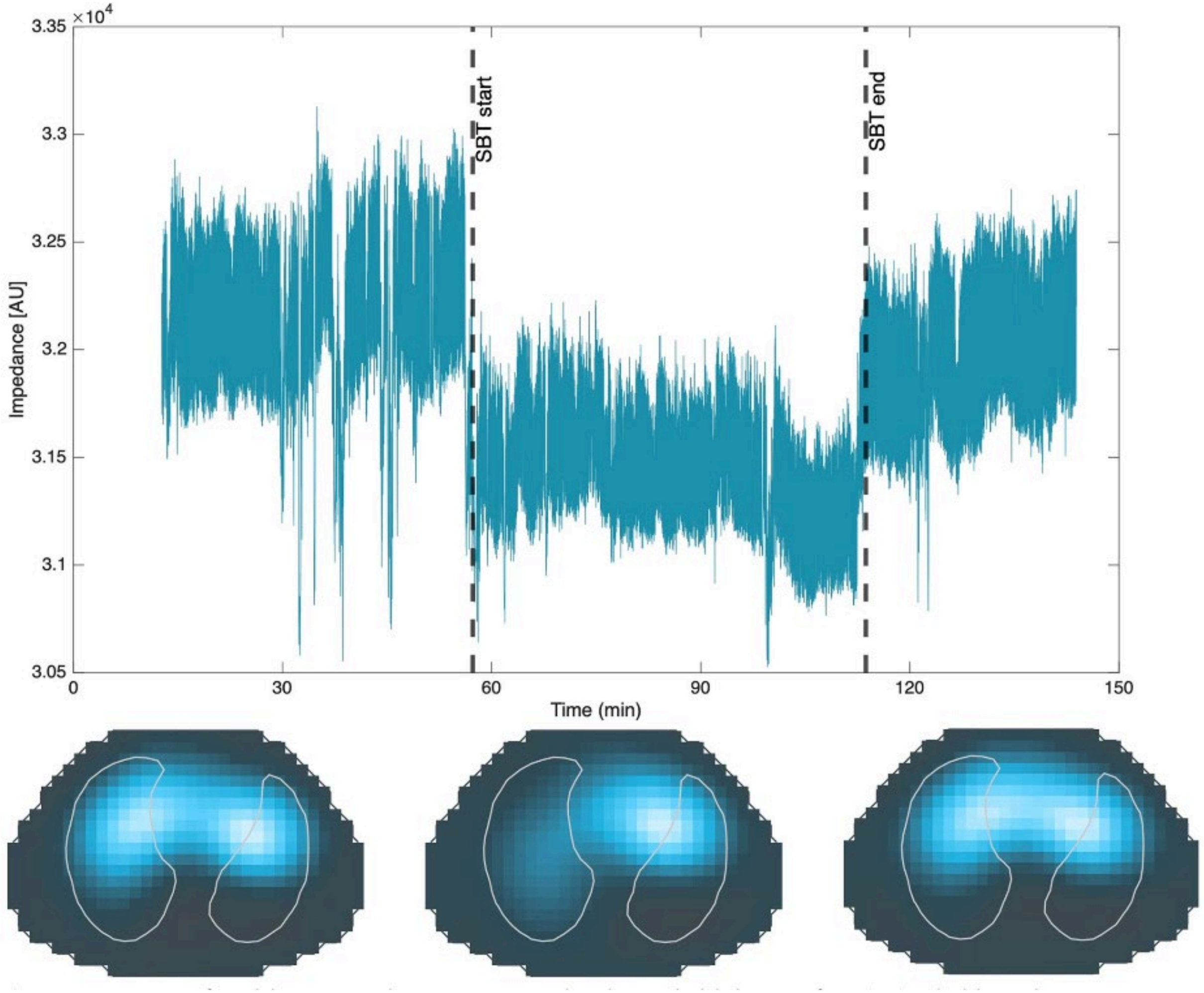
Check for updates

Rémi Coudroy, PhD; Alice Lejars, MD; Maeva Rodriguez, MD; Jean-Pierre Frat, PhD; Christophe Rault, PhD; François Arrivé, MD; Sylvain Le Pape, PhD; and Arnaud W. Thille, PhD



An ancillary study of a RCT comparing SBT performed
with a T-piece or with PSV (*N Engl J Med* 2022;387:1843-185)

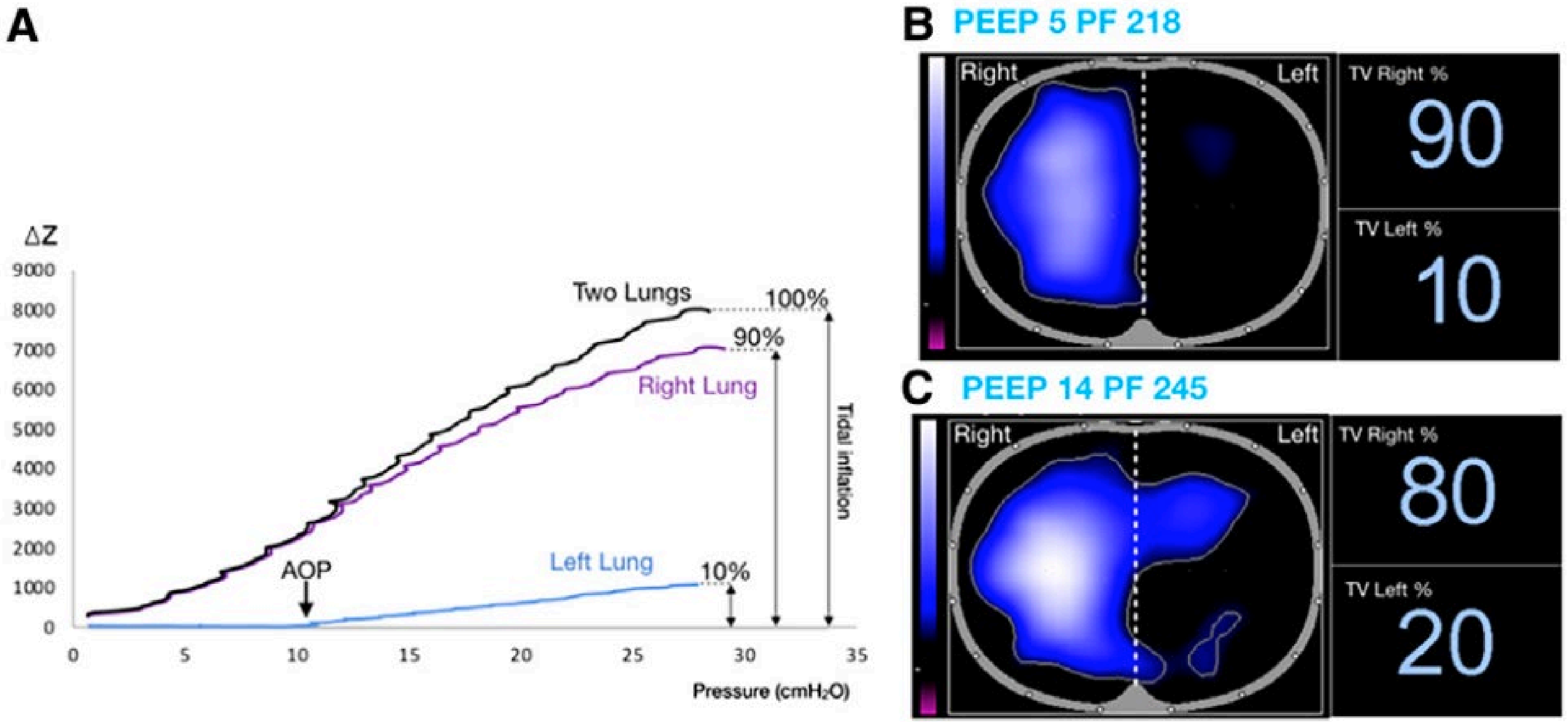
Assisted-breathing/weaning monitoring



Spontaneous effort → **EELI less stable**
SBT start (↓PEEP) → **EELI drops**
Post-SBT → **partial EELI recovery**
+ **ventilation redistribution**

Frerichs et al. *Intensive Care Med Exp*. 2026 Jan 6;14(1):1.

Airway opening pressure (AOP)

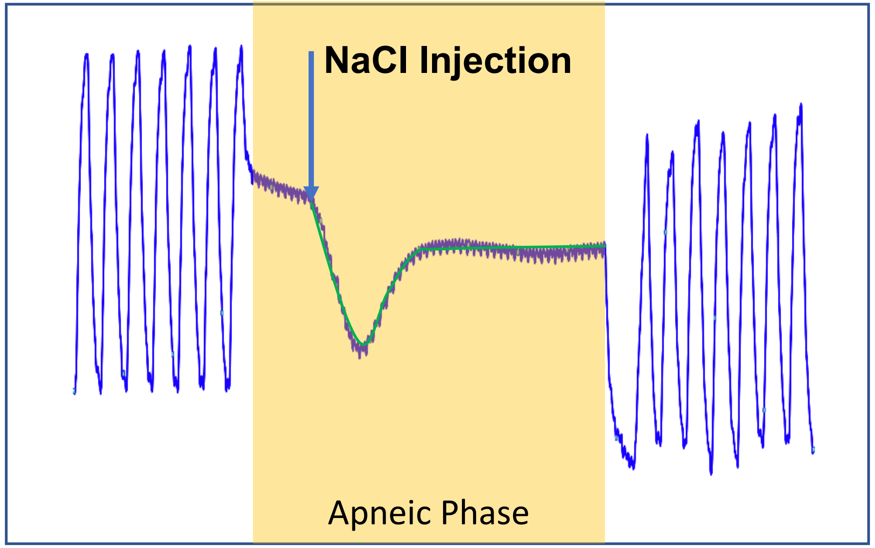


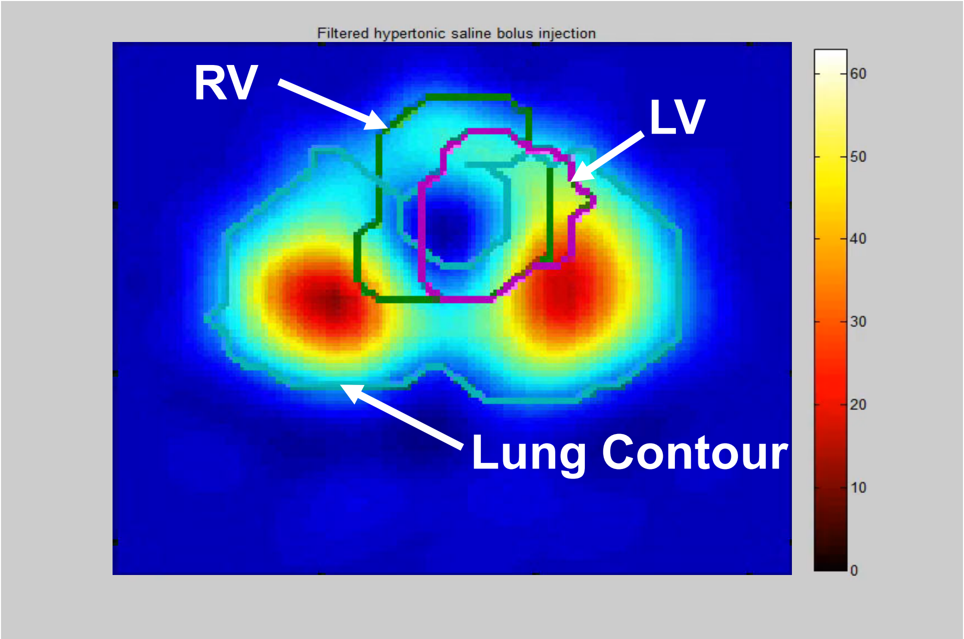
A. airway opening pressure (AOP) of left lung is not captured when both lungs analyzed simultaneously
B. PEEP lower than AOP of left lung, P/F ratio 218
C. PEEP higher than AOP of left lung, P/F ratio 245

Franchineau et al. AJRCCM. 2024 Mar 15;209(6):670-682.

EIT perfusion

Uses the first-pass dilution of an injected conductive contrast (usually hypertonic saline) through the pulmonary circulation to map regional blood flow based on transient impedance changes

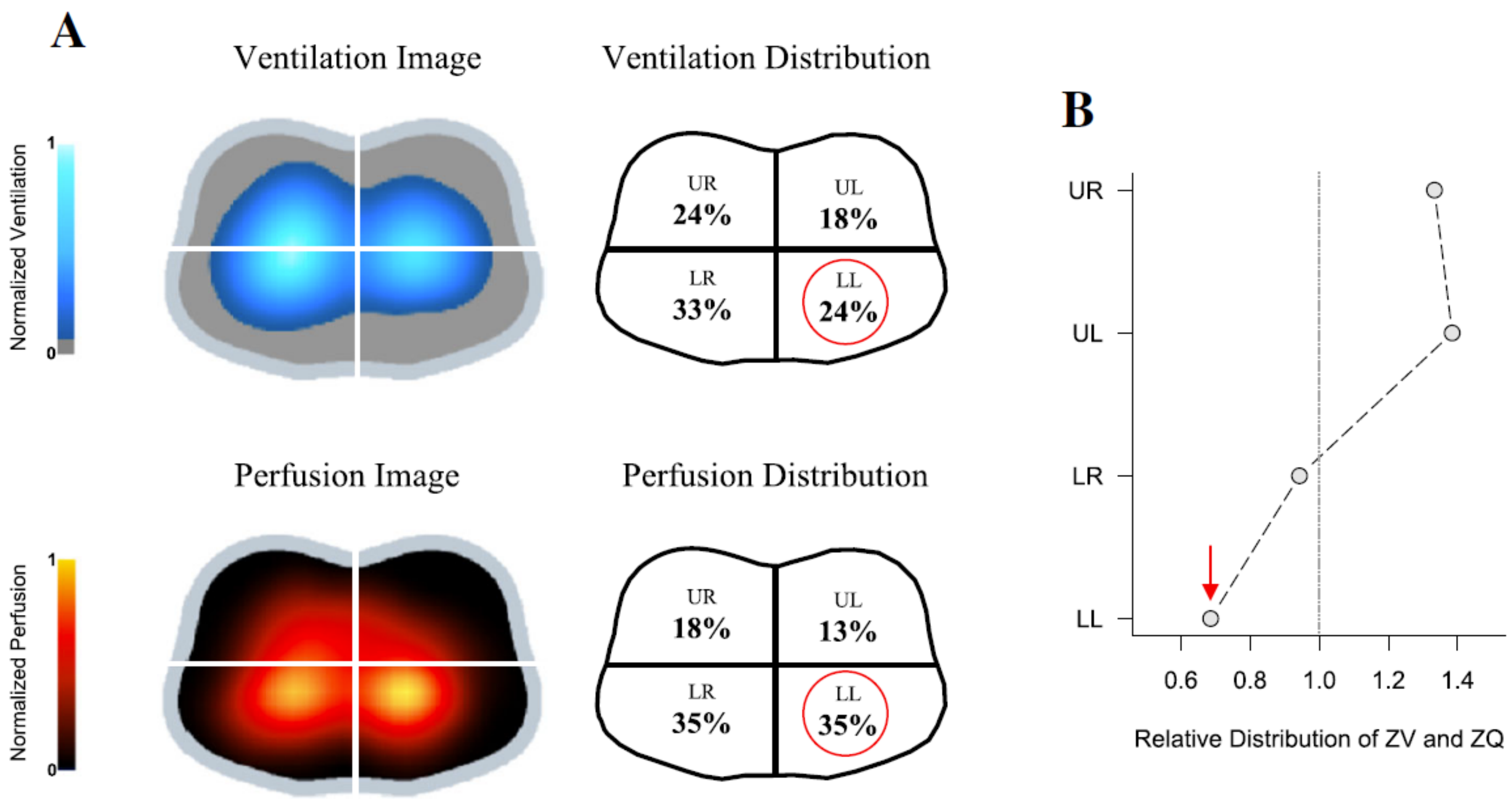




Xu et al. Front Physiol. 2021 Oct 13:12:748724.

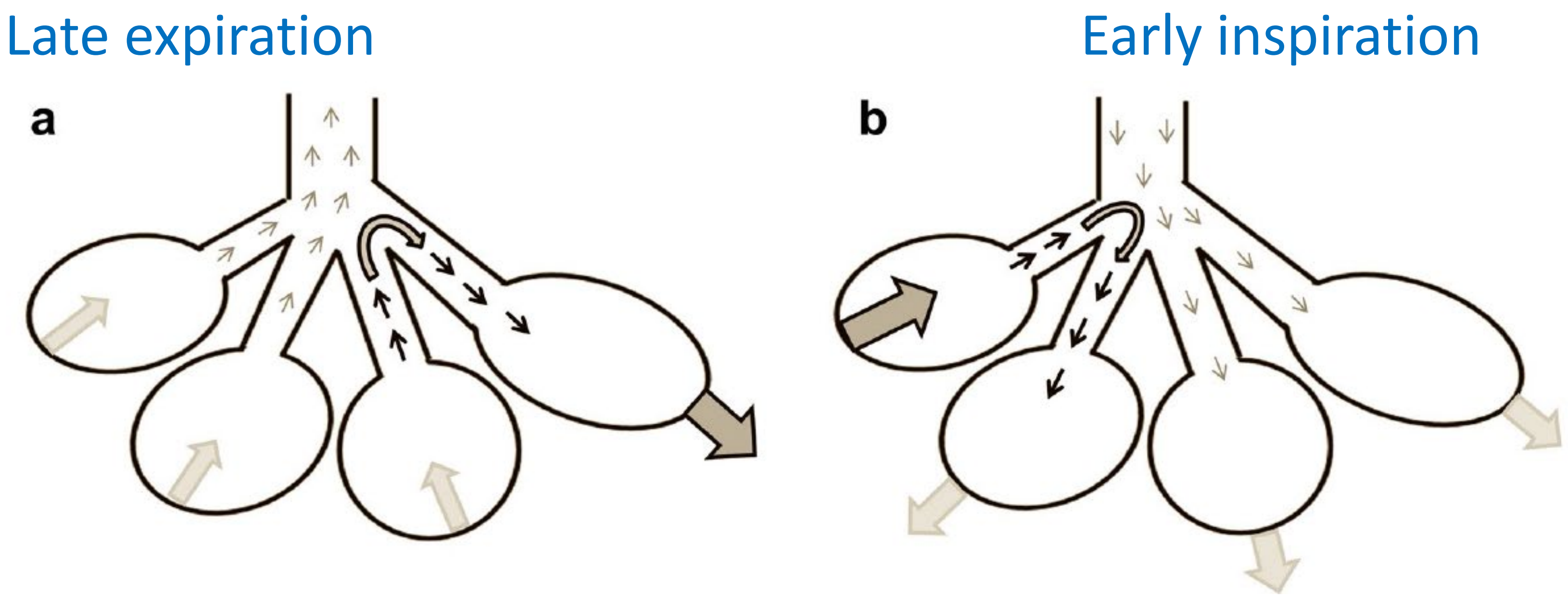
Regional ventilation-perfusion mismatch

A case of left lower lung pneumonia



Bachmann et al. Crit Care.2018 Oct 25;22(1):263.

Pendelluft during spontaneous effort

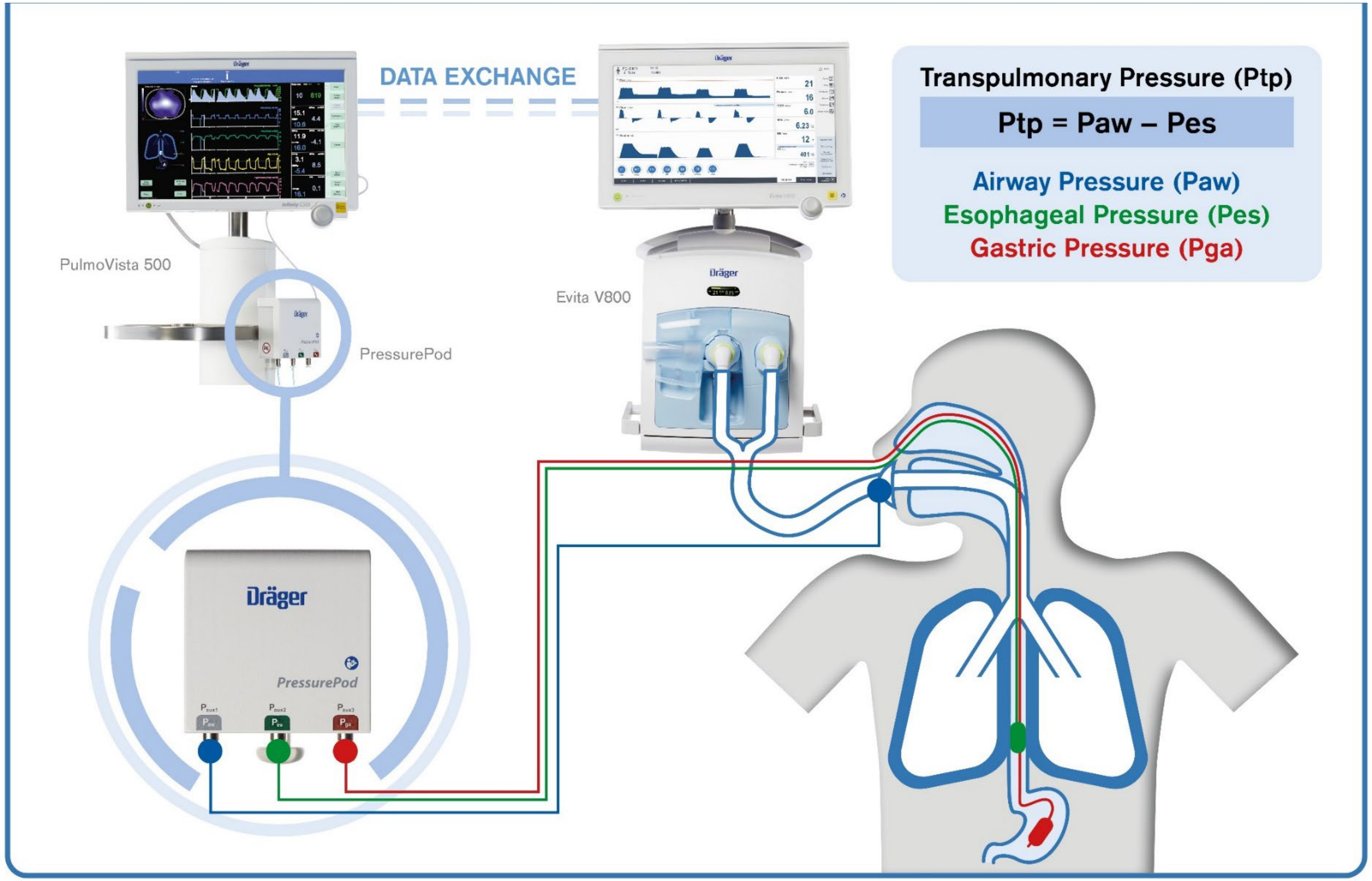


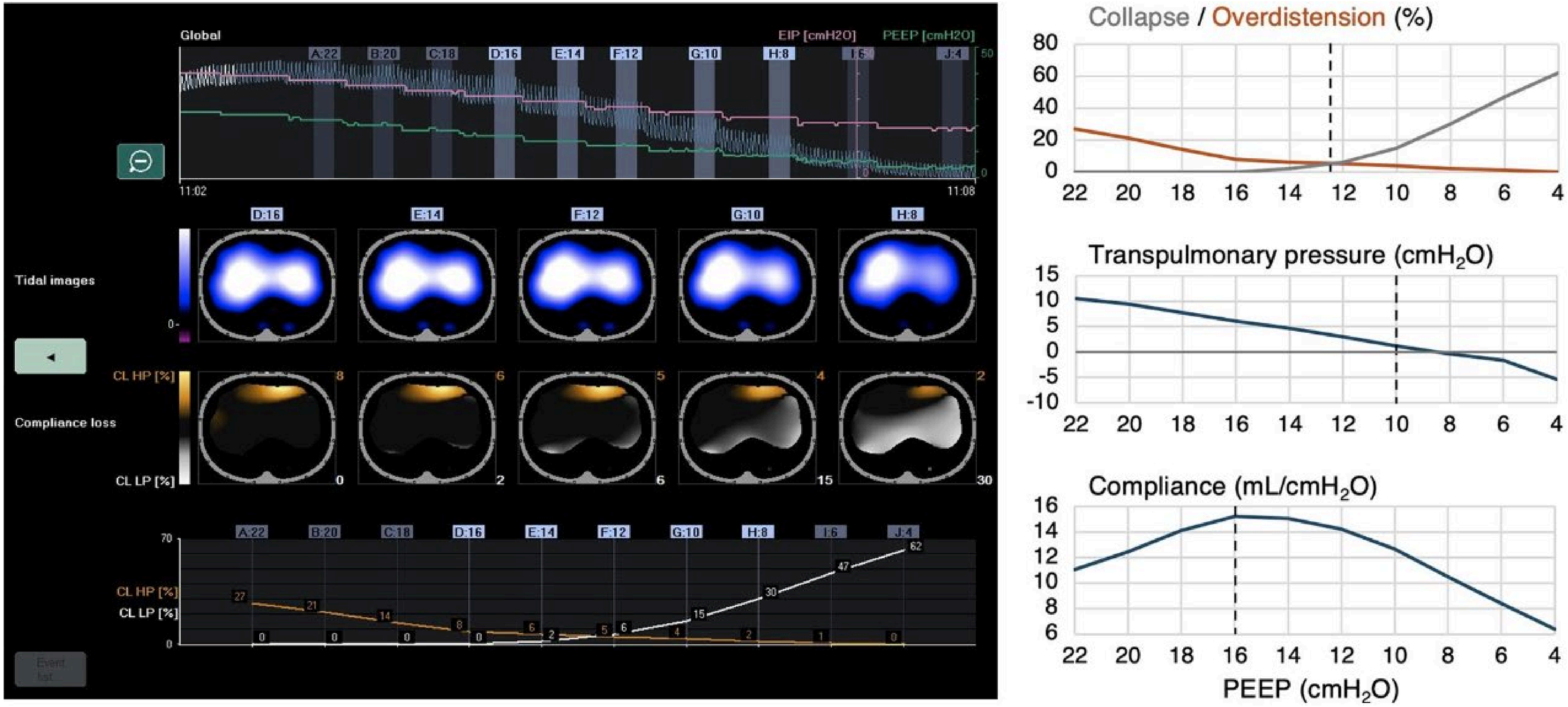
Intrapulmonary gas redistribution occurring around **end-expiration** (T0), during late expiration and early inspiration, independent of ventilator TV

Could contribute to **patient self-inflicted lung injury (P-SILI)** due to inhomogeneous effort

Coppadoro et al. Ann Intensive Care. 2020 Apr 7;10(1):39.

Combined with esophageal balloon





Different targets give different PEEP: EIT-derived PEEP can **differ** from PEEP chosen by **transpulmonary pressure (Pes)** or by **best respiratory-system compliance**

Frerichs et al. *Intensive Care Med Exp*. 2026 Jan 6;14(1):1.

THE CONTRIBUTIONS OF EIT TO ARDS OUTCOME

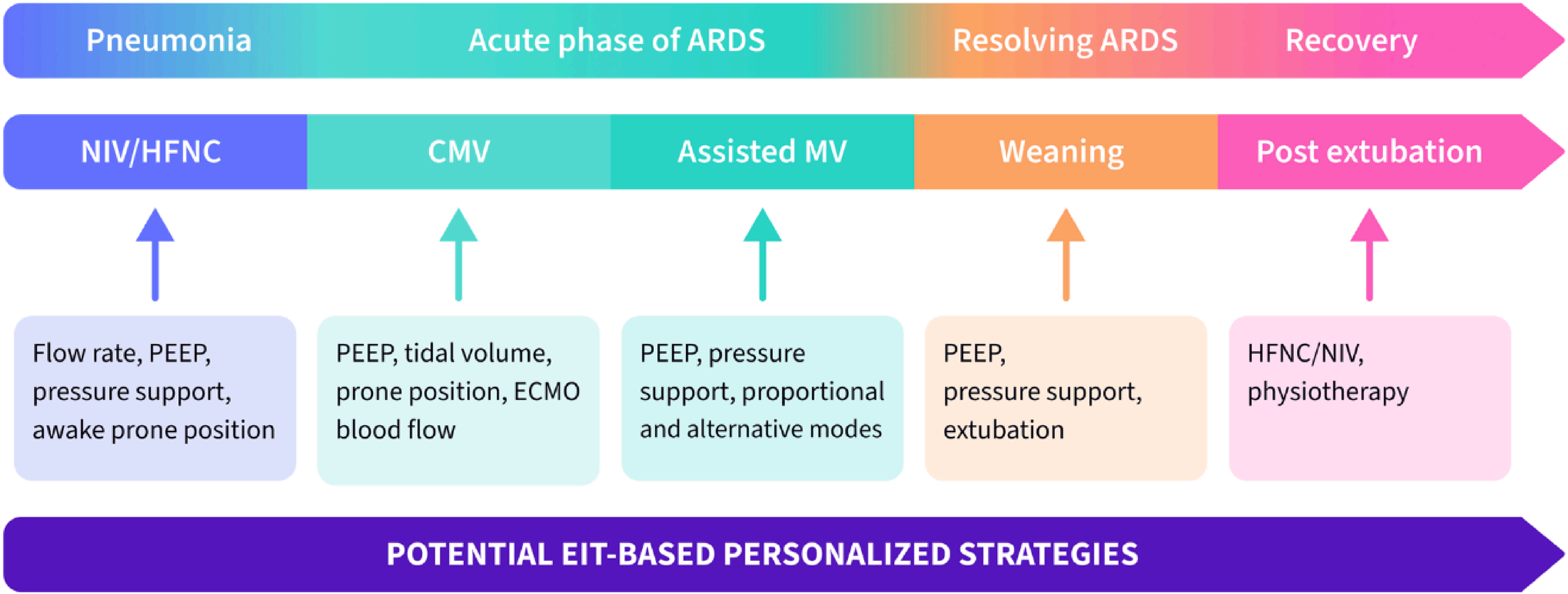


Fig. 1 Personalised strategies guided by Electrical Impedance Tomography along the clinical course of ARDS

Mauri et al. Intensive Care Med. 2026 Jun 30.

Summary

- EIT is a noninvasive, real-time, and continuous tool monitoring regional lung ventilation
- EIT complements conventional global monitoring and supports individualized ventilation—particularly **PEEP titration, assessment of prone response, and monitoring during assisted breathing/weaning**
- The physiological benefits of EIT-guided ventilation are increasingly recognized, while its impact on patient-centered outcomes remains to be established.

Thanks for your attention！

kyw@ntu.edu.tw

R:I ratio (Recruitment to Inflation ratio) – 概念與計算

核心概念：加 PEEP 後增加的肺容量，有多少是打開原本關閉的肺（recruitment），
：有多少只是把已經開放的肺吹得更大（inflation）？

1 先在低 PEEP 測量 Crs_{low}

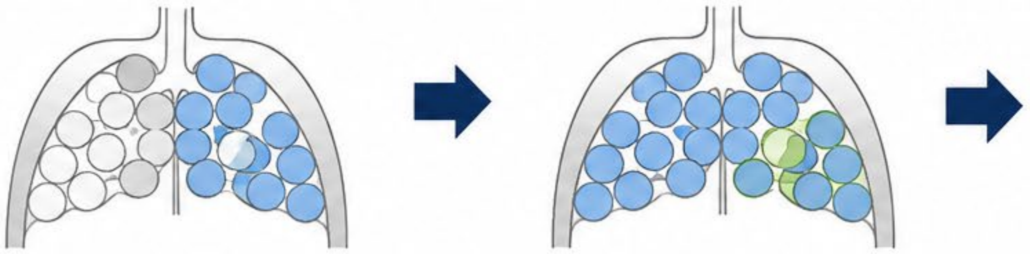
- 模式：VCV
- PEEP = 5 cmH_2O
- 測得 Crs_{low} (mL/cmH_2O)

2 升高 PEEP 到高 PEEP 並穩定

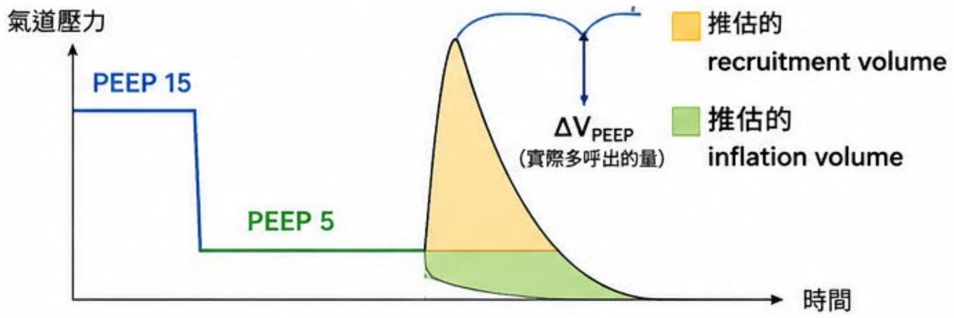
- $PEEP_{high}$ = 15 cmH_2O（例）
- 穩定 1 分鐘以上

3 一次從高 PEEP 降到低 PEEP

- 將 PEEP 從 15 → 5 cmH_2O
- 觀察下降後「第一口呼氣」的額外呼出量 ΔV_{PEEP}



已開放　關閉（collapse）



如何區分 recruitment 與 inflation？

下降後第一口多呼出的總量 ΔV_{PEEP} 由兩部分組成：

Inflation volume（已開放的肺被吹大）	Recruitment volume（打開原本關閉的肺）
$= Crs_{low} \times \Delta PEEP$	$= \Delta V_{PEEP} - (Crs_{low} \times \Delta PEEP)$

其中：　$\Delta PEEP = PEEP_{high} - PEEP_{low}$

R:I ratio 計算

$$\text{R:I ratio} = \frac{\text{Recruitment volume}}{\text{Inflation volume}}$$

$$= \frac{\Delta V_{PEEP} - (Crs_{low} \times \Delta PEEP)}{Crs_{low} \times \Delta PEEP}$$

等價寫法：$R{:}I = (V_{recruit} / \Delta PEEP) / Crs_{low}$

$$= \frac{\text{Compliance of recruited lung}}{\text{Compliance of baby lung}}$$

R:I ratio 解讀（常用門檻）

R:I > 0.5（高 recruitability）
招募的肺量較多，高 PEEP 較可能有幫助
→ 考慮進一步以 EIT-guided PEEP titration

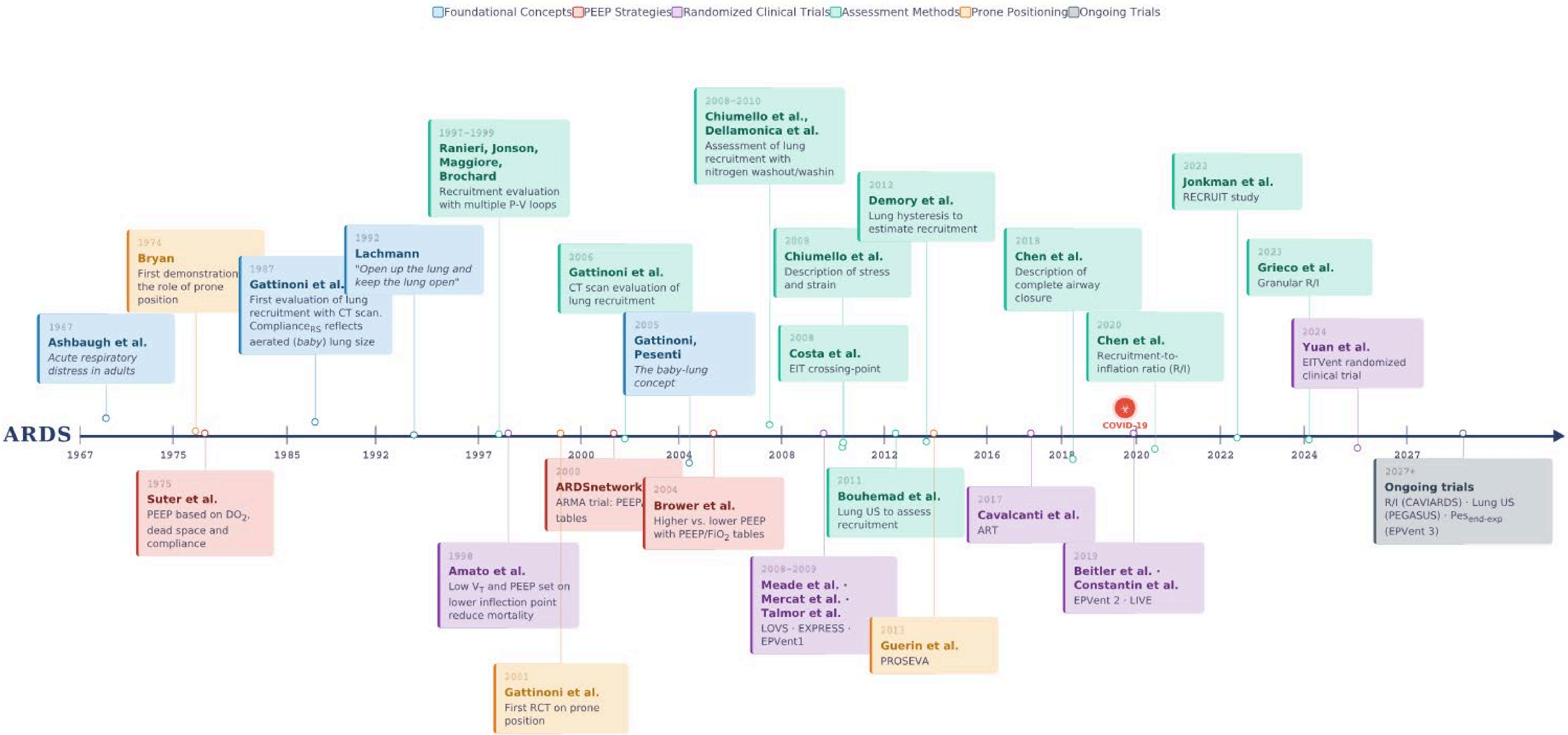
R:I ≤ 0.5（低 recruitability）
多為 inflation，過高 PEEP 可能造成過度擴張（overdistension）
→ 採較低 PEEP 策略

重點總結： R:I ratio 告訴我們「加 PEEP 後增加的量，是打開新的肺，還是把已開的肺吹更大？」
R:I 越高 → recruitment 越多； R:I 越低 → 以 inflation 為主。

註：範例數值僅供理解，實際依病人設定與量測為準。

60 Years of ARDS: PEEP and Lung Recruitment

Key milestones in the understanding and management of positive end-expiratory pressure



Grieco et al. Intensive Care Med. 2026 Jun 22.