Lung protection in thoracic surgery anaesthesia

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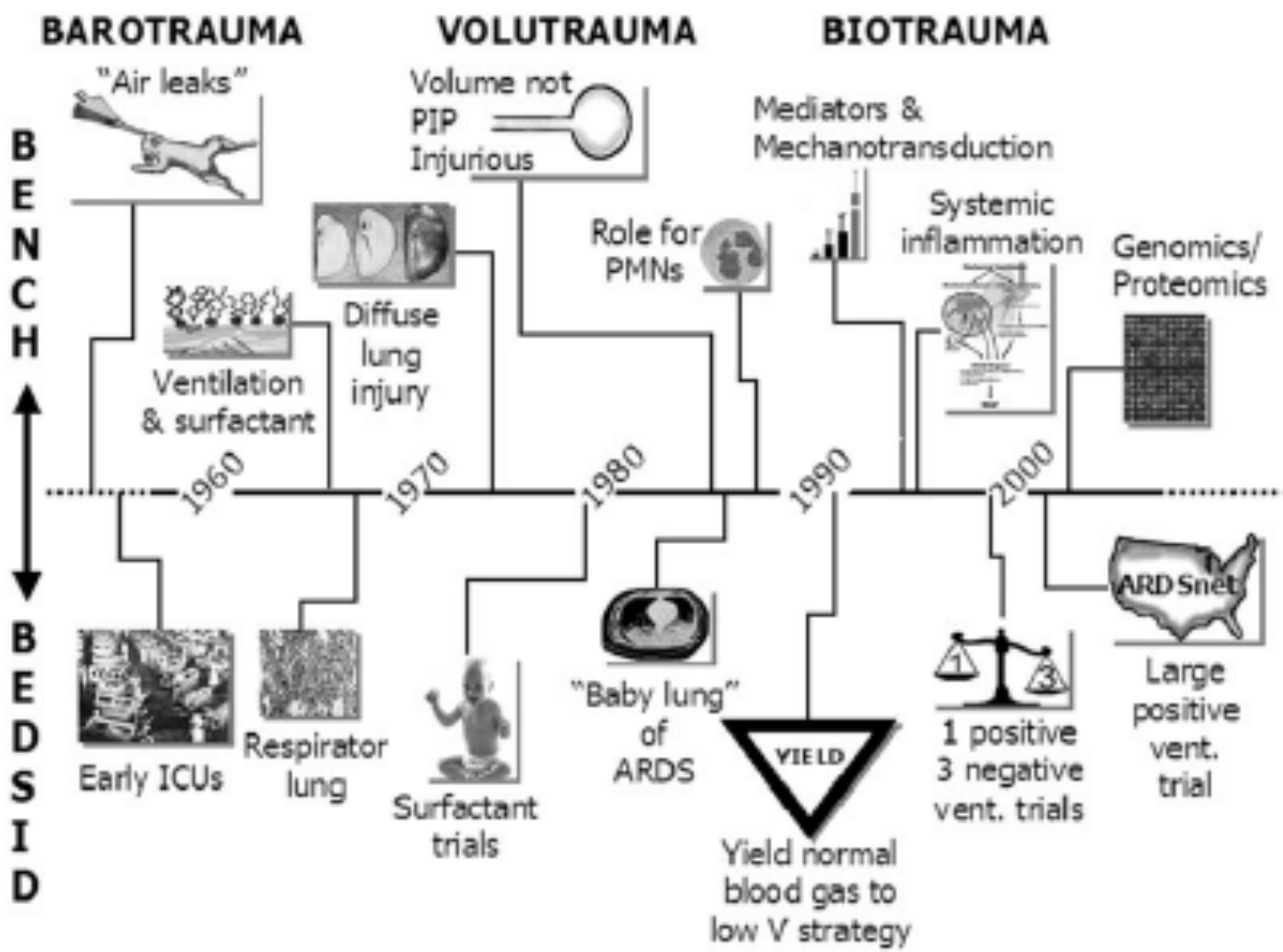
Introduction



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ICM 2006

Normal lungs | After 5 min of ventilation | After 20 min of ventilation

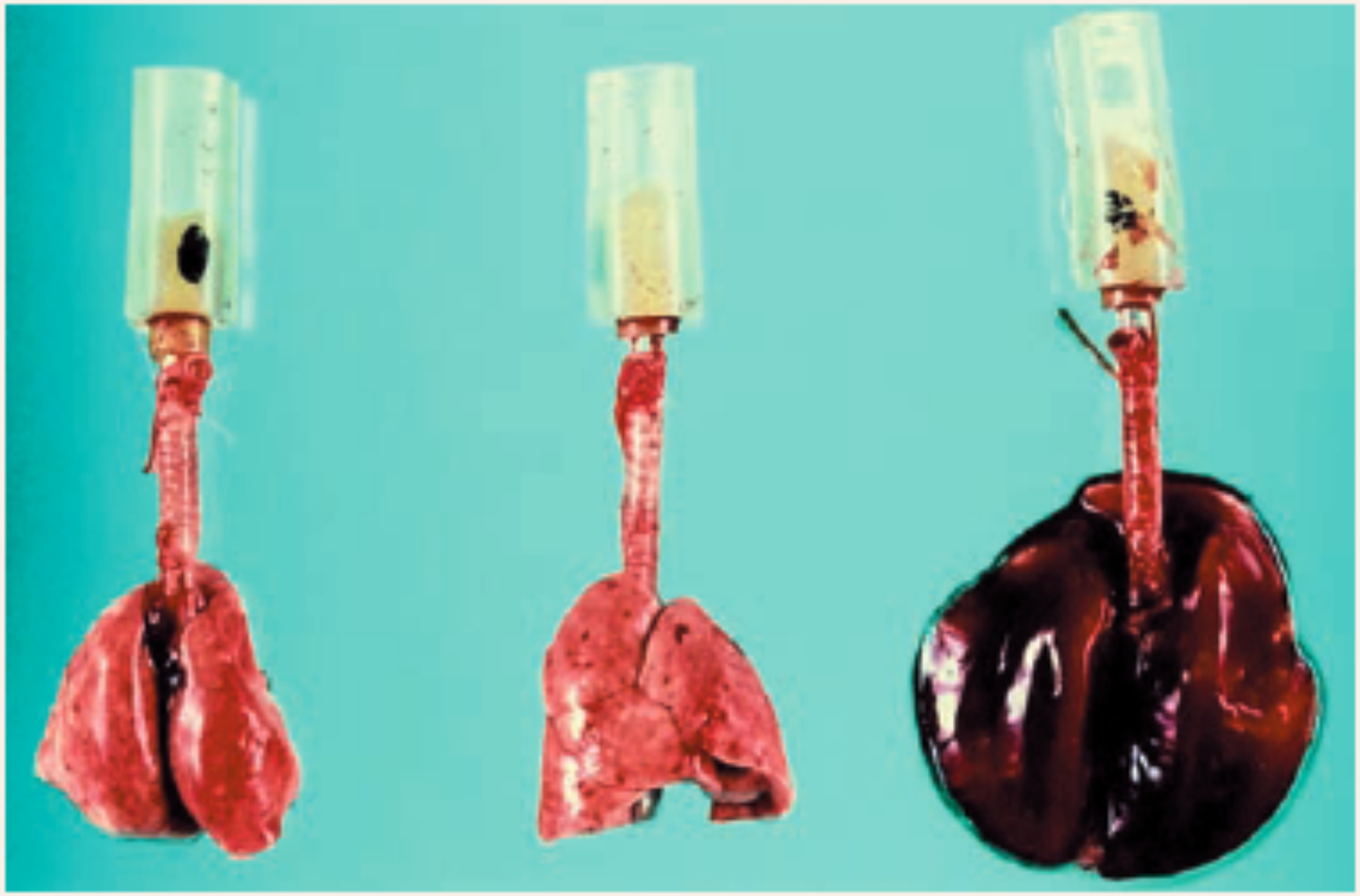

Figure 1. Normal Rat Lungs and Rat Lungs after Receiving High-Pressure Mechanical Ventilation at a Peak Airway Pressure of 45 cm of Water.

After 5 minutes of ventilation, focal zones of atelectasis were evident, in particular at the left lung apex. After 20 minutes of ventilation, the lungs were markedly enlarged and congested; edema fluid filled the tracheal cannula. Adapted from Dreyfuss et al.[8] with the permission of the publisher.

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NEJM 2007

Ventilator-associated Lung Injury (VALI)

Definition: Lung damage caused by application of positive or negative pressure to the lung by mechanical ventilation.

Mechanisms of VALI

Volutrauma: Damage caused by alveolar over-distension. High volume causes injury

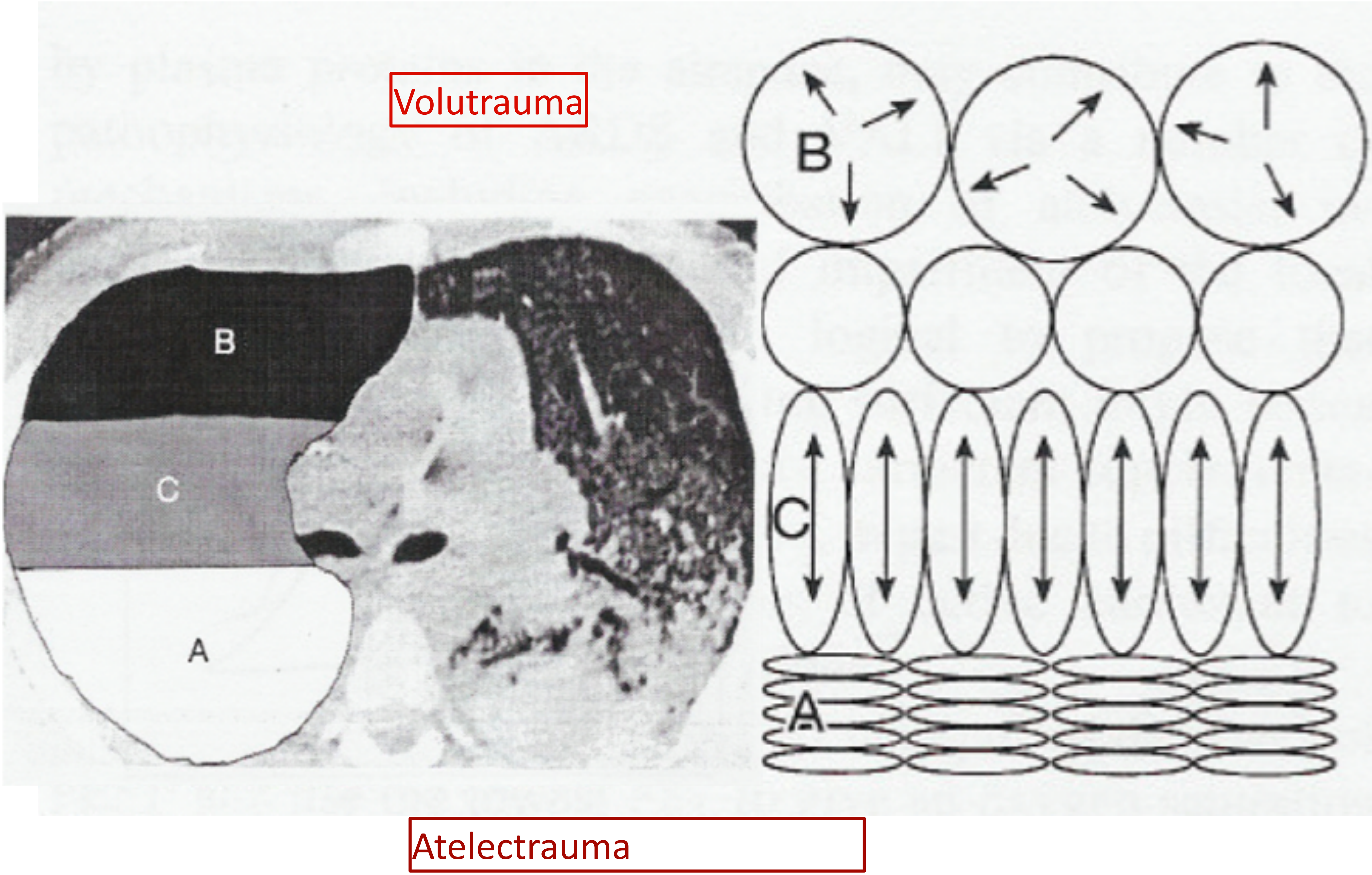
Barotrauma: High pressure induced lung damage

Similar histological appearance, high-permeability pulmonary oedema in uninjured lung & exacerbated damage in injured lung (OLV)

Mechanisms of VALI

Atelectotrauma: Lung injury associated with repeated recruitment and collapse.

Theoretically prevented by using a level of positive end-expiratory pressure (PEEP) greater than the lower inflection point of the pressure volume curve



BJA 2004

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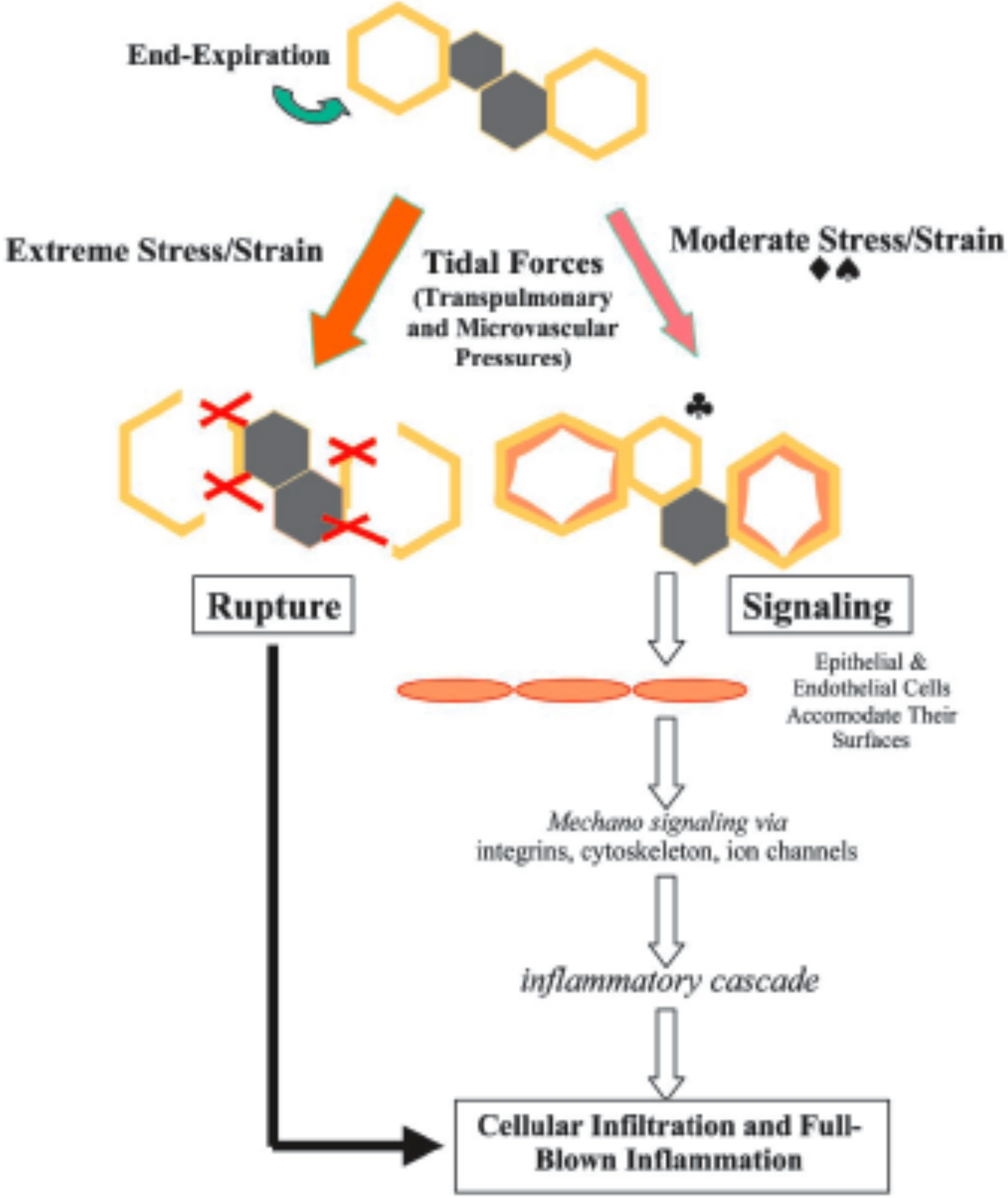

♦ Global stress/strain reduced by lowering Trans-Pulmonary Pressure (TPP)
♠ Local stress/strain less if TPP is more homogeneously applied (prone position)
♣ Local stress/strain reduced if PEEP "keeps open"

CCM 2004

The New England Journal of Medicine

VOLUME 342 MAY 4, 2000 NUMBER 18

VENTILATION WITH LOWER TIDAL VOLUMES AS COMPARED WITH TRADITIONAL TIDAL VOLUMES FOR ACUTE LUNG INJURY AND THE ACUTE RESPIRATORY DISTRESS SYNDROME

THE ACUTE RESPIRATORY DISTRESS SYNDROME NETWORK*

TABLE 1. SUMMARY OF VENTILATOR PROCEDURES.*

VARIABLE	GROUP RECEIVING TRADITIONAL TIDAL VOLUMES	GROUP RECEIVING LOWER TIDAL VOLUMES
Ventilator mode	Volume assist–control	Volume assist–control
Initial tidal volume (ml/kg of predicted body weight)†	12	6
Plateau pressure (cm of water)	≤50	≤30
Ventilator rate setting needed to achieve a pH goal of 7.3 to 7.45 (breaths/min)	6–35	6–35
Ratio of the duration of inspiration to the duration of expiration	1:1–1:3	1:1–1:3
Oxygenation goal	PaO_2, 55–80 mm Hg, or SpO_2, 88–95%	PaO_2, 55–80 mm Hg, or SpO_2, 88–95%
Allowable combinations of FiO_2 and PEEP (cm of water)‡	0.3 and 5 0.4 and 5 0.4 and 8 0.5 and 8 0.5 and 10 0.6 and 10 0.7 and 10 0.7 and 12 0.7 and 14 0.8 and 14 0.9 and 14 0.9 and 16 0.9 and 18 1.0 and 18 1.0 and 20 1.0 and 22 1.0 and 24	0.3 and 5 0.4 and 5 0.4 and 8 0.5 and 8 0.5 and 10 0.6 and 10 0.7 and 10 0.7 and 12 0.7 and 14 0.8 and 14 0.9 and 14 0.9 and 16 0.9 and 18 1.0 and 18 1.0 and 20 1.0 and 22 1.0 and 24
Weaning	By pressure support; required by protocol when FiO_2 ≤0.4	By pressure support; required by protocol when FiO_2 ≤0.4

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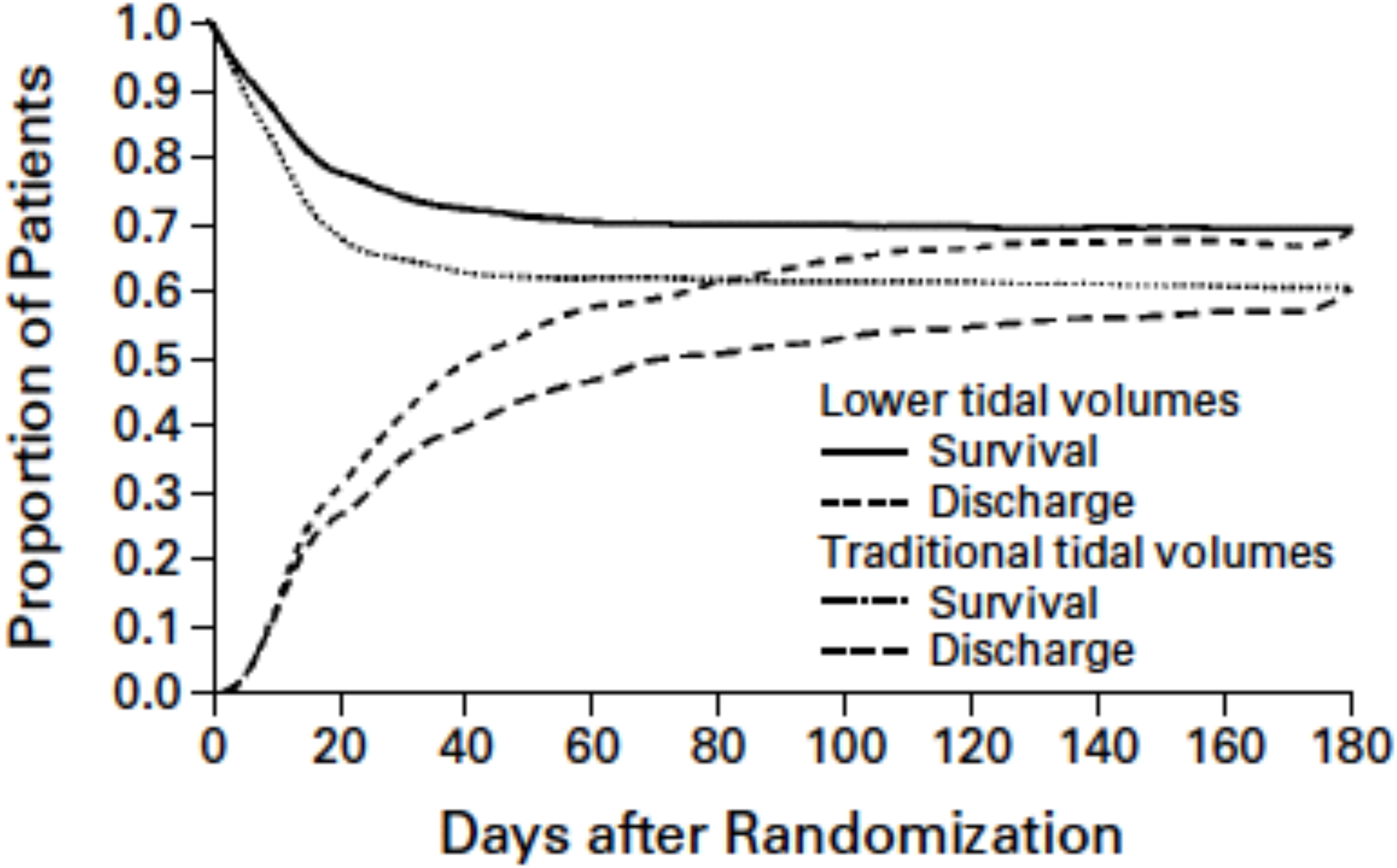
Conventional vrs. Protective ventilation in patients with ARDS

Protective: Tidal volume about 4-6ml/kg

Accept hypercarbia

Conventional: Tidal volume of 10ml/kg

maintain a normocarbia



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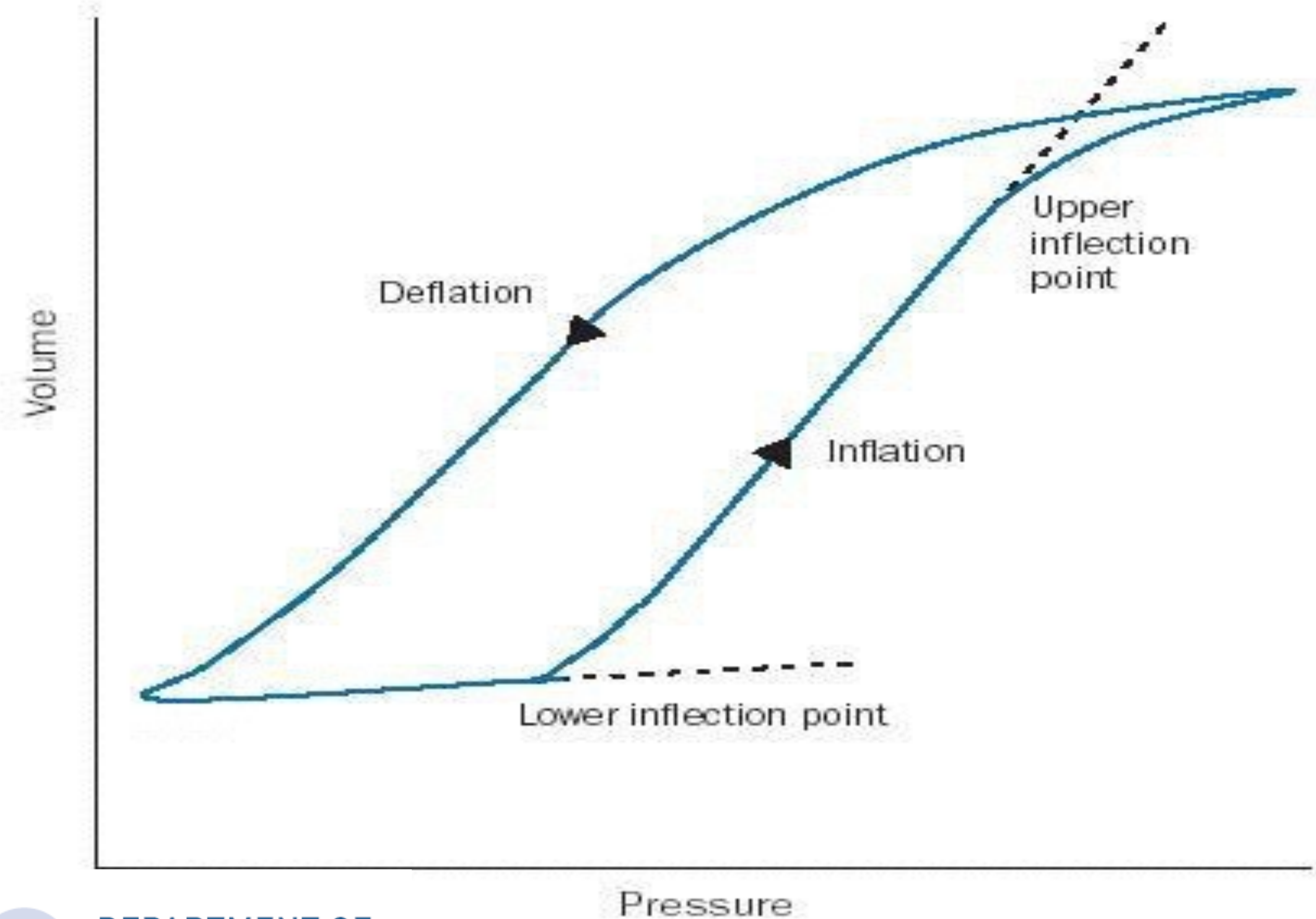

12~18 cmH2O

26~32 cmH2O

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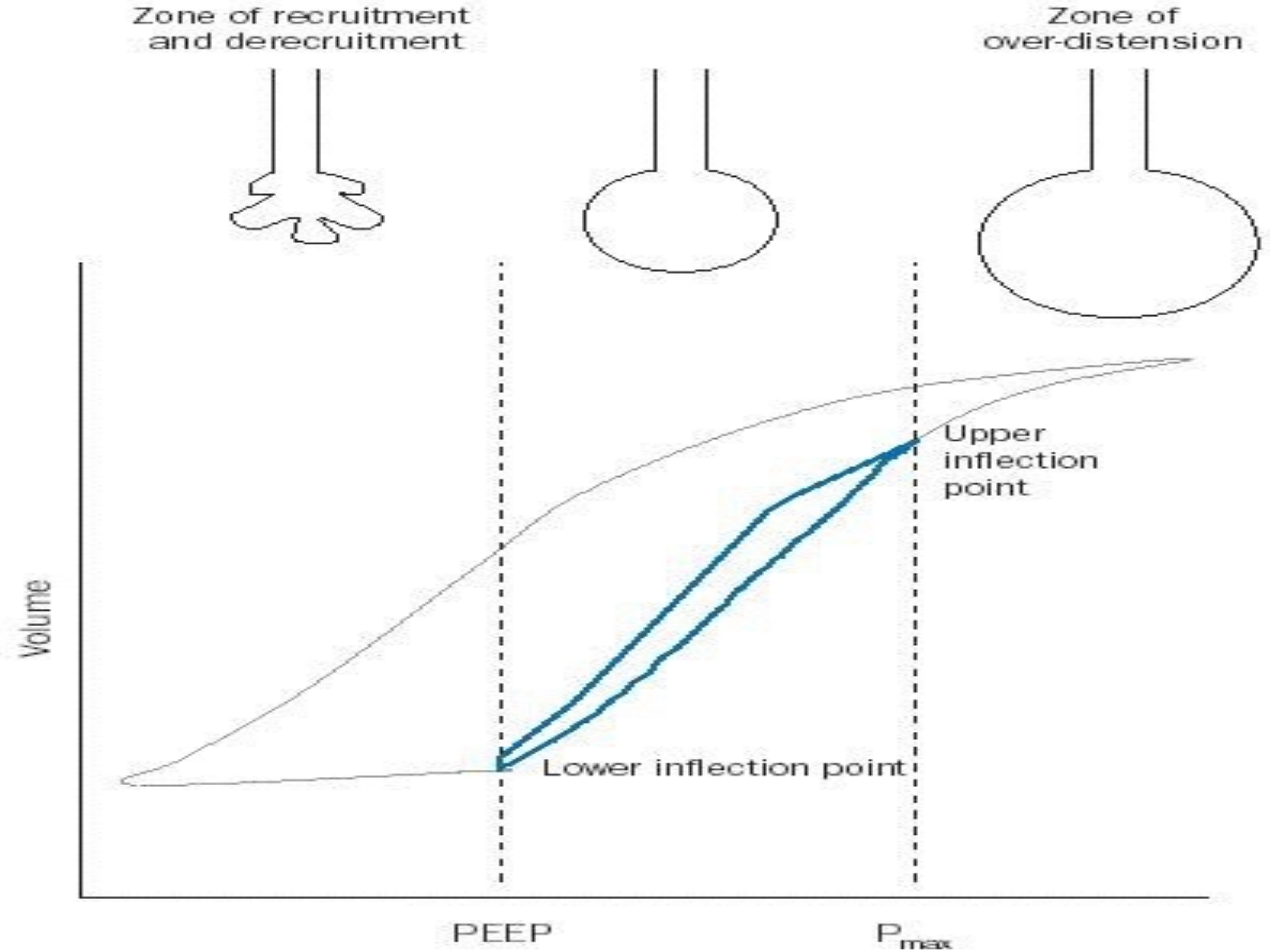

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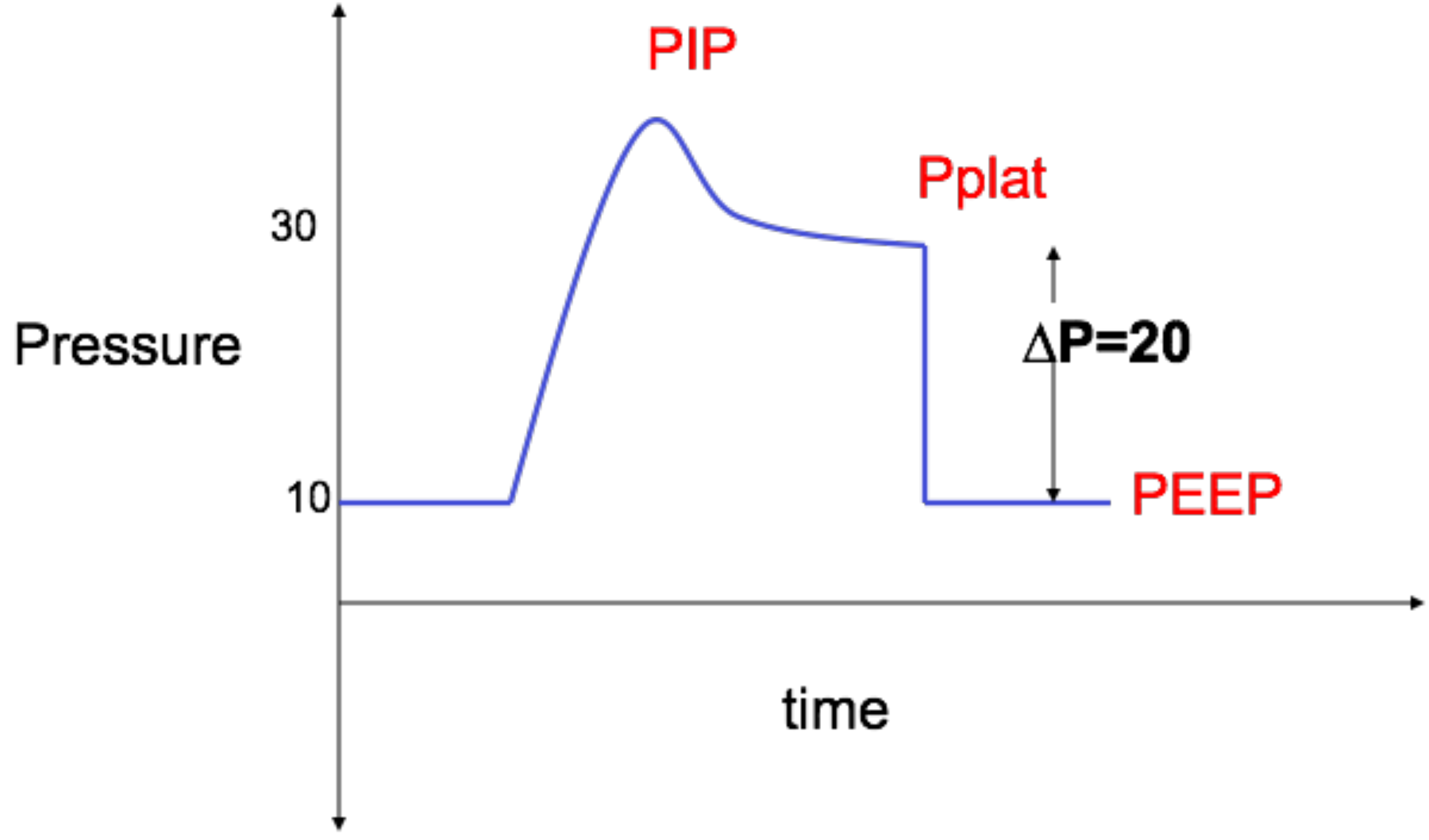
Transpulmonary pressure

Driving pressure



PEEP Table by ARDSNet

- ARDS Network, 2000: Multicenter, randomized 861 patients

Principle for FiO2 and PEEP Adjustment								
FiO2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
PEEP	5	5-8	8-10	10	10-14	14	14-18	18-24

NEJM 2000; 342: 1301-1308

What we know from ICU literature:

1 Non-physiological ventilation in healthy lungs induces ALI.

2 Protective lung ventilation in patients with ALI/ ARDS improves outcome.

3 VALI has important implications remote to the lungs and may be associated with significant morbidity and mortality.

Intraoperative lung-protective ventilatory strategies in thoracic Anaesthsia

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AIMS: to decrease the extent of injury :

Acute respiratory distress syndrome (ARDS)

Acute Lung injury (ALI)

Atelectasis

Pneumothorax

Kilpatrick B, Slinger P. Lung protective strategies in anaesthesia. Br J Anaesth 2010; 105(S1): i108-i116

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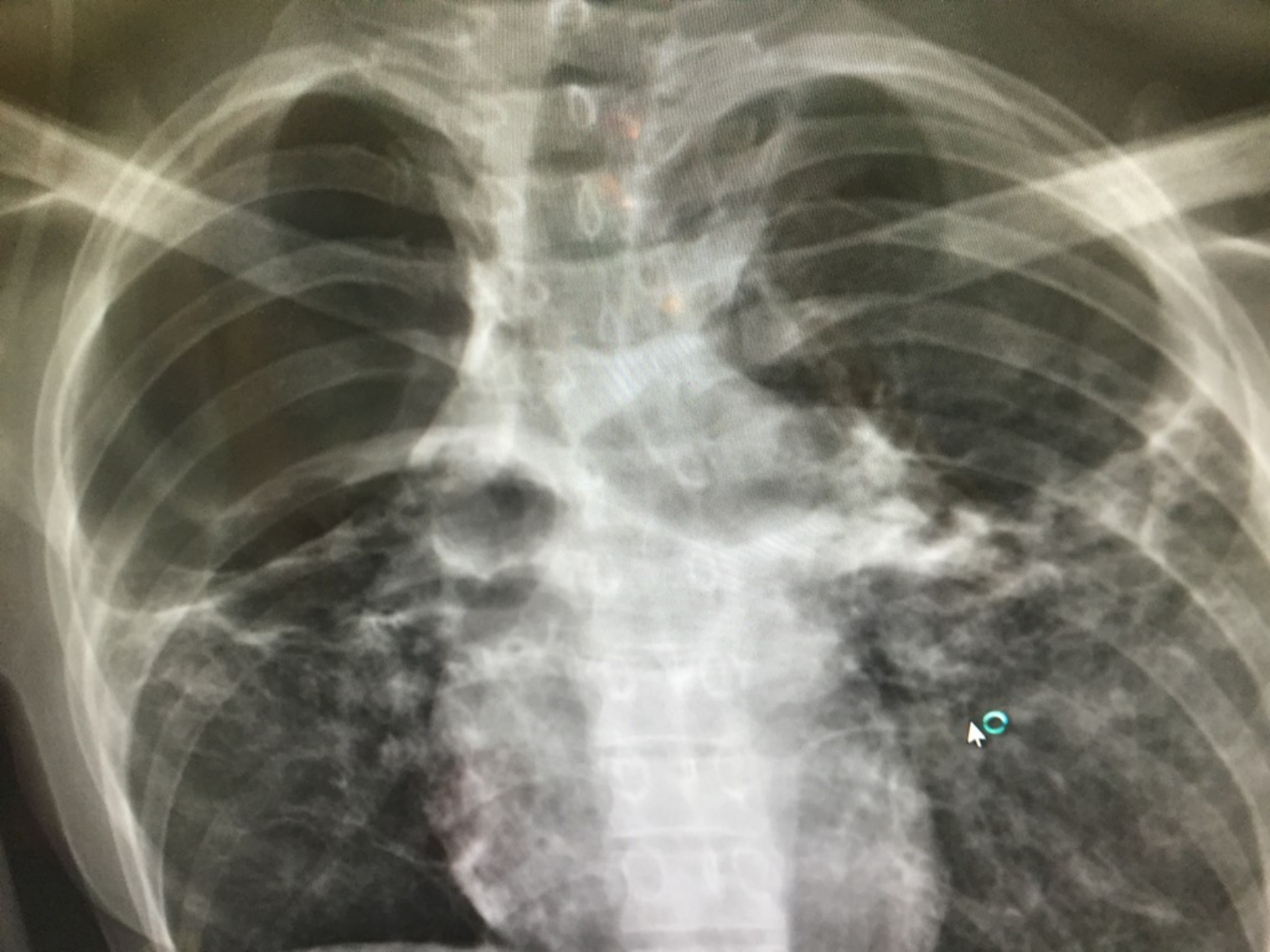
Spontaneous ventilation or positive pressure ventilation

- Sedation with face mask/LMA/ETT and SV
- Plan in place to convert to PPV



Bronchial blocker or DLT

BBs provided equivalent surgical exposure to left-sided DLTs during left-sided open or video-assisted thoracoscopic surgery thoracic procedures.

However BBs required longer to position.

Narayanaswamy, McRae, Slinger, Dugas, Roscoe, Lacroix ; Choosing a Lung Isolation Device for Thoracic Surgery: A Randomized Trial of Three Bronchial Blockers Versus Double-Lumen Tubes: Anaesthesia & Analgesia: April 2009 - Volume 108 - Issue 4

Reducing VT (4-6ml/kg vrs 8-10ml/kg)

- Ferna´ndez-Pe´rez ER. Intraoperative tidal volume as a risk factor for respiratory failure after pneumonectomy. Anesthesiology 2006; 105: 14–8
- Licker M, de Perrot M, Spiliopoulos A, et al. Risk factors for acute lung injury after thoracic surgery for lung cancer. Anesth Analg 2003; 97: 1558–65
- Licker M, Diaper J, Villiger Y, et al. Impact of intraoperative lungprotective interventions in patients undergoing lung cancer surgery. Crit Care 2009; 13.R41
- Michelet P, D'Journo XB, Roch A, et al. Protective ventilation influences systemic inflammation after esophagectomy: a randomized controlled study. Anesthesiology 2006; 105: 911–9

Low TV and PEEP

During OLV, lowering VT and increasing PEEP, with the same low plateau pressure, reduced oxygenation compared with larger VT (8ml/kg) and lower PEEP.

Roze´, Lafargue, Perez et al : Journal of Anaesthesia 108 (6): 1022–7 (2012)

How much PEEP?

PEEP minimises lung collapse and prevents the repeated opening and collapse of lung units, but impairs intraoperative oxygenation during OLV, by increasing pulmonary vascular resistance and a shift of blood flow to the non-dependent lung.

Optimal PEEP to maintain oxygenation after reduction in VT during OLV remains unknown.

Slinger PD, Hickey DR. The interaction between applied PEEP and auto-PEEP during one-lung ventilation. J Cardiothorac Vasc Anesth 1998; 12: 133–6

PROTHOR trail

Protective Ventilation with higher versus Lower PEEP during one lung ventilation for thoracic surgery

Coppola *et al. Critical Care* 2014, **18**:210
http://ccforum.com/content/18/2/210

CRITICAL CARE

REVIEW

Protective lung ventilation during general anesthesia: is there any evidence?

Silvia Coppola, Sara Froio, Davide Chiumello*

				Ventilatory strategy						
				V_T (ml/kg)		PEEP (cmH_2O)		Recruitment maneuver (Yes/No)		
	First author [ref]	Year	N° pts	Case	Control	Case	Control	Case	Control	Outcomes
Abdominal	Wrigge [21]	2000	39	66 6	15	0 10	0	No	No	Systemic IL-6, IL-10, TNF-α: similar
	Wrigge [22]	2004	30	6	12–15	10	0	No	No	Systemic/pulmonary IL-8-1-6-10-12, TNF-α: similar
	Determann [23]	2008	40	6	12	10	0	No	No	Lung epithelial injury biomarkers: similar
	Weingarten [25]	2010	40	6	10	12	0	Yes	No	Intraoperative PaO_2, Lung mechanics: better Systemic IL-8, IL-6: similar
	Treschan [24]	2012	101	6	12	5	5	No	No	Postoperative dynamic spirometry: similar
	Severgnini [26]	2013	56	7	9	10	0	Yes	No	Clinical Pulmonary Infection Score: lower Postoperative respiratory function: better
	Futier [27]	2013	400	6-8	10–12	6–8	0	Yes	No	Pulmonary/extrapulmonary complications: lower Hospital stay: shorter
	PROVHILO [28]	–	900	< 8	< 8	12	≤ 2	Yes	No	Postoperative pulmonary complications
Thoracic	Schilling [33]	2005	32	5	10	0	0	No	No	Pulmonary TNF-α, IL-8, IL-10: lower TNF-α
	Michelet [36]	2006	52	5	9	5	0	No	No	Systemic IL-1β, IL-6, IL-8: lower Oxygenation: better Postoperative MV length: shorter
	Yang [35]	2011	100	6	10	5	0	No	No	Oxygenation: better Postoperative pulmonary complications: lower
Cardiac	Chaney [49]	2000	25	6	12	5	5	No	No	Postoperative lung mechanics: better
	Koner [42]	2004	44	6	10 10	5	0 5	No	No	Systemic IL-6, TNF-α: similar Hospital LOS: similar Postoperative pulmonary function: similar
	Zupancich [44]	2005	40	8	10–12	10	2–3	No	No	Pulmonary and systemic Il-6, IL-8: lower
	Reis [47]	2005	62	4–6	6–8	10	5	Yes	No	Systemic Il-8, IL-10: lower Systemic IL-6, TNF-α, IFN-γ: similar
	Reis [48]	2005	69	4–6	6–8	10	5	Yes	No	Postoperative hypoxemia: lower Postoperative FRC: better
	Wrigge [41]	2005	44	6	12	9*	7*	No	No	Systemic TNF-α, IL-6-8-2-4-10: similar Pulmonary TNF-α, IL-6-8-2-4-10: lower TNF-α
	Sundar [43]	2011	149	6	10	5*	4.9*	No	No	Time to extubation: similar Extubation at 6–8 h after surgery: better Reintubation: lower

Outcomes

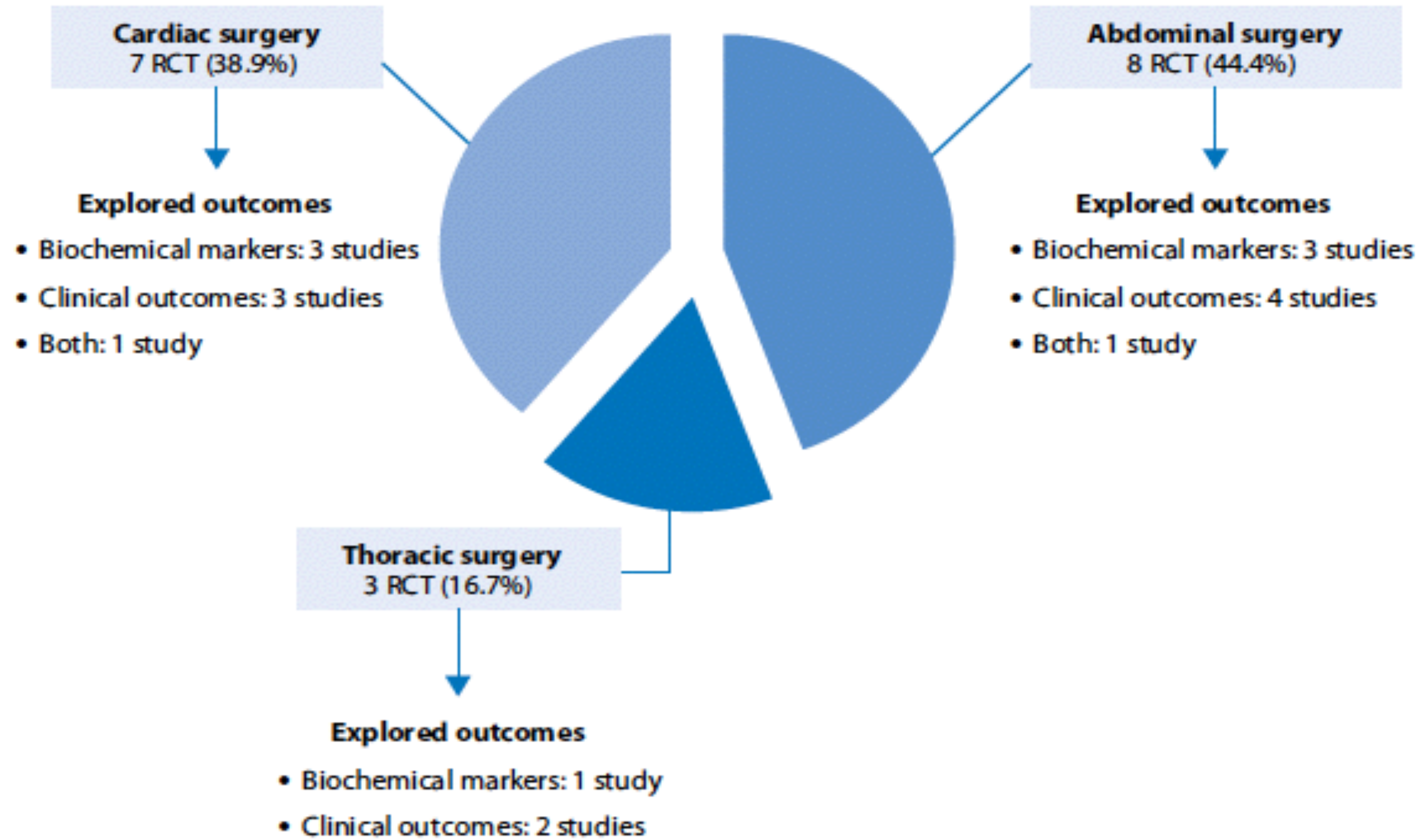


Figure 1. The number and percentage of randomized controlled trials (RCTs) included in Table 1, divided by type of surgery.

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Results for using lung protective strategies

Abdominal surgery slight benefit

Cardiac surgery equivocal

Thoracic surgery shows clear benefit

Intraoperative lung-protective ventilatory strategies

- Tidal volumes 5-7ml/kg
- Limit plateau airway pressures to 25 cmH20
- PEEP of 5 cm H2O to patients without auto-PEEP.
- COPD patients pressure-control ventilation in stead of volume-controlled ventilation.

Unzueat MC, Casas JI, Moral MV. Anesth Analg 2007; 104:1029-33

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Questions

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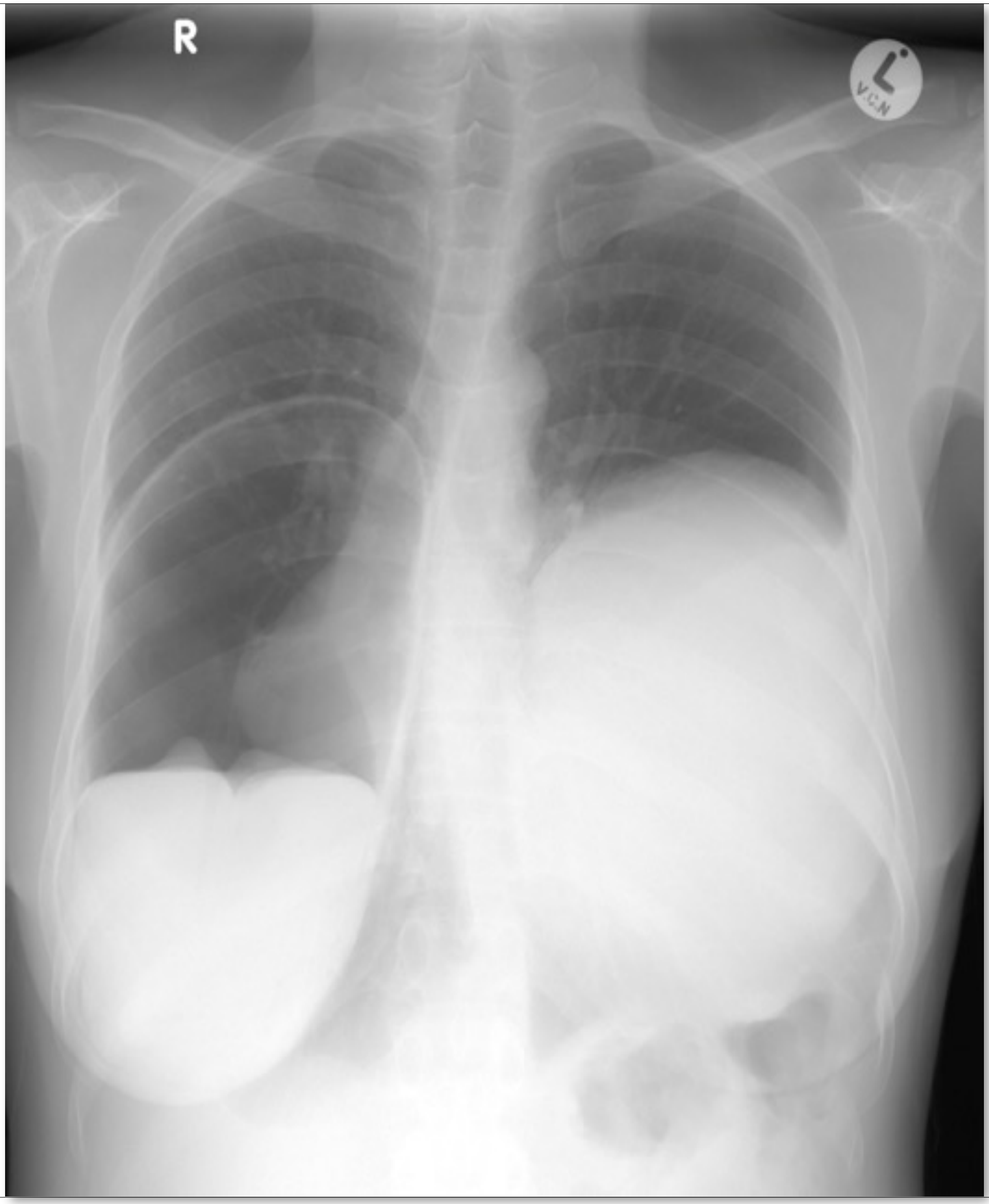
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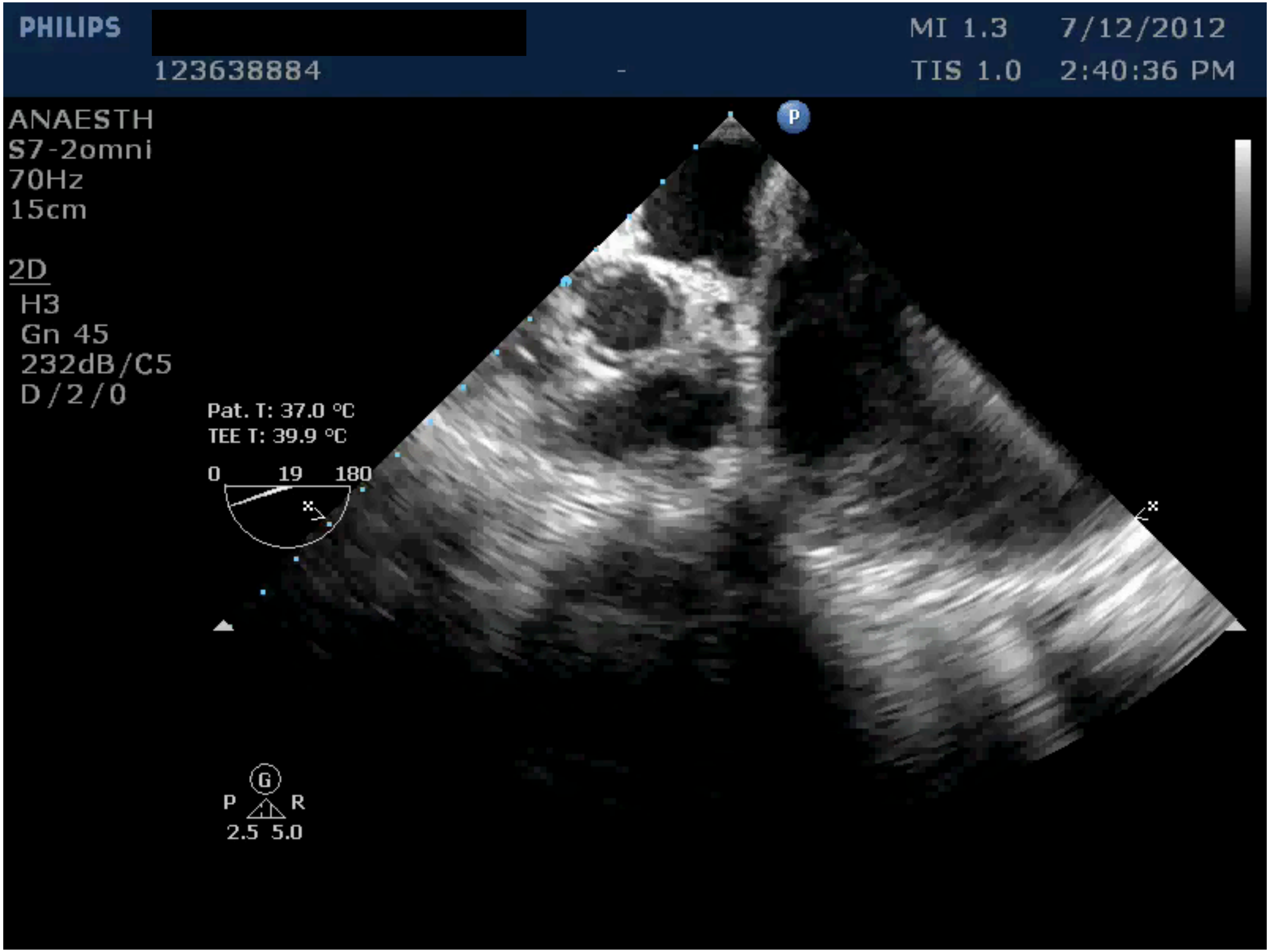

Picken, Myburgh :The use of intraoperative transoesophageal echocardiography as a monitor for haemodynamic instability during pulmonary hydatid cyst; SAJAA Vol 19, No 3 (2013)

Thank you

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Meta-analysis: Intraoperative ventilatory strategies to prevent postoperative pulmonary complications

Hemmes SN, Serpa Neto A, Schultz MJ. Intraoperative ventilatory strategies to prevent postoperative pulmonary complications: a meta-analysis. Curr Opinion anaesthesiol. 2013 Apr;26(2):126-33.

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Meta-analysis also showed a decrease in lung injury development (RR 0.29; 95% CI 0.14-0.60; I 0%; NNT 29), pulmonary infection (RR 0.62; 95% CI 0.40-0.96; I 15%; NNT 33) and atelectasis (RR 0.61; 95% CI 0.41-0.91; I0%; NNT 29) in patients ventilated with higher levels of PEEP, with or without recruitment maneuvers.

Number Needed To Treat (NNT)

Lower TV: Decrease in lung injury development : NNT=37

Higher PEEP: Decrease in lung injury development: NNT = 29

Higher PEEP: Prevention of pulmonary infection :NNT = 33

Higher PEEP: Prevention of atelectasis :NNT=29

Conclusion

Use lung protective strategies in the sick

Numbers Needed to Harm (NNH)

Beware of hypo-ventilation and hypercapnoea

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