Acute Respiratory Distress Syndrome
Why We Prone

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May 8, 2019

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Disclosures

- None

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ER calls: 26y F with no PMHx presents in severe respiratory distress. She has had flu-like symptoms starting about 1 week ago. At first she thought she was getting better, but she has had high fevers, productive cough, and increasing dyspnea over the past few days.

“We had to intubate her.”

“OK, what are her vent settings?”

“Err…”

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What tidal volume and PEEP should I use?

How tall is she?

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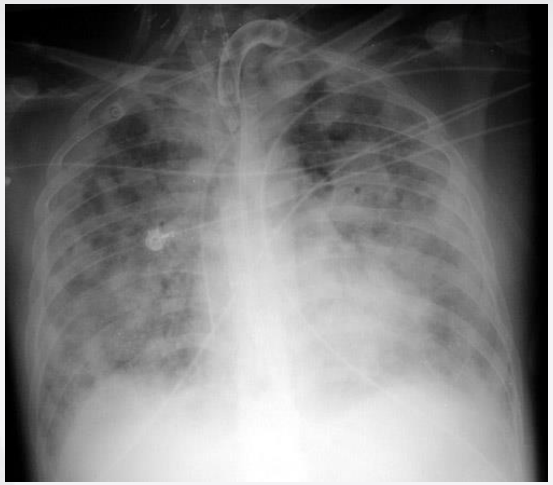
Goals

- Review the diagnosis of ARDS
- Review ventilator-induced lung injury
- Review the rationale for prone ventilation

ARDS definition



1) Acute onset (< 1 week)
2) Bilateral infiltrates
3) No clinical evidence of left heart failure
4) P:F ≤ 300

P:F 300 > 200	P:F 200 > 100	P:F < 100
Mild	Moderate	Severe

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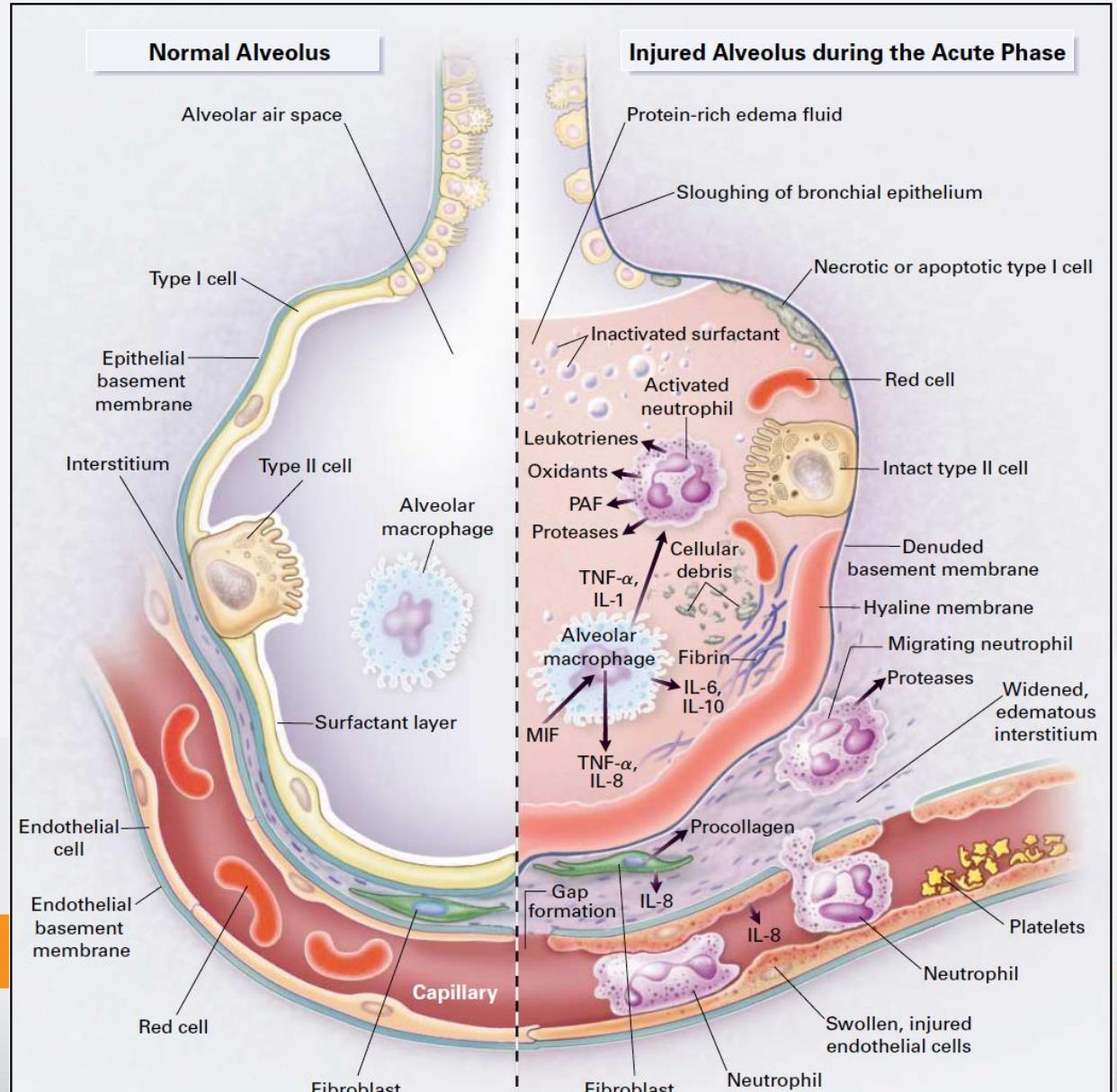
Bernard et al. *AJRCCM* 1994; 149:818
ARDS Task Force. JAMA 2012; 2526-2533

ALI/ARDS: Causes

Direct Lung Injury	Indirect Lung Injury
• Pneumonia • Aspiration • Pulmonary contusion • Fat emboli • Near-drowning • Inhalational injury • Reperfusion edema • Ventilator-induced lung injury • Alveolar hemorrhage	• **Sepsis (most common)** • Trauma • Cardiopulmonary bypass • Drug overdose (ASA, opiates) • Acute pancreatitis • TRALI • IL-2 infusion • ATRA syndrome • Tocolysis-induced

Pathophysiology



Ware et al. *NEJM* 2000; 342: 1334

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Mechanisms of Ventilator-Induced Lung Injury

- Atelectrauma
- Shear Stress (interface between open and closed units)
- Volutrauma (overdistension)
- Barotrauma
- Biotrauma

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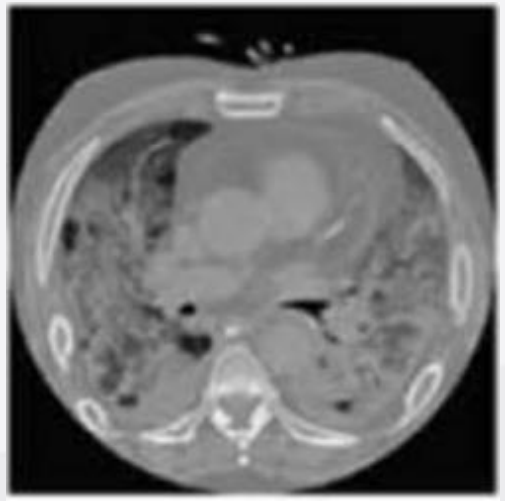
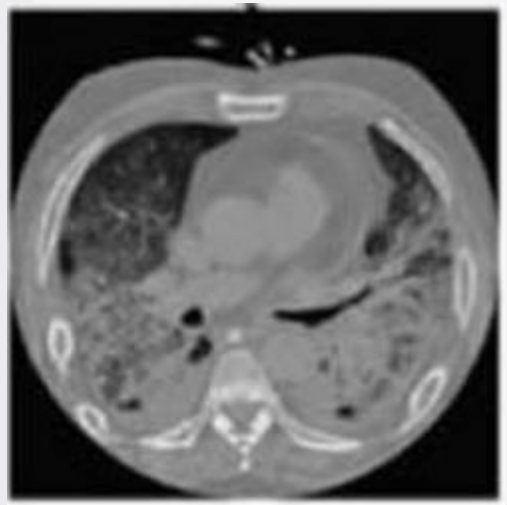
Slutsky and Ranieri, NEJM 2013

Atelectrauma
Shear Stress





Volume

V_T

ΔP

Pressure

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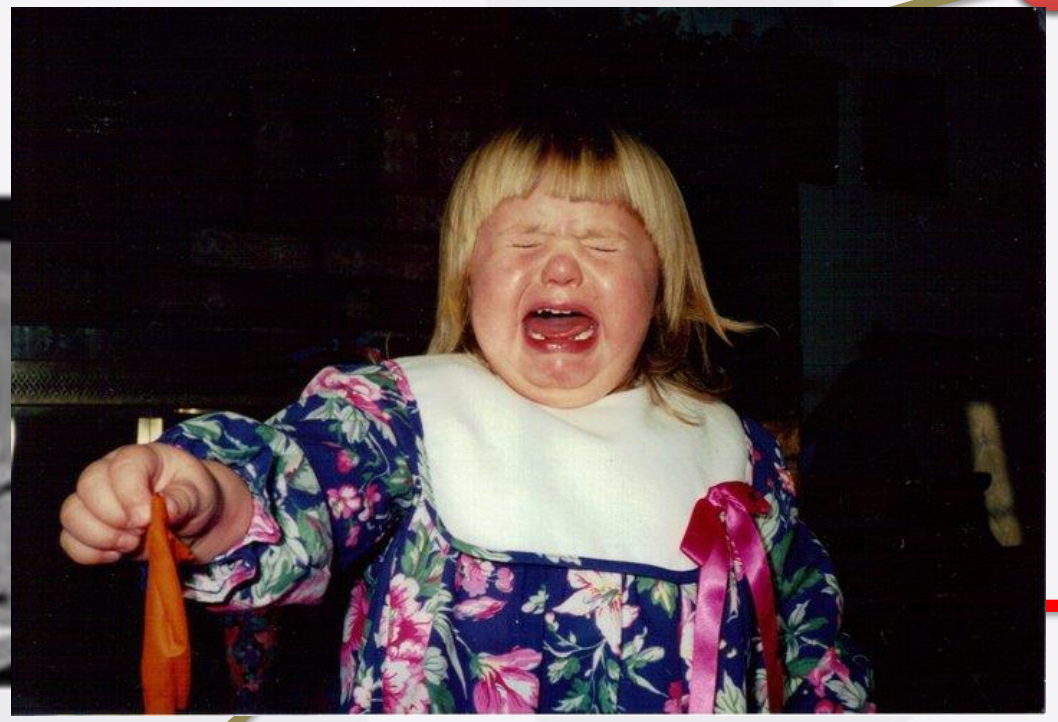
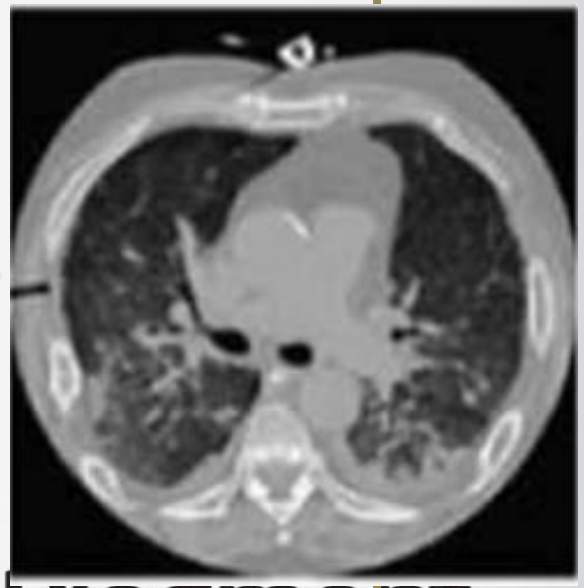
Volutrauma
Barotrauma



V_T



Volume

Pressure

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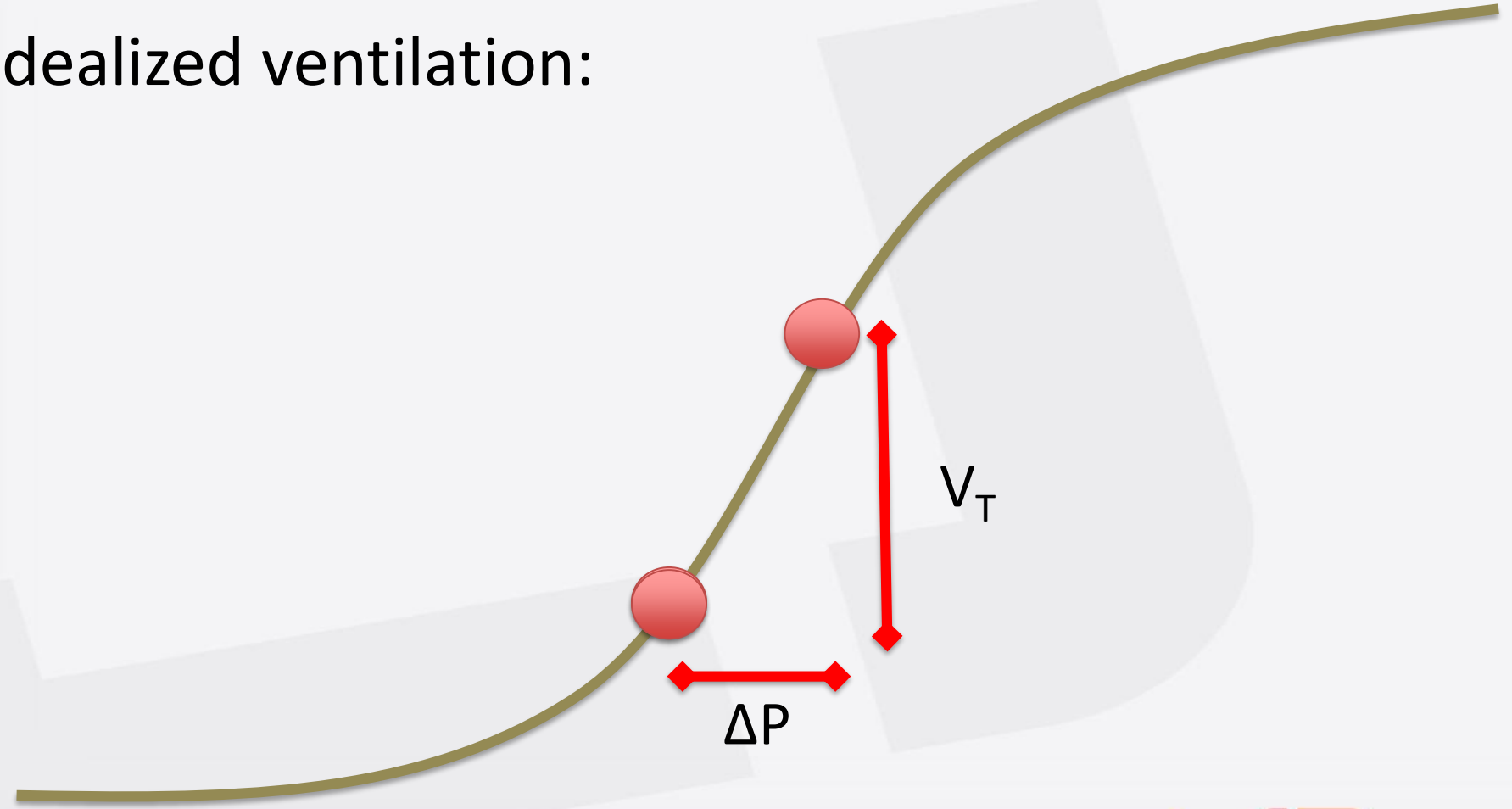
Idealized ventilation:



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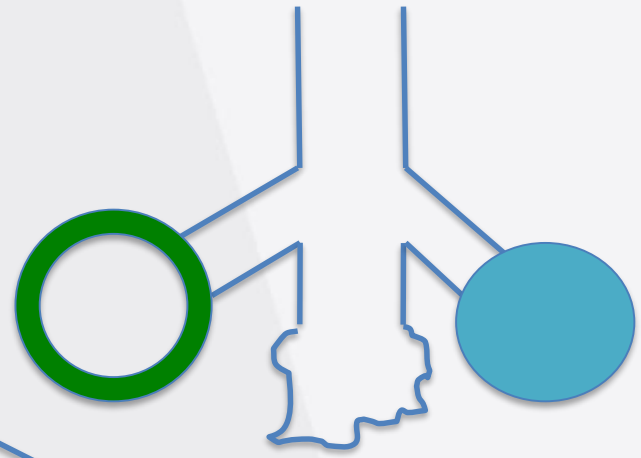
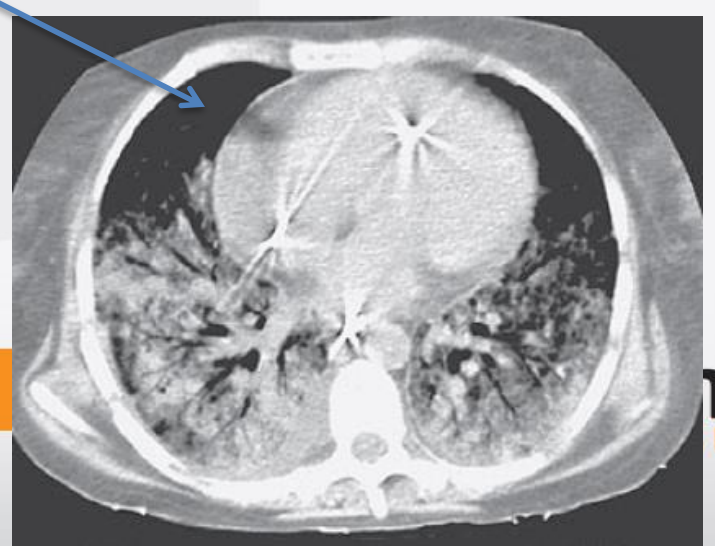
Low-tidal volume ventilation: rationale

- ARDS affects the lung in a heterogeneous fashion
  - Normal alveoli
  - Injured alveoli can potentially participate in gas exchange, susceptible to damage from opening and closing
  - Damaged alveoli filled with fluid, do not participate in gas exchange

Three-alveolus model





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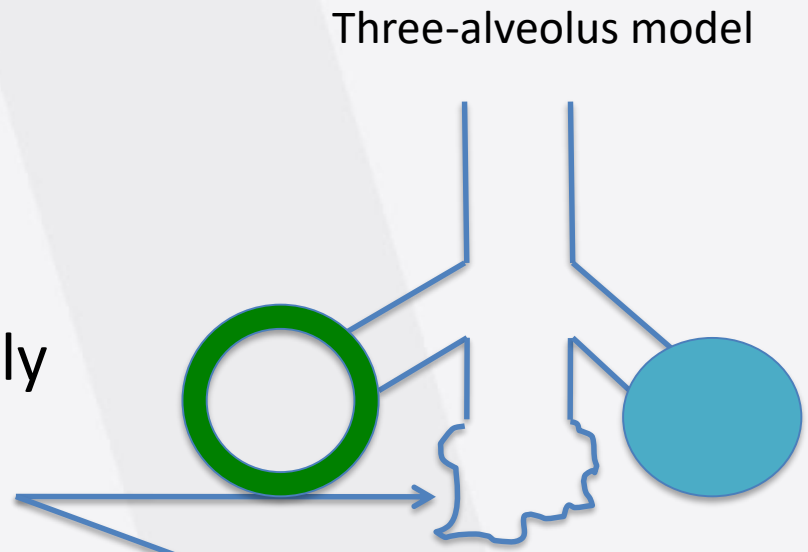

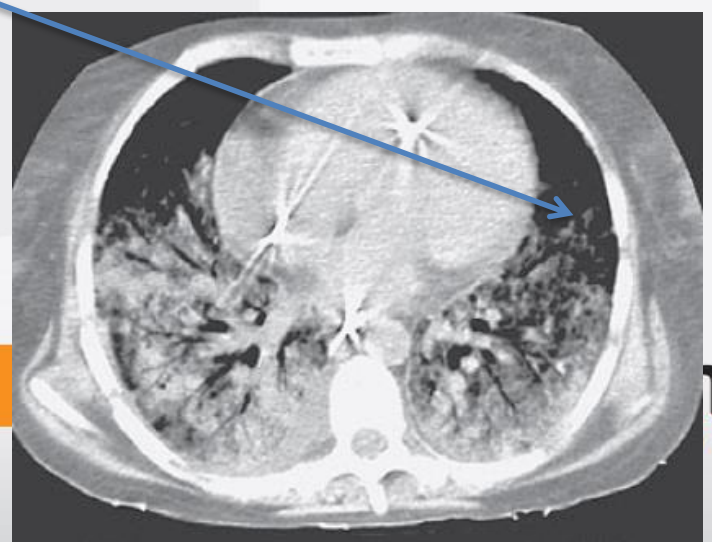

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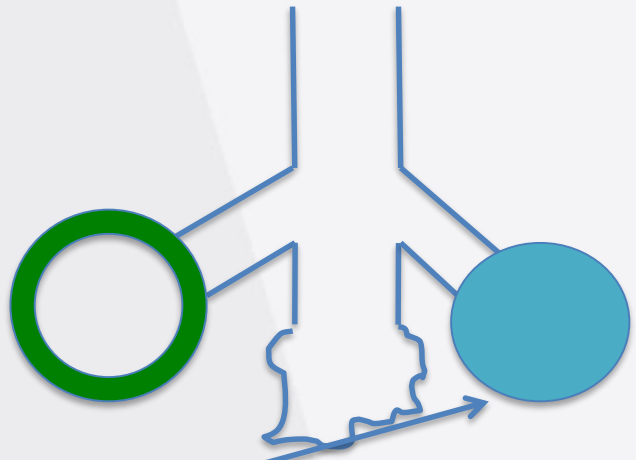
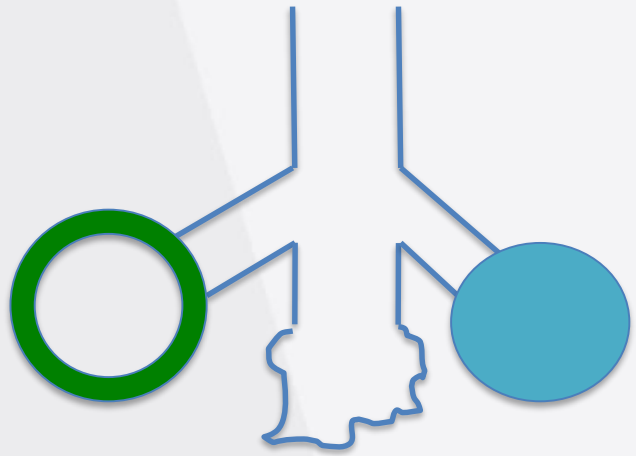


Low-tidal volume ventilation: rationale

- Low-tidal volume ventilation
- Protective measure to avoid over distension of the normal alveoli
- Uses low (normal) tidal volumes
- Minimize airway pressures
- Uses positive end-expiratory pressure (PEEP)

Three-alveolus model



ARMA

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*

Protocol

- Tidal volume targeting <6ml/kg *predicted body weight* and not more than 8 ml/kg/pbw
- Plateau pressure < 30cm H2O
- RR < 35
- pH 7.30 – 7.45

Low-tidal volume ventilation

- When compared to larger tidal volumes, Vt of 6ml/kg of ideal body weight:
  - Decreased mortality (ARR 9%)
  - Increased number of ventilator free days
  - Decreased extrapulmonary organ failure
- Mortality is decreased in the low tidal volume group despite these patients having:
  - Worse oxygenation
  - Increased pCO2
  - Lower pH

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ARDSnet. *NEJM* 2000; 342: 1301

PEEP

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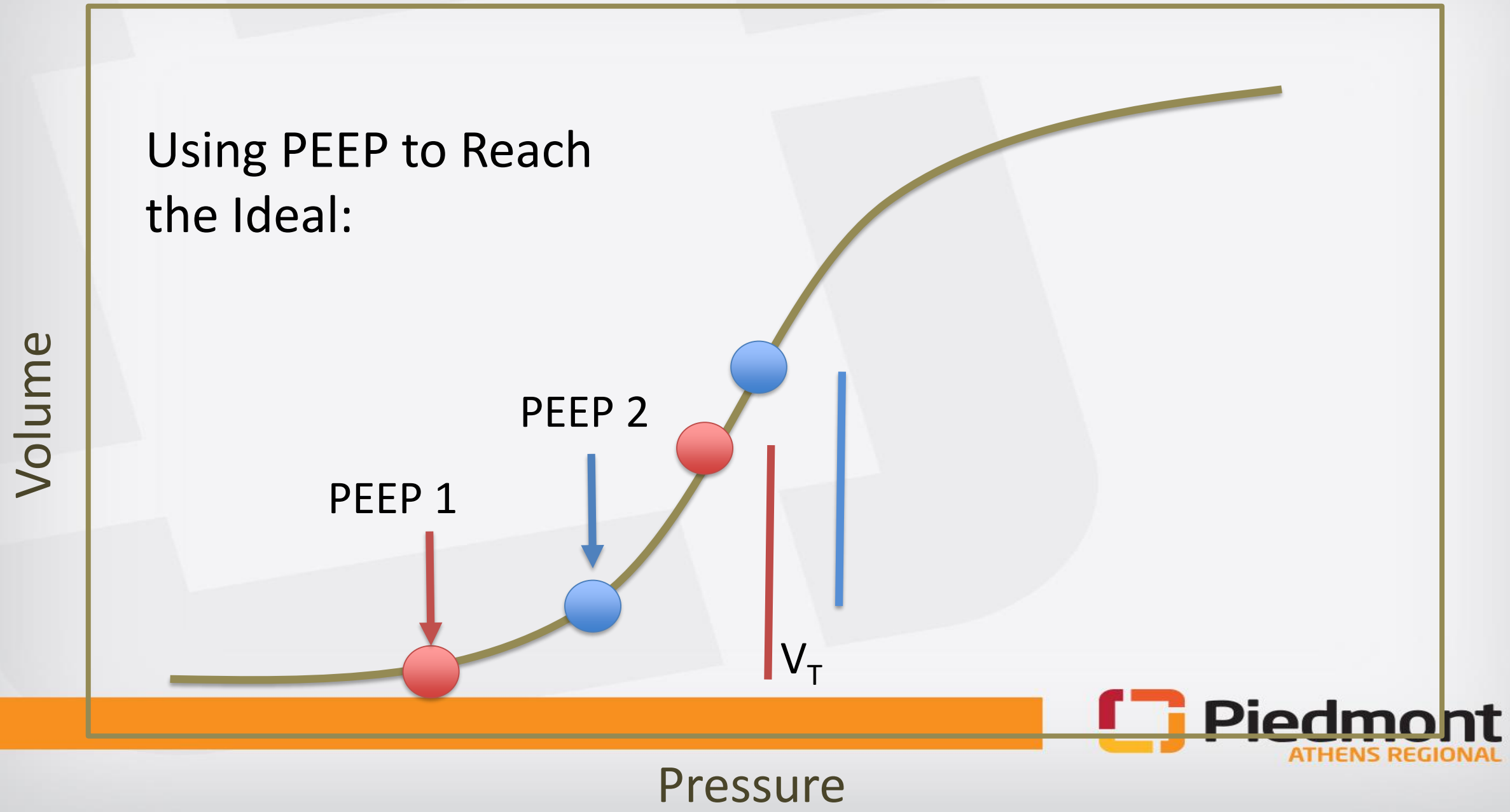
Using PEEP to Reach the Ideal:



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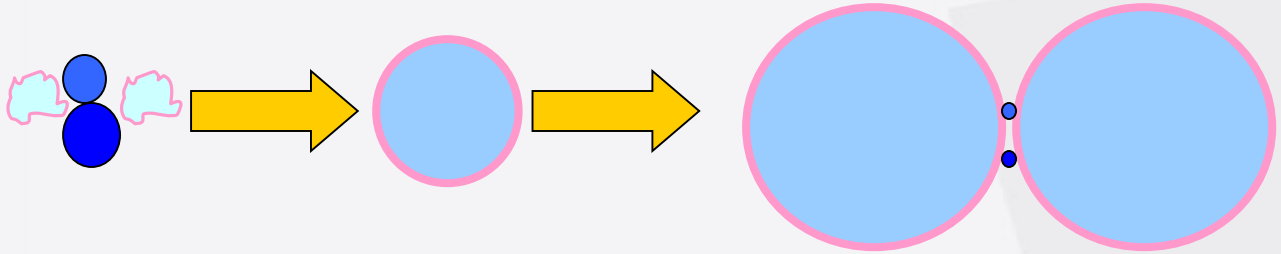
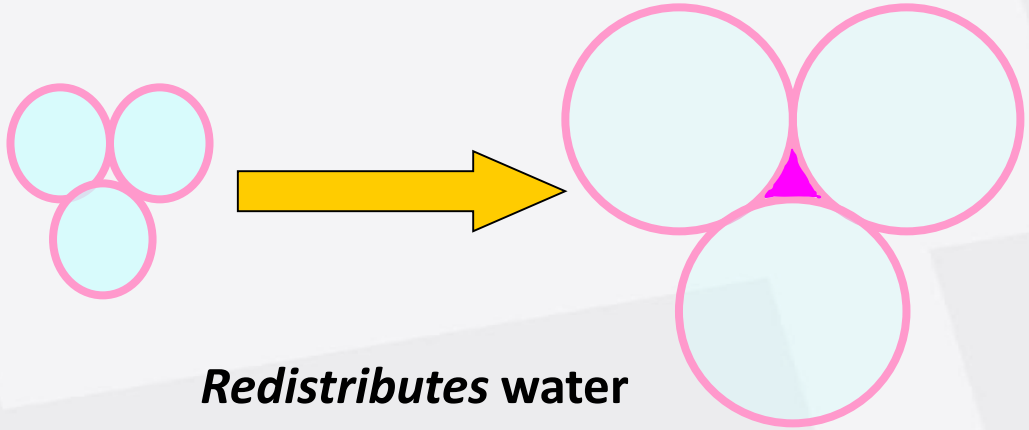
What does PEEP do?



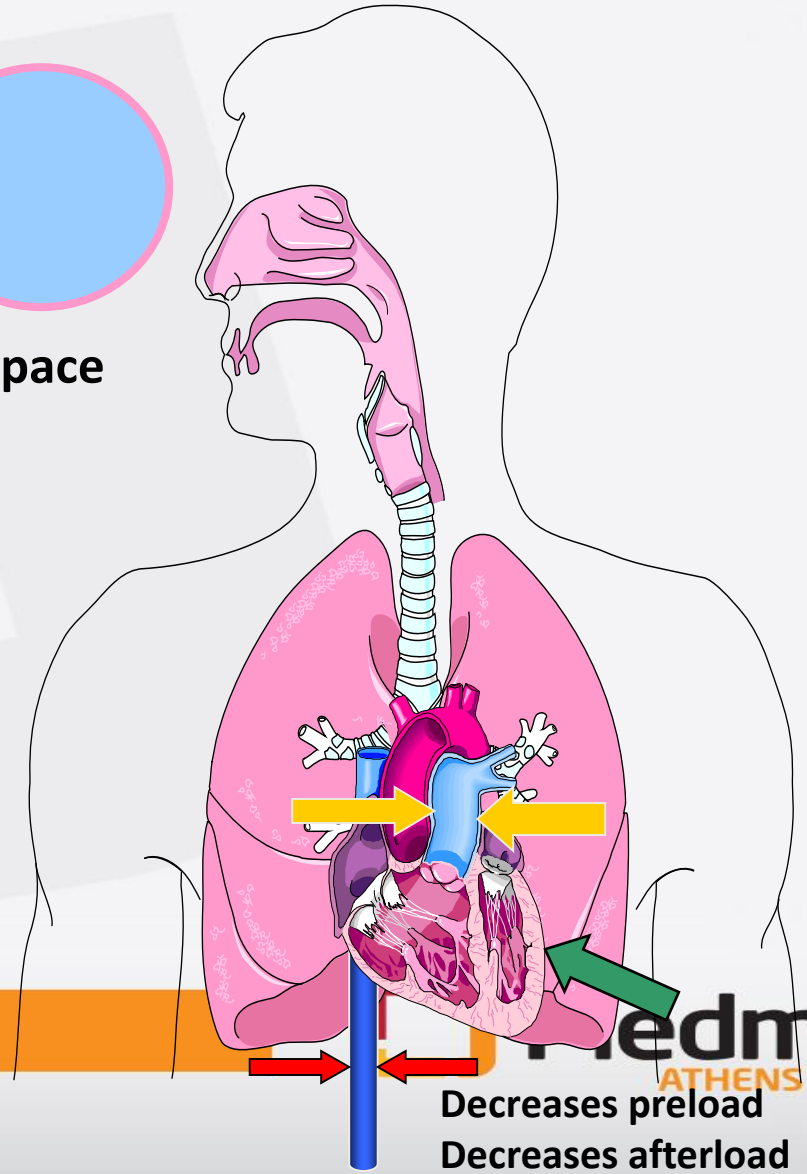
Recruits alveoli

Creates deadspace



Redistributes water

Can increase shunt fraction and hypoxia via directing blood to atelectatic areas and increasing R→L shunting through PFO



Decreases preload

Decreases afterload

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IF A LITTLE BIT IS GOOD, THEN…

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ALVEOLI

- Low PEEP vs *High* PEEP

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 JULY 22, 2004 VOL. 351 NO. 4

Higher versus Lower Positive End-Expiratory Pressures in Patients with the Acute Respiratory Distress Syndrome

The National Heart, Lung, and Blood Institute ARDS Clinical Trials Network*

Allowable combinations of PEEP and FiO_2†														
Lower-PEEP group														
FiO_2	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.7	0.7	0.8	0.9	0.9	0.9	1.0
PEEP	5	5	8	8	10	10	10	12	14	14	14	16	18	18–24
Higher-PEEP group (before protocol changed to use higher levels of PEEP)														
FiO_2	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.5–0.8	0.8	0.9	1.0	
PEEP	5	8	10	12	14	14	16	16	18	20	22	22	22–24	
Higher-PEEP group (after protocol changed to use higher levels of PEEP)														
FiO_2	0.3	0.3	0.4	0.4	0.5	0.5	0.5–0.8	0.8	0.9	1.0				
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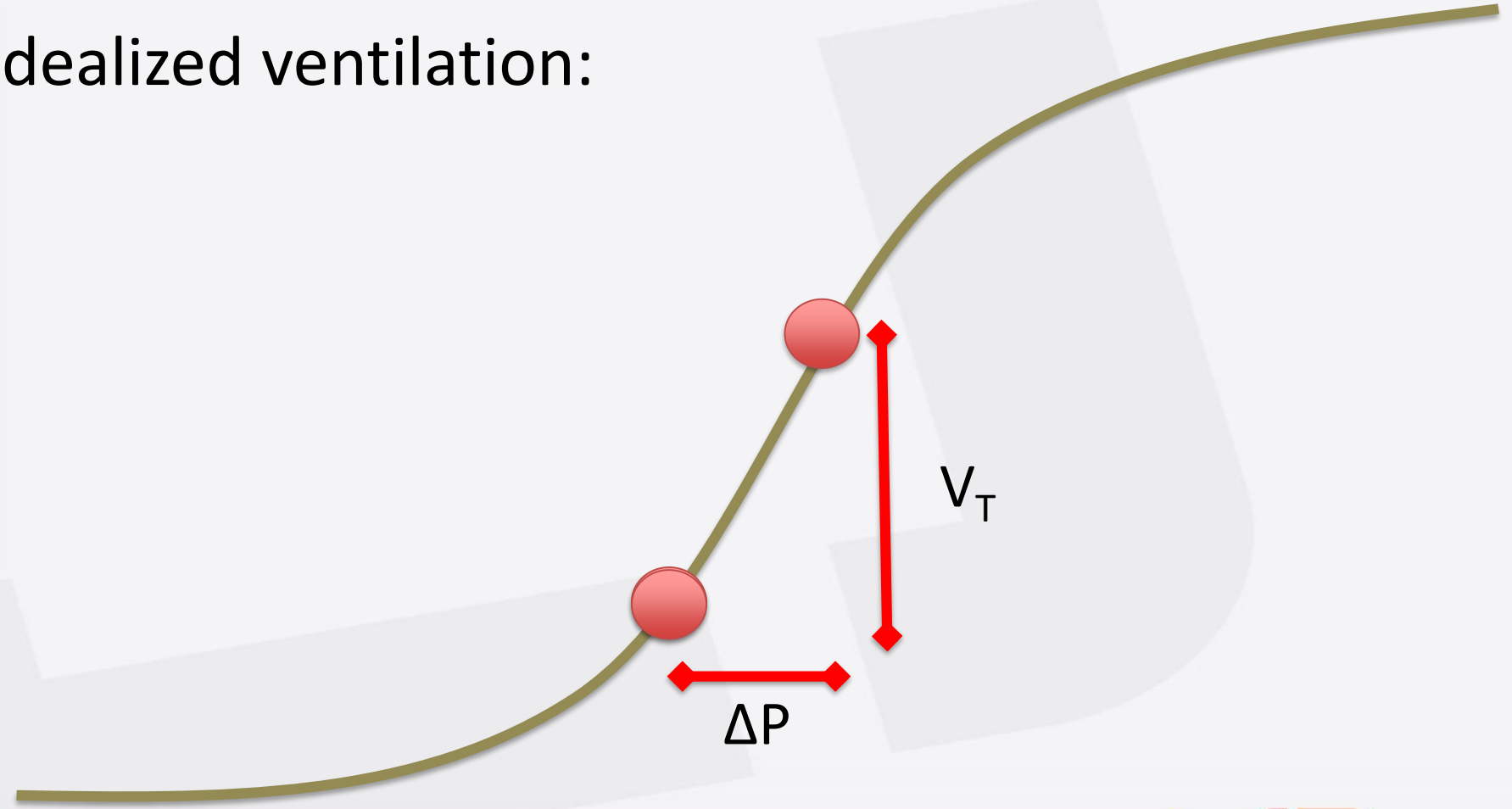
Idealized ventilation:



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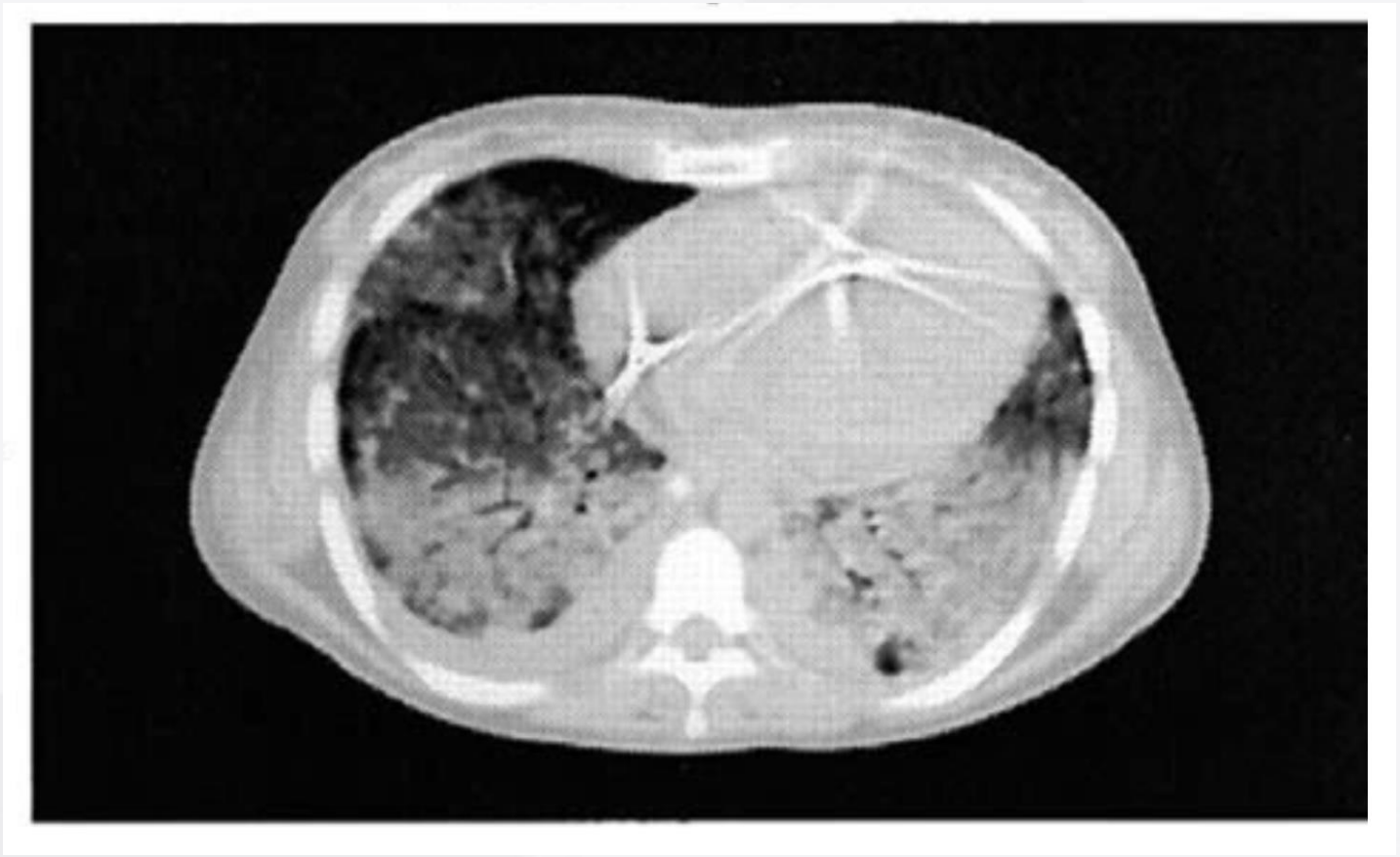
The “Baby Lung”



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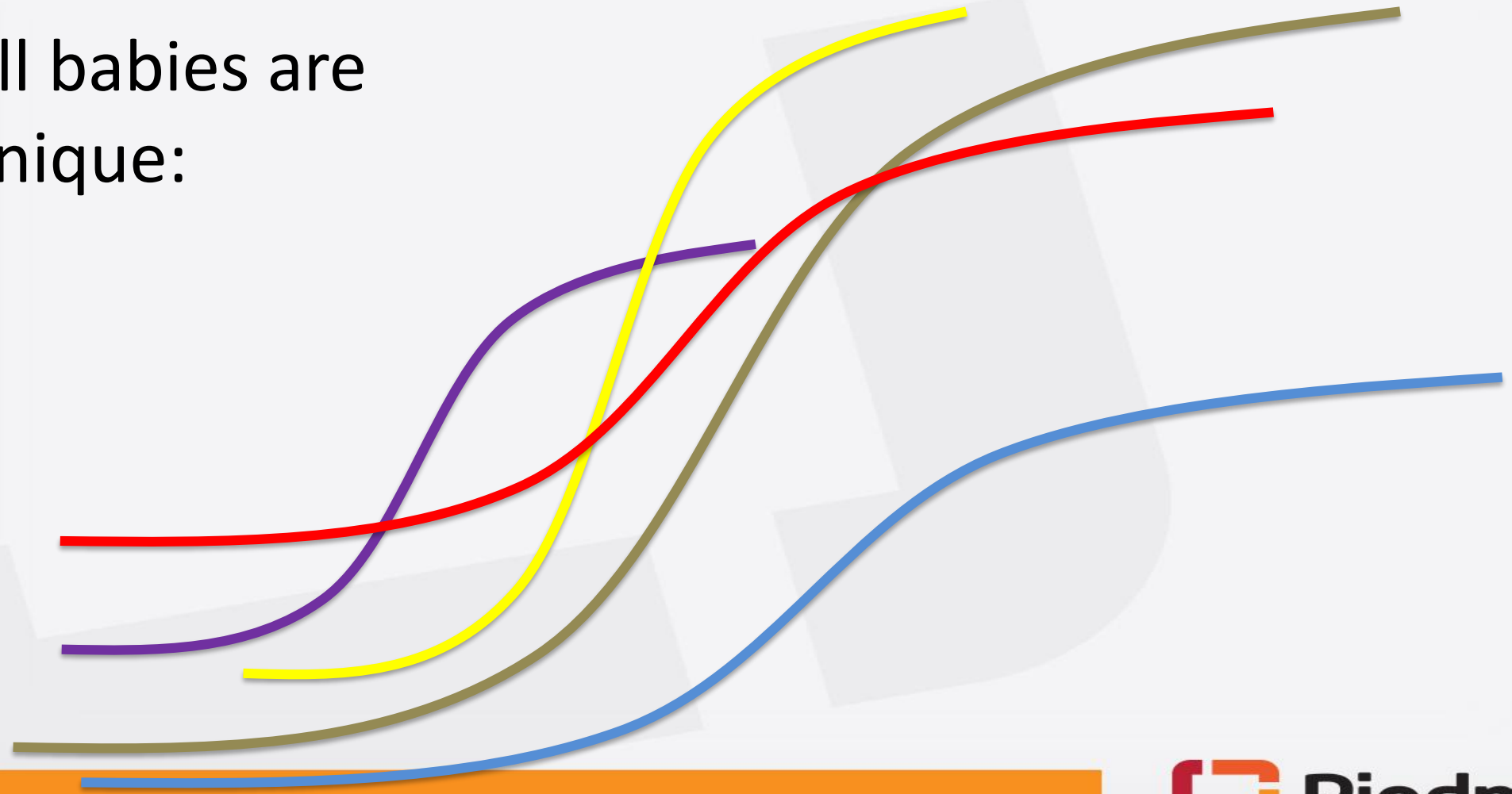
Gattinoni and Pesenti, 2012

All babies are unique:



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Positive and Negative Effects of PEEP

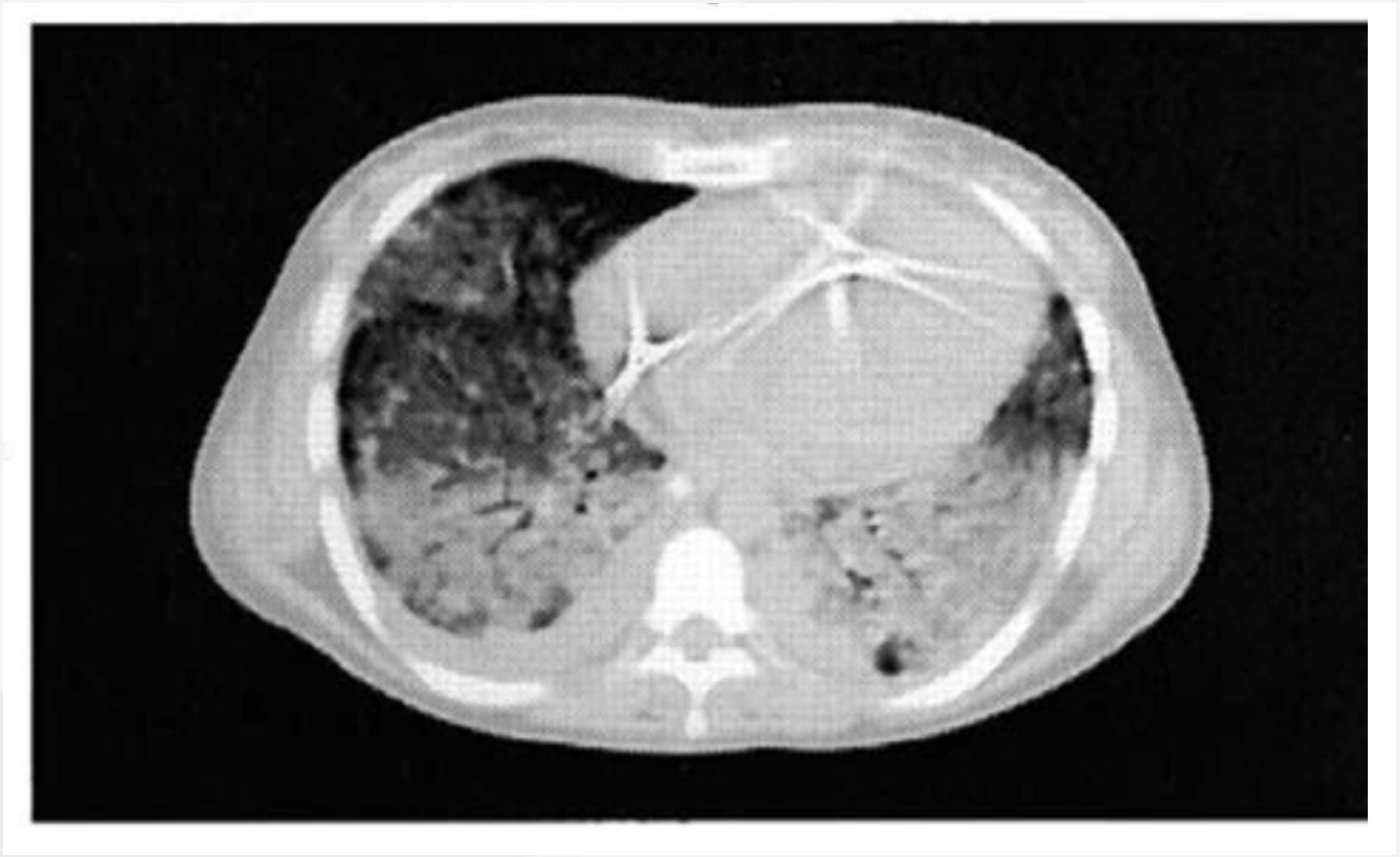
Potential Benefits

- Improve oxygenation
- Improve cardiac output
- Reduce atelectotrauma

Potential Harms

- Reduce cardiac output
  - By reducing venous return
  - Increasing pulmonary resistance
- Increase dead space
- Increase stress
- Increase strain

The “Baby Lung”



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Gattinoni and Pesenti, 2012

PROSEVA

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 JUNE 6, 2013 VOL. 368 NO. 23

Prone Positioning in Severe Acute Respiratory Distress Syndrome

Claude Guérin, M.D., Ph.D., Jean Reignier, M.D., Ph.D., Jean-Christophe Richard, M.D., Ph.D., Pascal Beuret, M.D.,

- 466 patients 16% vs 33% mortality

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Indications

Prevention of VILI

- PF <150 after 6 hours of ARDSnet ventilation AND
- FiO2 0.6 or more AND
- PEEP 5 or more AND
- Vt at 6 ml/kg

Immediate rescue therapy

- PF < 55 AND
- FiO2 1.0 AND
- High PEEP

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Contraindications

- Elevated intracranial pressure (ICP >30)
- Massive hemoptysis
- Recent tracheal surgery or sternotomy (15 days)
- Recent facial trauma or facial surgery (15 days)
- DVT treated for less than 2 days
- Unstable spine, femur, or pelvic fractures
- Single anterior chest tube with air leak

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Criteria to Stop

- Improvement in oxygenation (P/F >150 AND PEEP ≤ 10 and FIO2 ≤ 0.6) 4 hours after returning to supine
- 20% fall in P/F when going from supine to prone on 2 consecutive sessions
- Complications: cardiac arrest, severe bradycardia, persistent hypotension, accidental extubation or endotracheal tube obstruction, etc…

Thanks! Questions?

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