

Spontaneous efforts that result in high tidal volumes in mechanically ventilated patients should be pharmacologically suppressed

PRO

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Disclosures

- Boehringer Ingelheim: speaker's bureau
- GSK: advisory board
- Janssen: speaker's bureau
- Phillips: advisory board
- Portola: speaker's bureau
- Sunovion: speaker's bureau

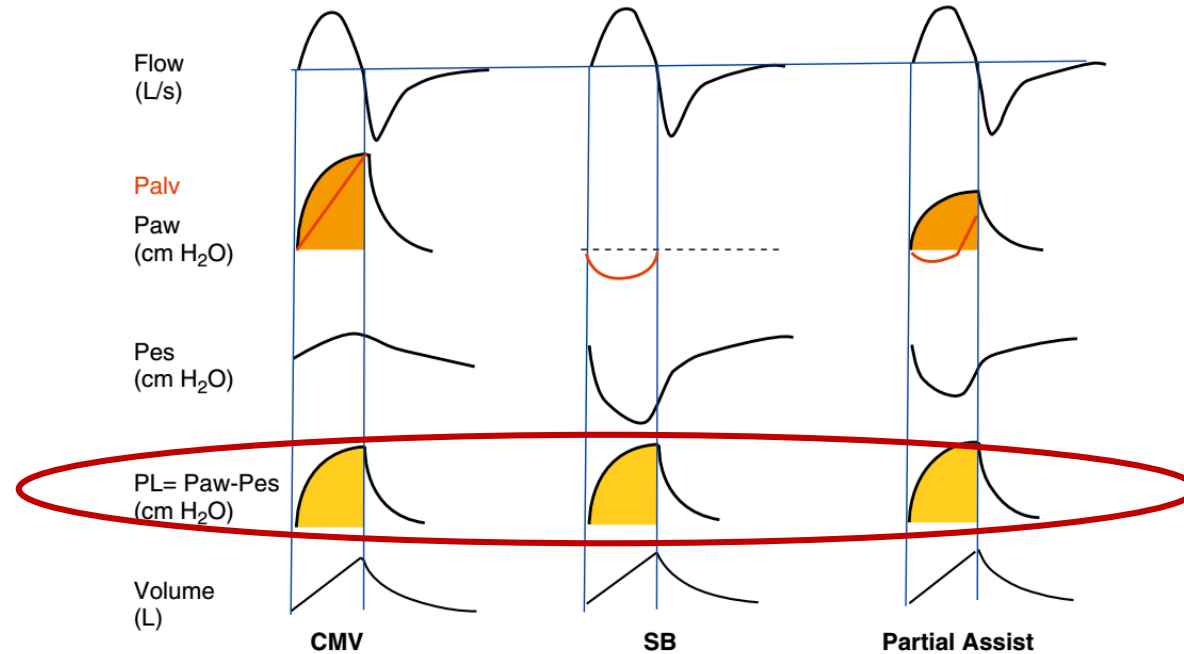
Objective

Review the potential harmful effects of spontaneous breathing during mechanical ventilation

Spontaneous Breathing during Mechanical Ventilation: Mechanisms of Lung Injury

- Increased lung stress
- Regional increase of transpulmonary pressure (in the presence of safe average P_L) generates “occult pendelluft”
- Increased lung perfusion
- Patient-ventilator asynchrony
- Biotrauma
- “Two-hit” concept: lungs with pre-existing injury more susceptible to injury

Transpulmonary Pressure: CMV, SB, Partial Assist



Transpulmonary Pressure: $P_L = P_{aw} - P_{es}$

High TV Delivered by Negative or Positive Pressure Injures the Lung

High Inflation Pressure Pulmonary Edema

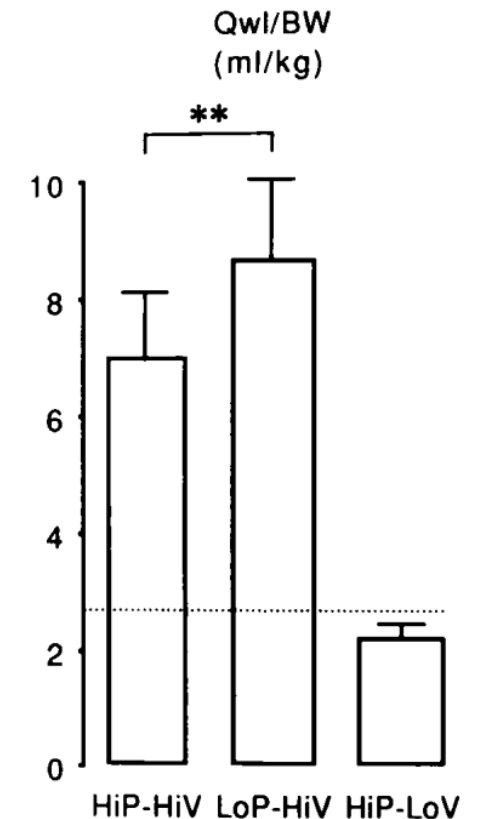
Respective Effects of High Airway Pressure, High Tidal Volume, and Positive End-expiratory Pressure¹⁻³

DIDIER DREYFUSS, PAUL SOLER, GUY BASSET, and GEORGES SAUMON

Animal experiment

- High P/High TV: positive pressure
- Low P/High TV: negative pressure with iron lung
- High P/Low TV: TV constrained with thoracoabdominal strapping

Extravascular lung water



Spontaneous Hyperventilation Can Injure the Lung

Intensive Care Med (1988) 15:8–14

Intensive Care
Medicine
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Original articles

Acute respiratory failure following pharmacologically induced hyperventilation: an experimental animal study

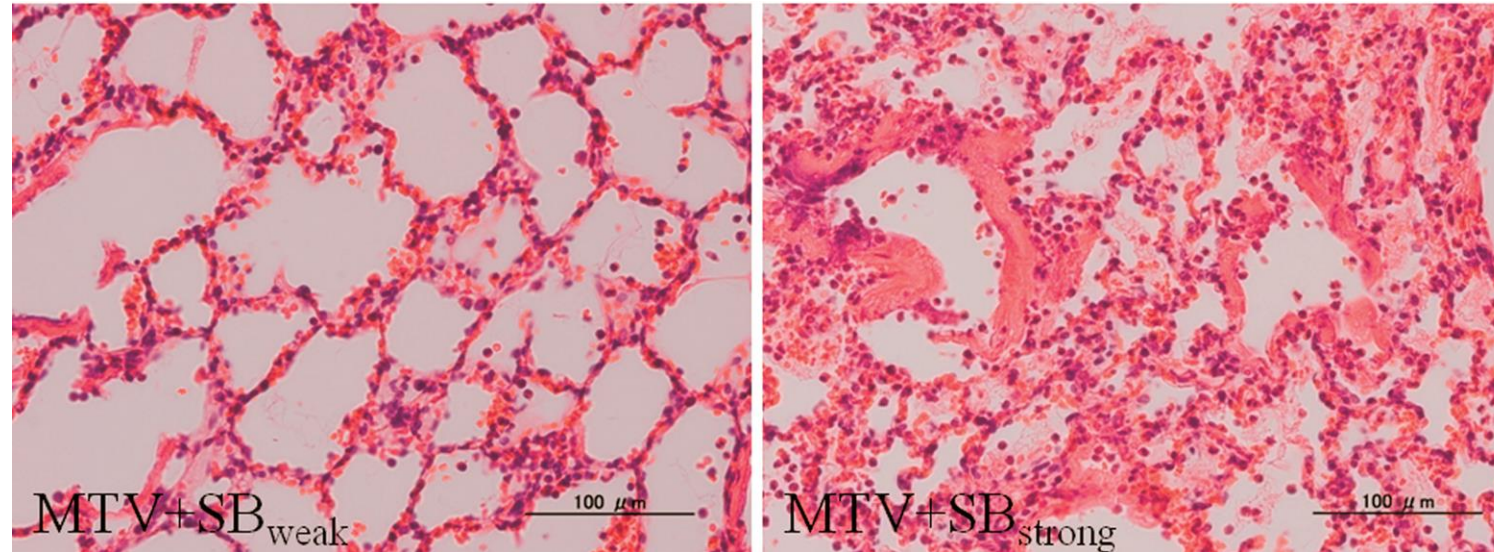
D. Mascheroni*, T. Kolobow, R. Fumagalli*, M. P. Moretti**, V. Chen and D. Buckhold

National Institutes of Health, National Heart, Lung and Blood Institute, Laboratory of Technical Development, Bethesda, Maryland, USA

Spontaneous hyperventilation - sodium salicylate into sheep cisterna magna

	VT (ml/kg)	P _L (cm H ₂ O)	Dead	Abnormal lungs
Hyperventilated	9 -15	9.2	6/16	14/167
Control	7	5.3	0/10	0/10

Mechanical Ventilation + Spontaneous Breathing in Acute Lung Injury



Animal model: lavage-induced acute lung injury; Ventilation: plateau pressure limited to 30 cm H₂O; Assisted PC ventilation with inspiratory pressure = 20 cm H₂O, resulting in TV 7 – 9 ml/kg, PEEP 8 cm H₂O

SB_{weak}: propofol & dexmedetomidine; SB_{strong}: doxapram (respiratory stimulant)

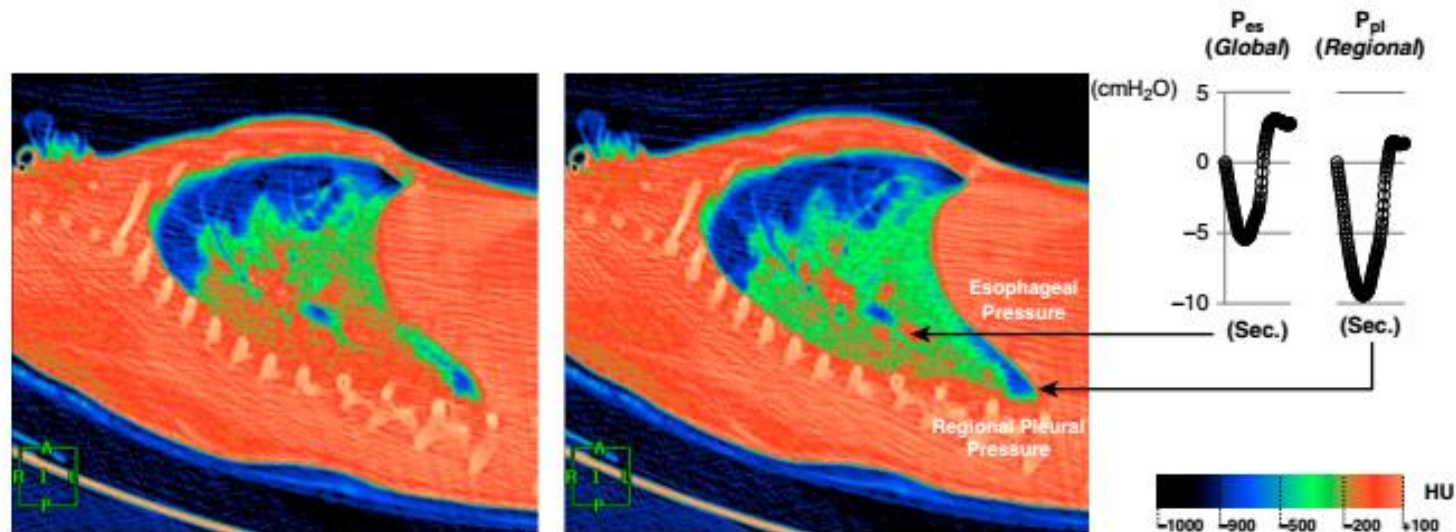
SB_{weak} : Δ esophageal P* = 1.3 ± 0.2 cm H₂O; P_L = 29.6 ± 0.4 cm H₂O; p < 0.5

SB_{strong}: Δ esophageal P* = 4.6 ± 1.1 cm H₂O; P_L = 34.5 ± 1.6 cm H₂O; p < 0.5

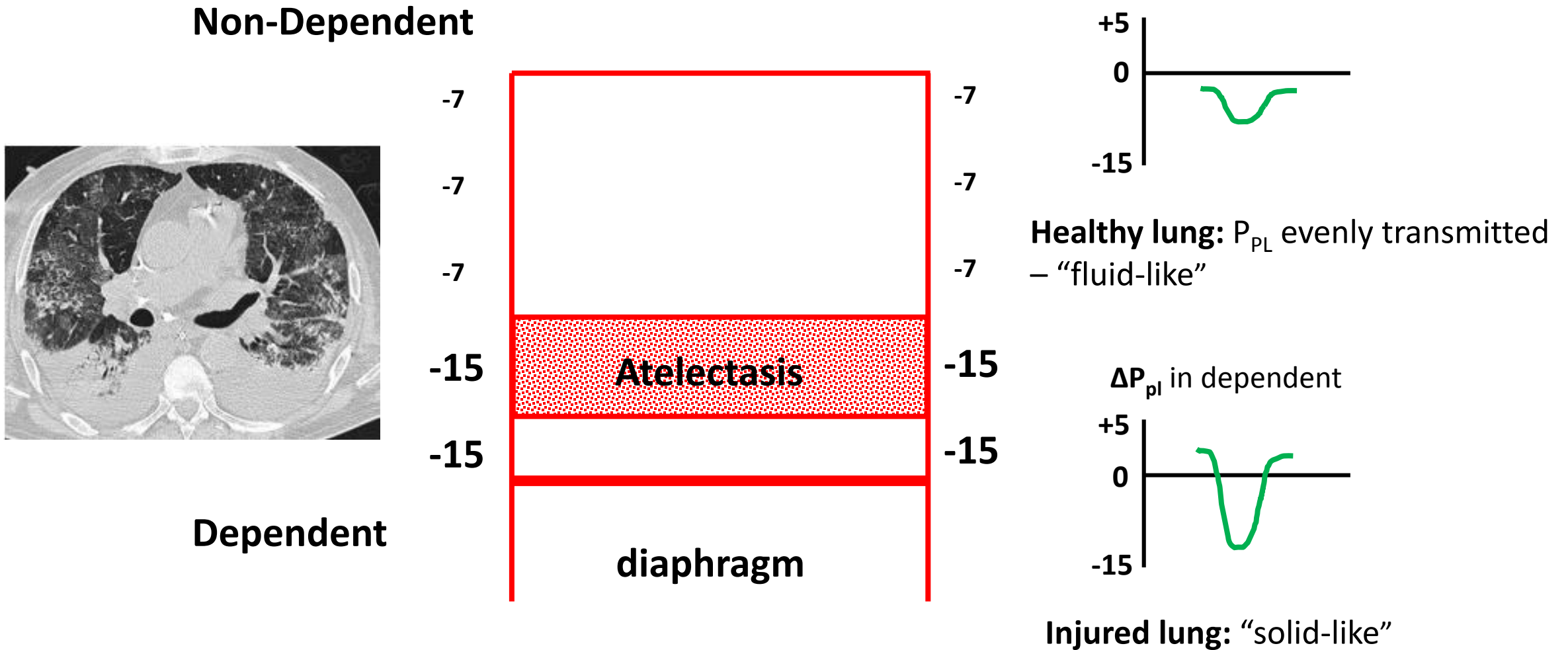
**Δesophageal P* = decrease of *Pes* from the start of inspiration

Volume-Controlled Ventilation Does Not Prevent Injurious Inflation During Spontaneous Effort

- Theoretically volume-controlled ventilation limits “ventilator” breaths by measuring delivered TV – limiting the P_{aw} and thus P_L
- Spontaneous effort causes greater tidal recruitment of dorsal regions (> 2X)
- Regional differences in transpulmonary pressure not always reflected in global measurement of P_{es}

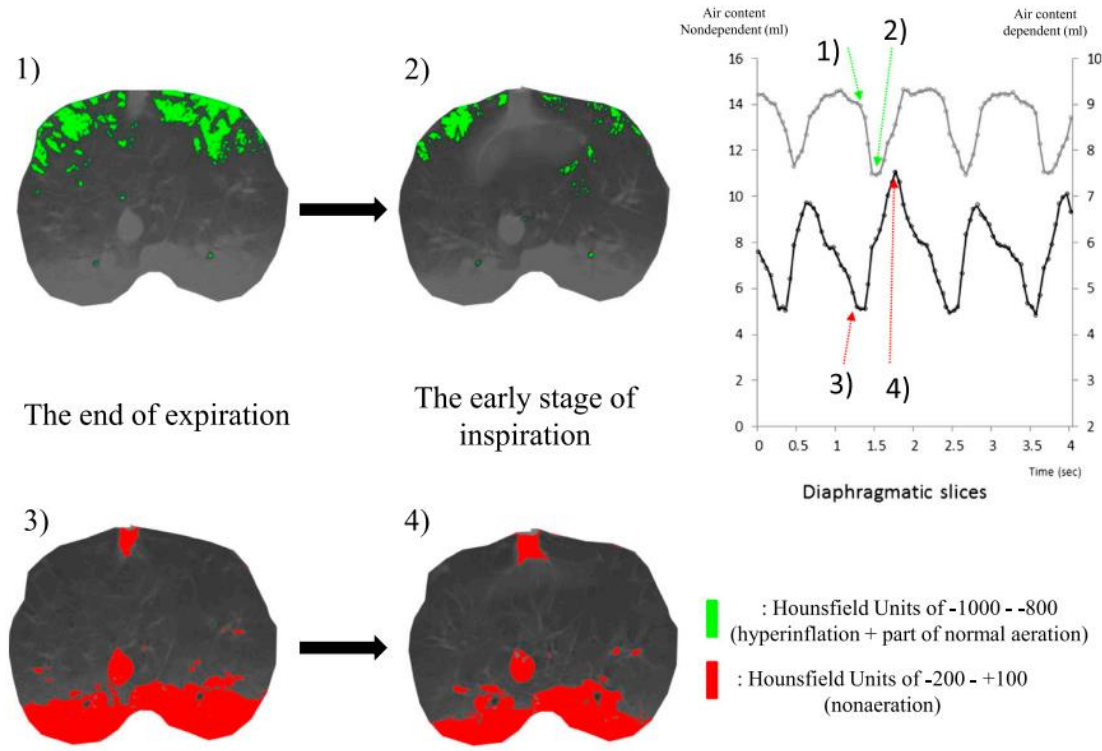


Atelectatic Lung impairs transmission of ΔP_{PL}



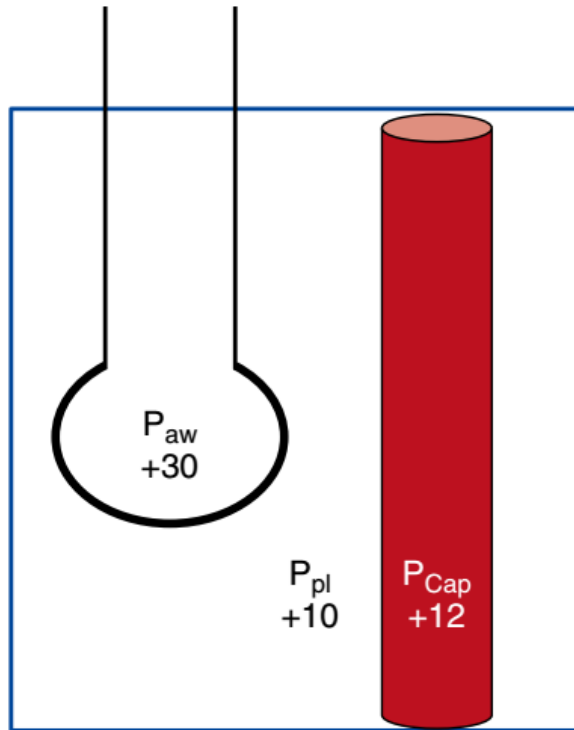
Occult Pendelluft: strong spontaneous effort can result in hidden, local overstretch of the dependent lung

Pendelluft = “swinging air” – gas is passed back & forth between different lung regions because of different dynamics of regional inflation and deflation. With acute lung injury air shifts from nondependent lung regions, without changes in TV

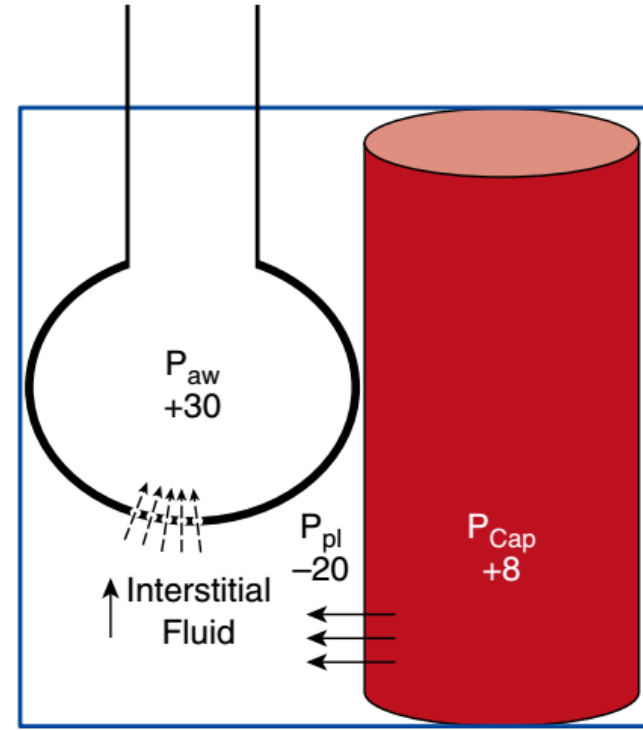


Spontaneous Effort: Transpulmonary & Transvascular Pressure

Spontaneous effort: distends thoracic & pulmonary vessels & may lead to ↑pulmonary edema



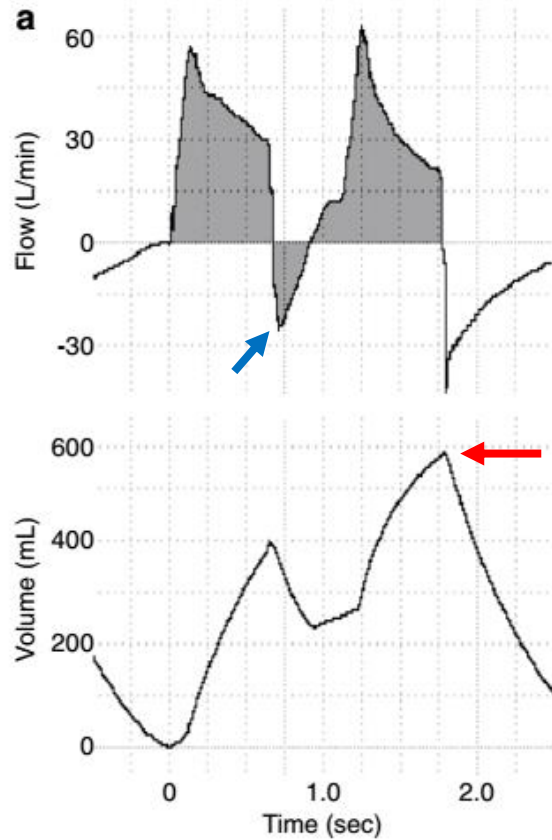
$$P_L = 20 (30-10)$$
$$\text{Transvascular pressure} = 2 (12-10)$$



Spontaneous breathing

$$P_L = 50 (30 - -20)$$
$$\text{Transvascular pressure} = 28 (8 - -20)$$

Patient-Ventilator Asynchrony

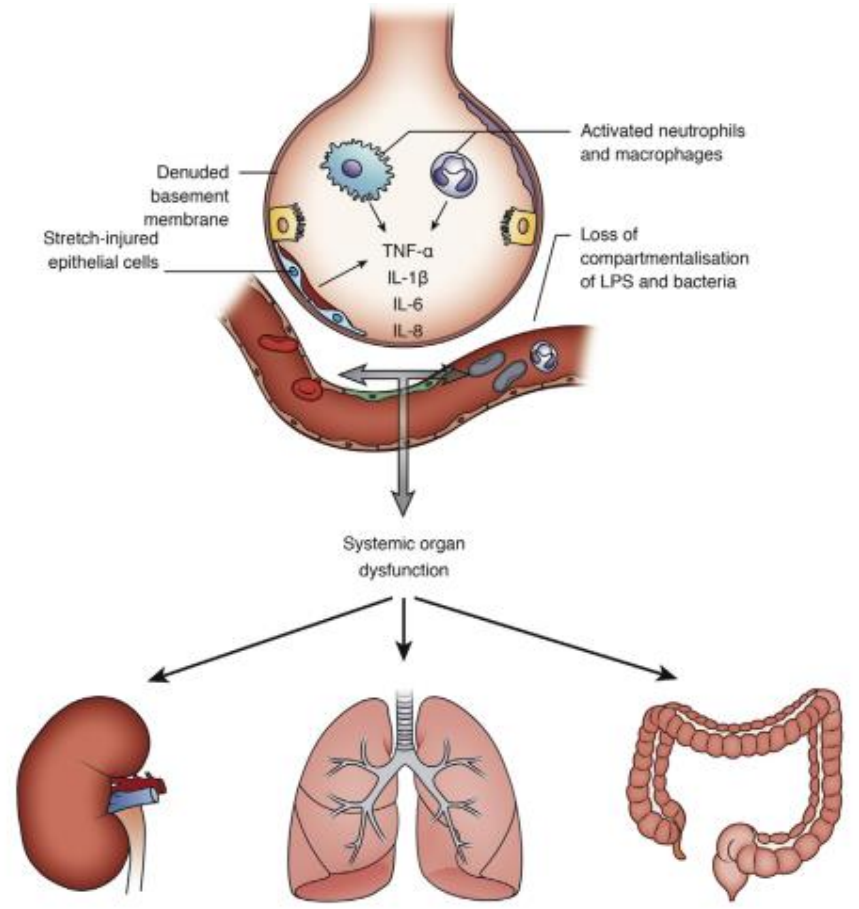
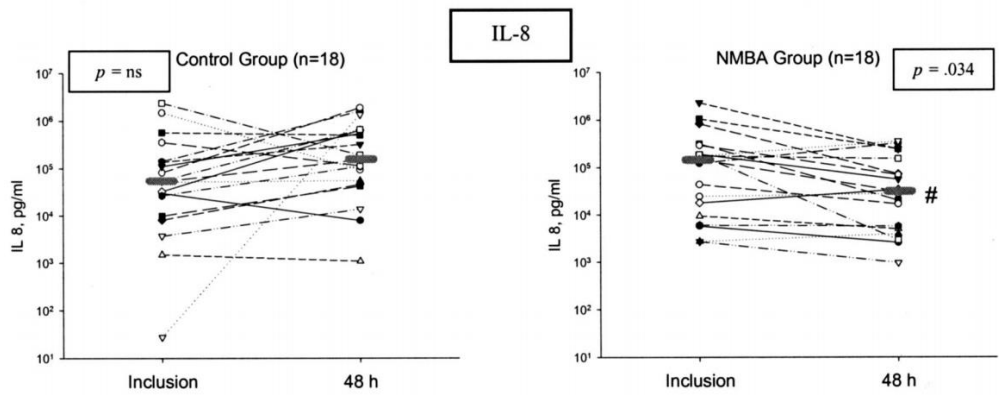


Higher frequency of asynchronies (AI > 10%)

Associated with ↑ ICU & hospital mortality

Double triggering leads to excessive TV

Biotrauma: Neuromuscular Blockade Decreases Inflammatory Response in ARDS



Summary

- Spontaneous breathing causes similar transpulmonary pressures and stress injury as mechanical breaths
- Regional differences in transpulmonary pressure & TV not always reflected by global P_{es} or TV
- Spontaneous breathing increases transvascular pressure → increased pulmonary edema
- Patient-ventilator asynchronies can lead to high TV (& possibly ↑ mortality)
- Spontaneous breathing in mechanical ventilation may increase “biotrauma” in ARDS