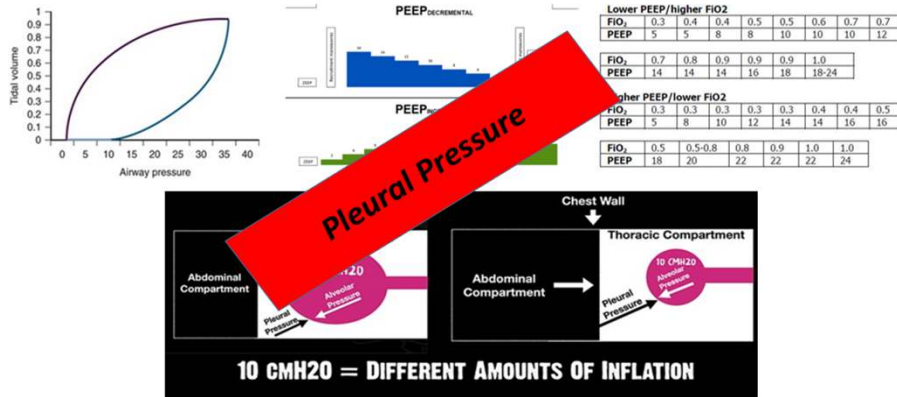


Partitioning the Thoracic Cavity

Patrick McDonagh MS. RRT-NPS, ACCS, C-NPT.



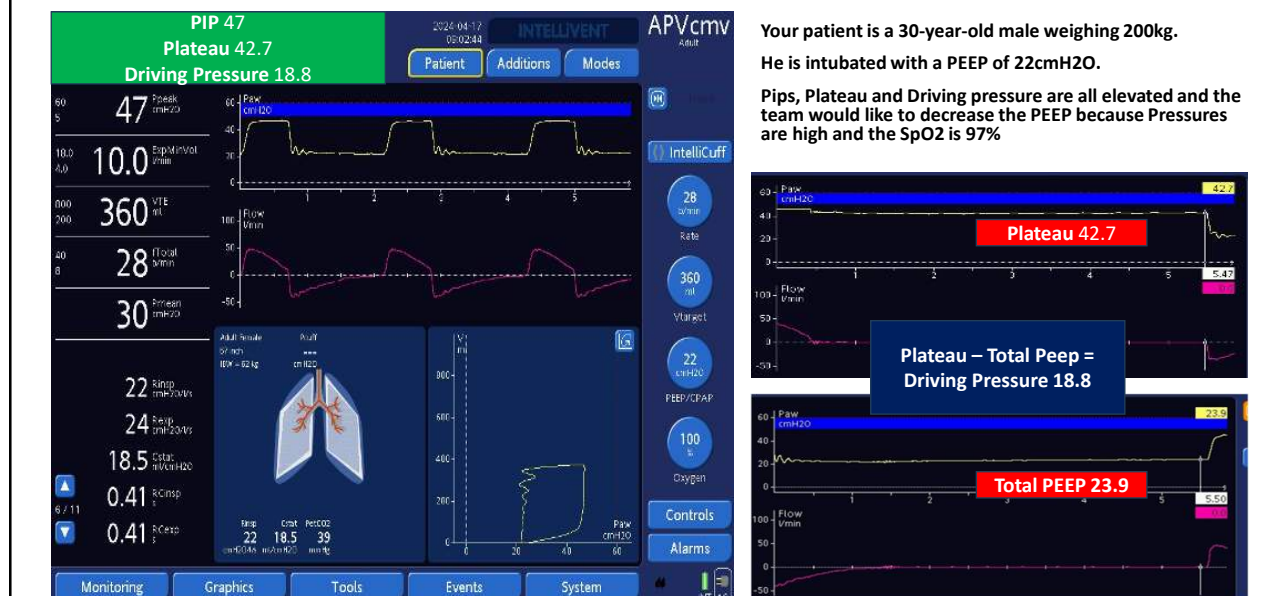
Disclosures

None to Report

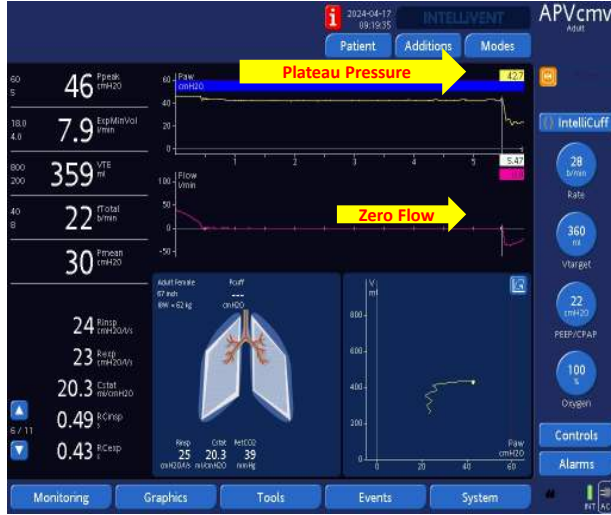
Objectives

1. The effect Pleural pressure has on lung inflation
2. Transpulmonary Pressure's relationship to Lung Inflation

Scenario



Plateau Pressure

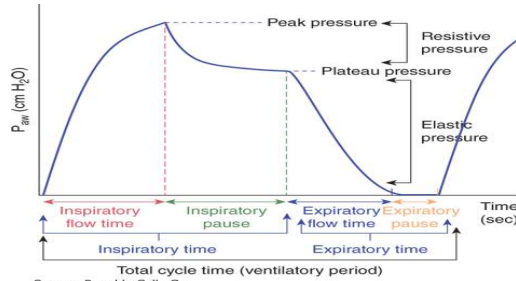


Static Measurement at the end of a full inspiration

Indicates The pressure within the alveoli
Used to trend alveolar compliance

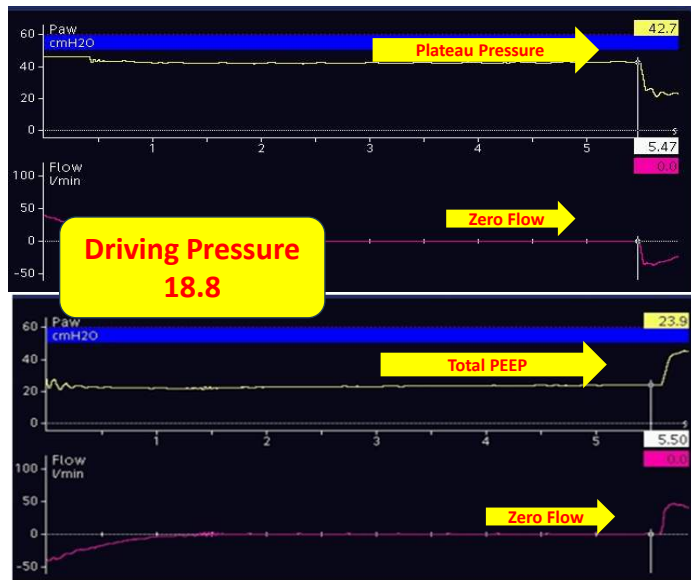
Goal is < 30cmH₂O
High = Noncompliant lung

Represents a Global Pressure
Eg: Patient with a large Body habitus



Source: Ronaldo Collo Go
Critical Care Examination and Board Review.
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Driving Pressure

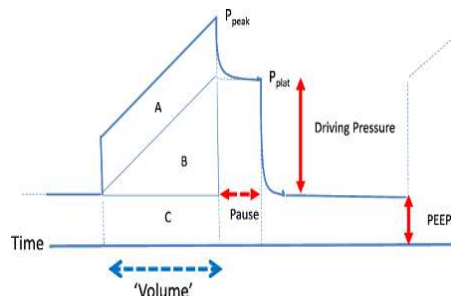


Shearing Force at the end of a full inspiration

Indicates ratio of V_t to CRS

Goal is < 15cmH₂O
High = Noncompliant lung

Represents a Global Pressure
Eg: Patient with a large Body habitus



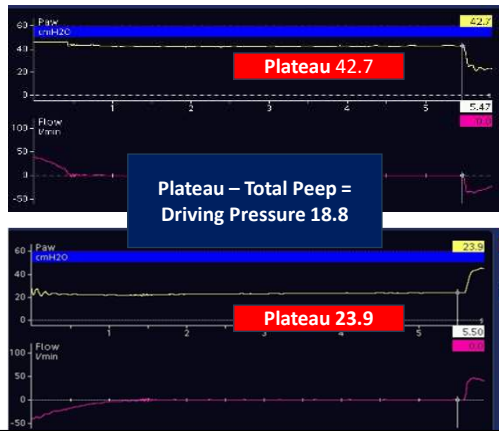
Korean J Anesthesiol. 2020 Jun; 73(3): 194-204.
 Published online 2020 Feb 26. doi: 10.4097/kja.20041

PMCID: PMC7280884
 PMID: 32098009

Driving pressure is [Pplat - PEEP] and is the pressure required for the alveolar opening [17]. Static lung compliance (Cstat) is expressed as [V_T / (Pplat - PEEP)]. Thus, driving pressure is also expressed as [V_T / Cstat]. Driving pressure has an inverse relationship with Cstat and an orthodromic relationship with V_T according to this formula. High driving pressure indicates poor lung condition with decreased lung compliance.

Driving pressure guided ventilation

Hyun Joo Ahn,¹ MiHye Park,¹ Jie Ae Kim,¹ Mikyung Yang,¹ Susie Yoon,² Bo Rim Kim,² Jae-Hyon Bahk,² Young Jun Oh,³ and Eun-Ho Lee⁴



Passive/Active →

47 Tidal Volume (ml)

10.0 Respiratory Rate (1/min)

360 VTE (ml)

28 PEEP (cmH2O)

30 PIP (cmH2O)

22 PIP (cmH2O)

24 PIP (cmH2O)

18.5 Cstat (ml/cmH2O)

0.41 sCmap (ml/cmH2O)

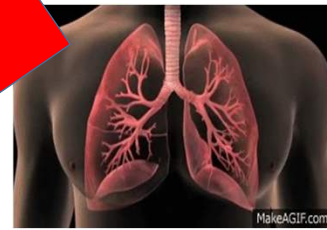
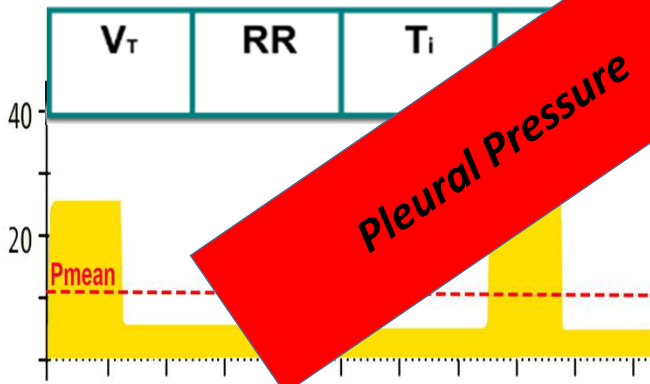
0.41 sCexp (ml/cmH2O)

Driving Pressure = $\frac{V_T}{C_{ST}}$

Vte 360/Cstat18.5 = DP 19.45

Each and Every Breath Cycle: The Mean Airway Pressure

P_{mus} + P_{vent} = Resistance x Flow + Elastance x Volume
Breath Delivery = Airway Resistance x Lung Compliance



Pendelluft and Global Airway Pressures

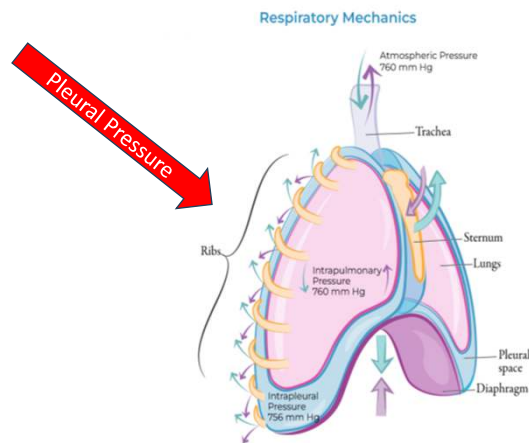
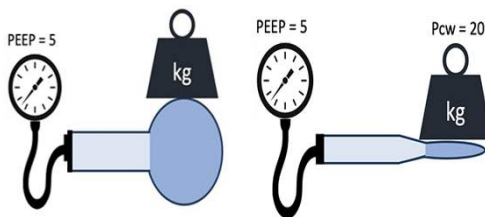
The movement of flow between two regions of the lung is affected by airway resistance and alveolar compliance



Rapid inflation-deflation is injurious in both passive and active patients that may cause local overstretching of the lungs.

What is Pleural Pressure

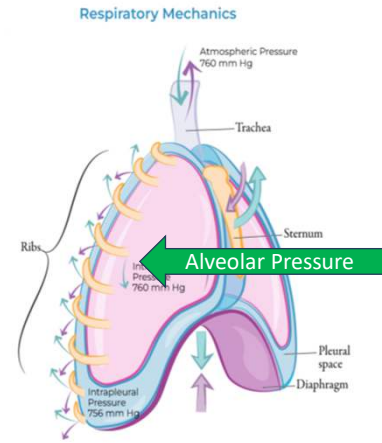
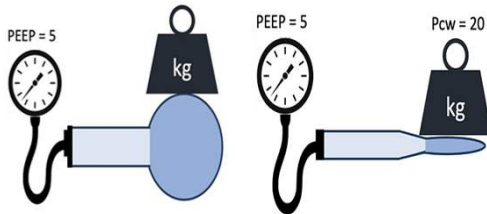
The Pressure surrounding the Lungs within the Pleural Space
 Normal is -2cmH2O to -5cmH2O and based on Positioning



What is Alveolar Pressure

The Pressure within the Alveoli and determines how much air can flow into the lungs

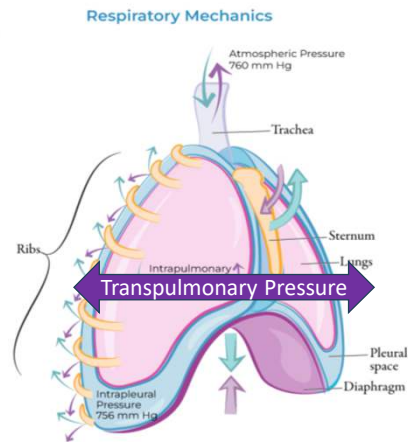
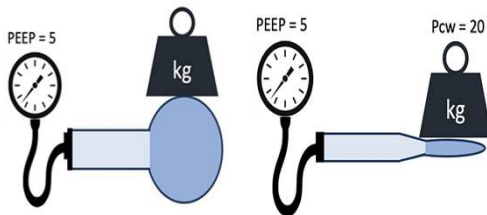
Typically slightly higher than the Pleural Pressure



Transpulmonary Pressure

The difference between the pleural and alveolar pressure is the Transpulmonary Pressure. The pressure across the lungs

Normal is -2cmH2O to +2cmH2O



Positioning Variability of Pleural Pressures and Air Flow

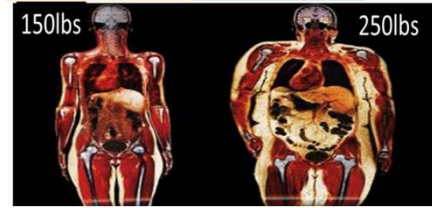
Weight of Mediastinum and Abdomen pressure

PL is calculated from the ratio of compliances of the respiratory system and lungs estimated during a tidal volume inflation (from peep to end inspiratory pressures)

Semi Fowlers Position = Middle Pleural pressure

Supine: Ventral to Dorsal increase in pleural pressures

Prone: Dorsal to Ventral decrease in pleural pressures



Compliance: Change in Volume/Pressure

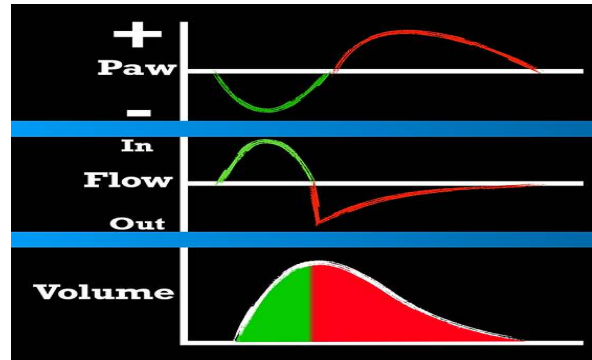
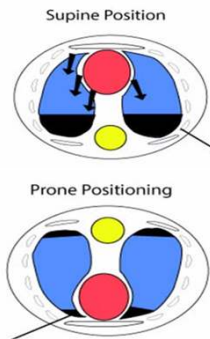
Low lung compliance

Excessive pleural pressure

Results in;

High PIPS, Plateau, Driving Pressure

Mean Airway Pressure

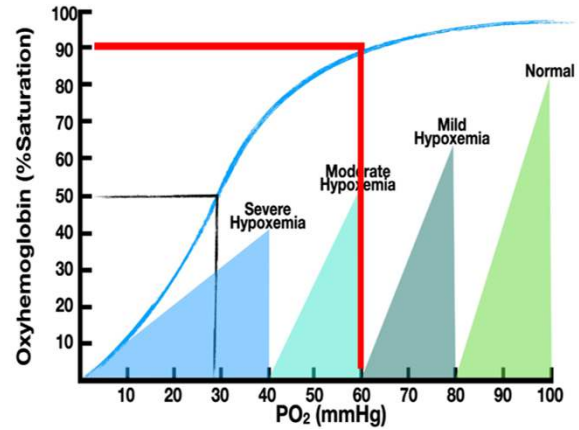
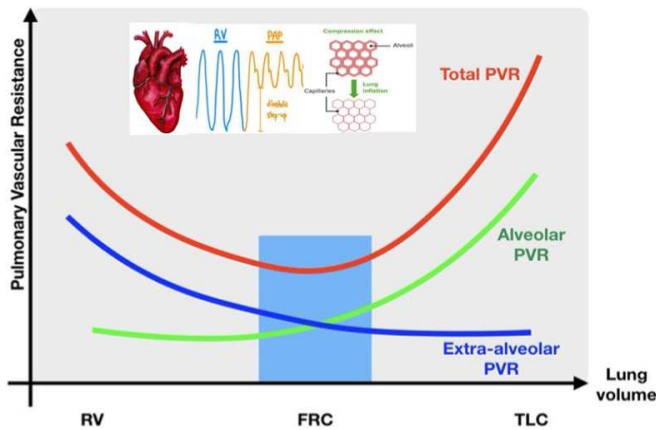


Is PEEP just for Oxygenation?

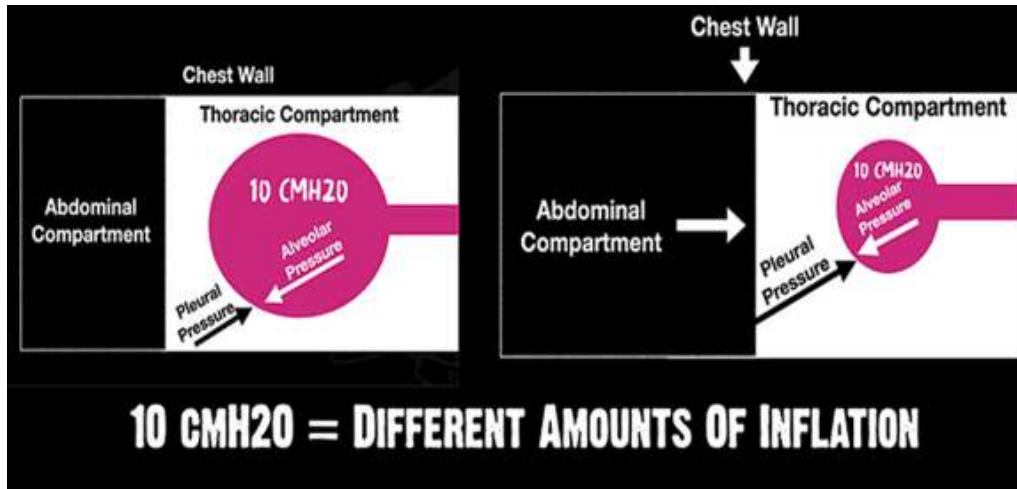
Your patient is a 30-year-old male weighing 200kg. He is intubated with a PEEP of 22cmH2O.

Pips, Plateau and Driving pressure are all elevated and the team would like to decrease the PEEP because Pressures are high and **the SpO2 is 97%**

Optimal PEEP is essential to maintain forward pulmonary blood flow and Hemodynamics



Global Airway Pressures versus Chest Wall Compliance



ARDS Table: Dynamic and Never Static but is it enough PEEP?

Lower PEEP/higher FiO2

FiO ₂	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.7
PEEP	5	5	8	8	10	10	10	12

FiO ₂	0.7	0.8	0.9	0.9	0.9	1.0
PEEP	14	14	14	16	18	18-24

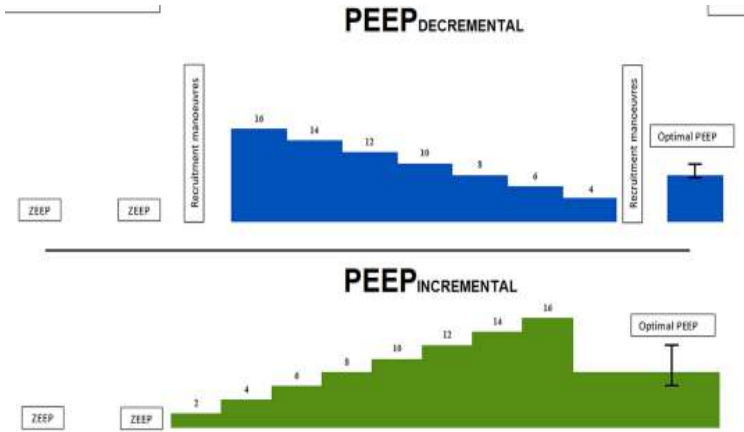
Higher PEEP/lower FiO2

FiO ₂	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5
PEEP	5	8	10	12	14	14	16	16

FiO ₂	0.5	0.5-0.8	0.8	0.9	1.0	1.0
PEEP	18	20	22	22	22	24

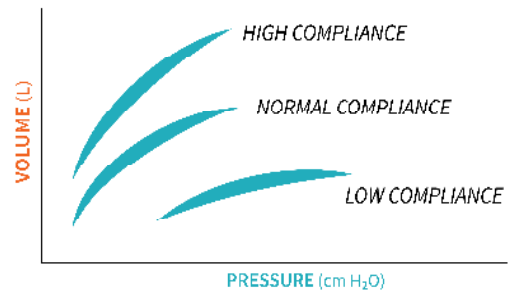
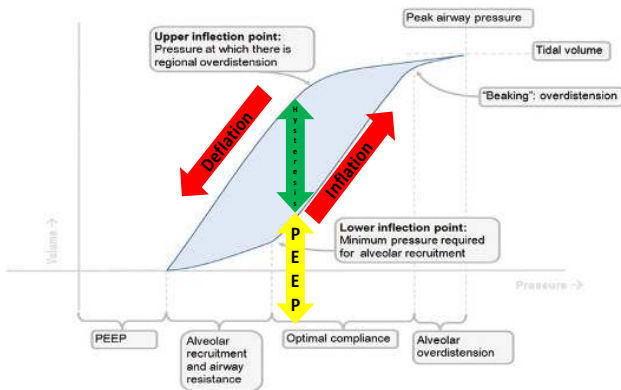
PEEP	Plateau	DP	SpO2	BP (MAP)
22	38	16	82	64
20	36	14	85	68
18	32	14	88	70
16	28	12	92	78
14	28	14	93	82

Incremental and Decremental PEEP Trial

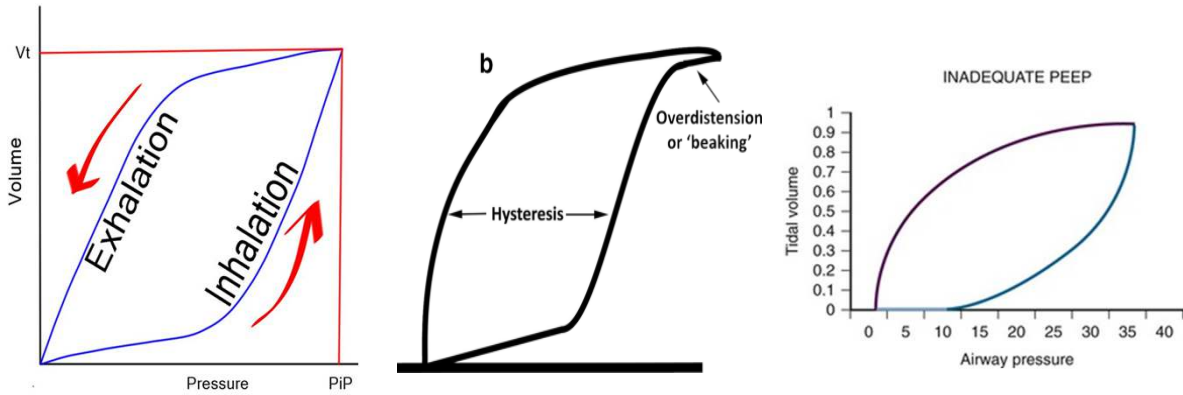


PEEP	Plateau	DP	SpO2	BP (MAP)
22	38	16	82	64
20	36	14	85	68
18	32	14	88	70
16	28	12	92	78
14	28	14	93	82

PV Loop Review

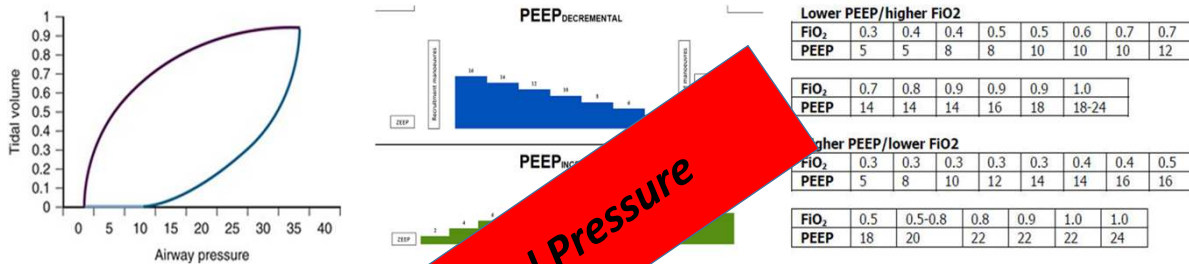


Optimizing VT/PEEP

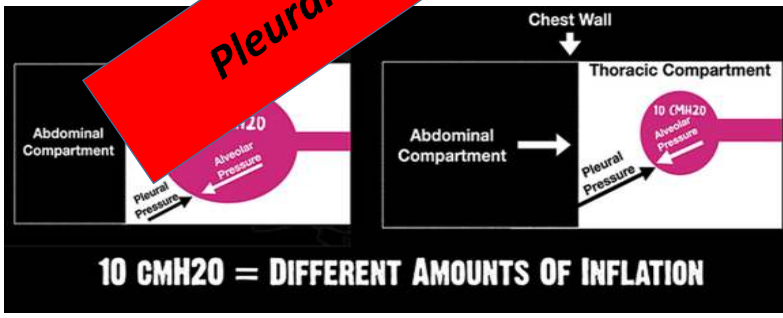


**Global pressures
Can be difficult to find inflection points
Guessing Optimal Peep**

Extrinsic Factors = Global Pressures



Pleural Pressure

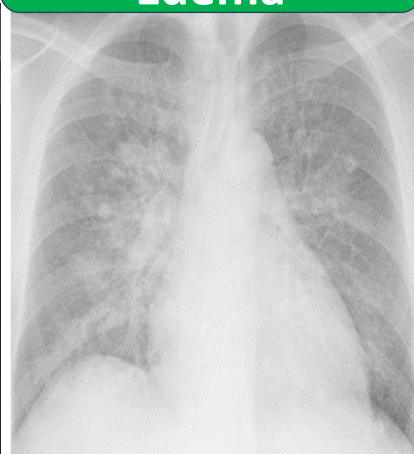


Functional Lung Size Matters: Which one would need a decrease in PEEP?

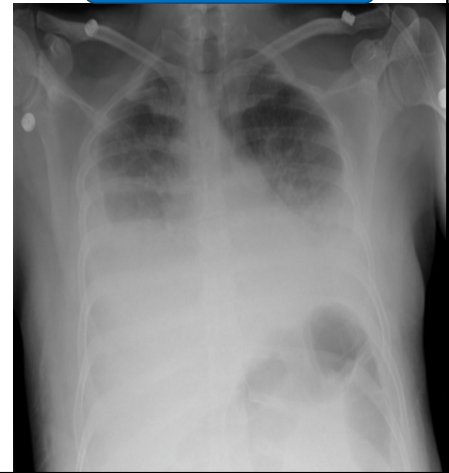
Fibrosis



Pulmonary Edema

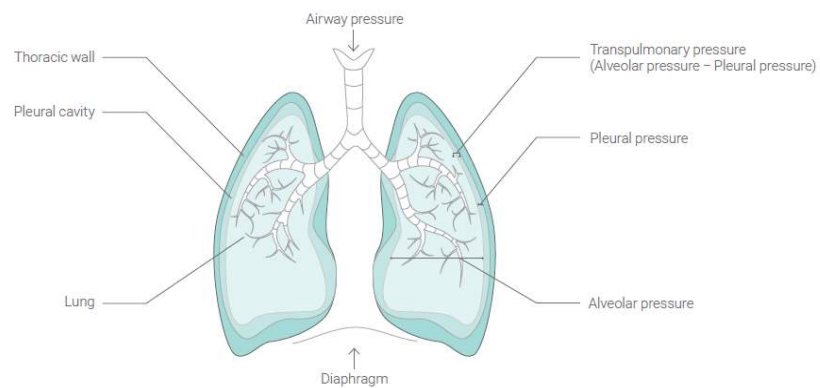


Atelectasis

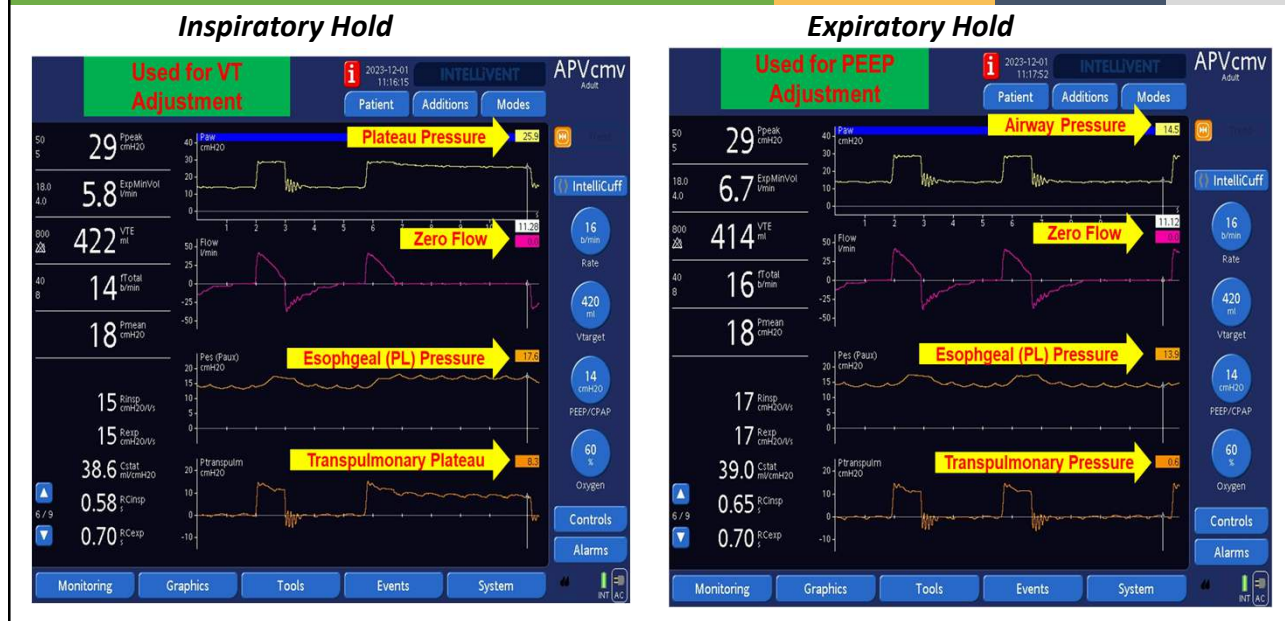


Airway Pressures \neq Functioning Lungs

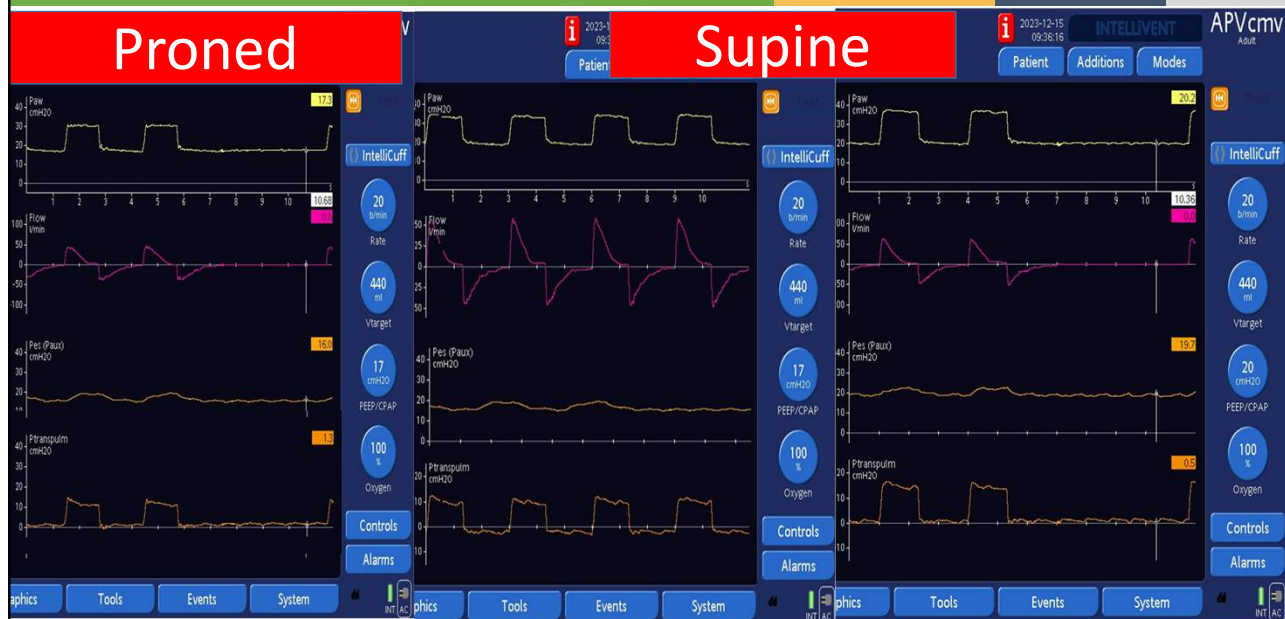
Partitioning the Respiratory System from Global Measurements With Esophageal Manometry



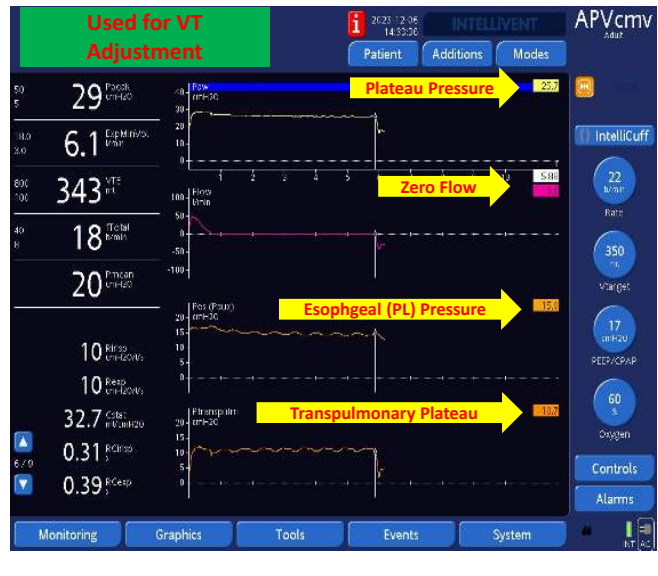
Esophageal Manometry: Transpulmonary Pressures



Transpulmonary Pressure: Prone to Supine



Transpulmonary Plateau: Inspiratory Hold



Transpulmonary Pressure: Expiratory Hold



Scenario: Lets Look Again



Your patient is a 30-year-old male weighing 200kg. He is intubated with a PEEP of 22cmH2O. Pips, Plateau and Driving pressure are all elevated and the team would like to decrease the PEEP because Pressures are high and the SpO2 is 97%

Scenario: Lets Look Again



Noninvasive Estimation of Optimal PEEP

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Meeting Report | Ventilators/Ventilation Part 1

Noninvasive Estimation of Optimal PEEP for Mechanically Ventilated Obese Patients

Laura R Reindl, Lisa M Peterson, Regina Manansala, Jessica J.F. Kram, Marianne Klumph, Bijan Nezami, George Markert, Paul Niebuhr and David J. Kramer
Respiratory Care October 2018, 63 (Suppl 10) 2988085;

BMI divided by 4 can be used as a conservative estimate for optimal PEEP (positive end-expiratory pressure) in obese patients. This formula is based on a study that found that optimal PEEP increases by 1 mm Hg for every 0.79 kg/m² increase in BMI. The study was small and limited and included patients who had an esophageal balloon placed.

Things to Remember

Medical providers tend to be hesitant to use/and increase PEEP

PEEP: Maintains Recruitment

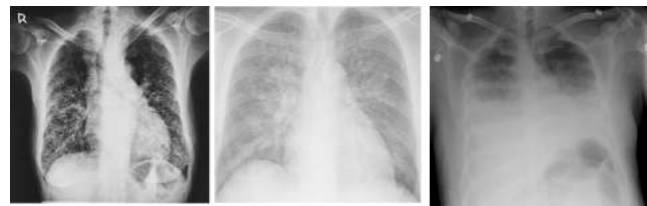
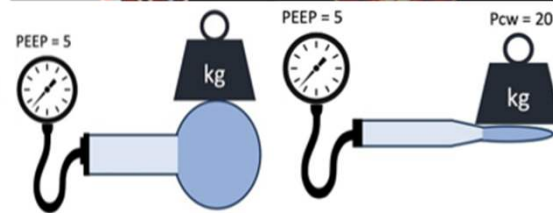
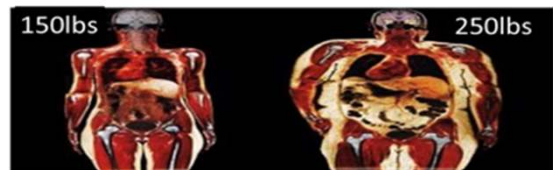
Right Ventricle Functions best when Lungs are at FRC

Overcomes excessive Pleural Pressure due to disease processes and Body Habitus

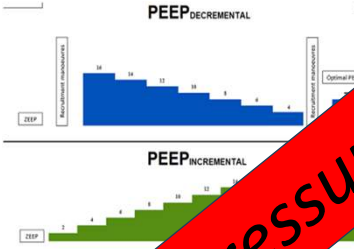
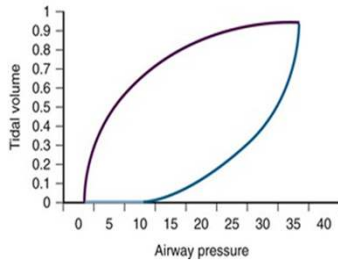
Many ways to set PEEP: All have their own Pros and Cons

Changes are Dynamic and never Static

At times high airway pressures to not transmit to the Alveoli



Summary: Extrinsic Factors = Global Pressures



Lower PEEP/higher FIO ₂									
FIO ₂	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.7	
PEEP	5	5	8	8	10	10	10	12	

FIO ₂	0.7	0.8	0.9	0.9	0.9	1.0			
PEEP	14	14	14	16	18	18-24			

Higher PEEP/lower FIO ₂									
FIO ₂	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5	
PEEP	5	8	10	12	14	14	16	16	

FIO ₂	0.5	0.5-0.8	0.8	0.9	1.0	1.0			
PEEP	18	20	22	22	22	24			



Pleural Pressure