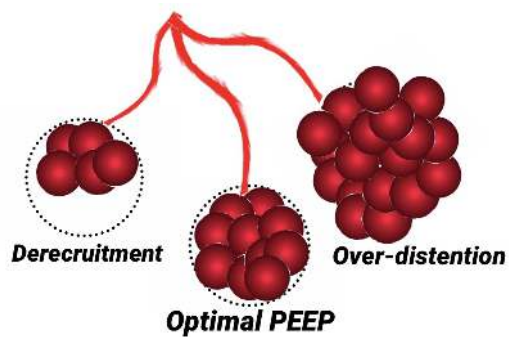


Are we ventilating to FRC

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



Disclosures

No Disclosures to Report

Objectives

1. Obtaining Optimal PEEP

Many techniques: The focus should be on which one is best for your patient.
No one way has been proven to be best

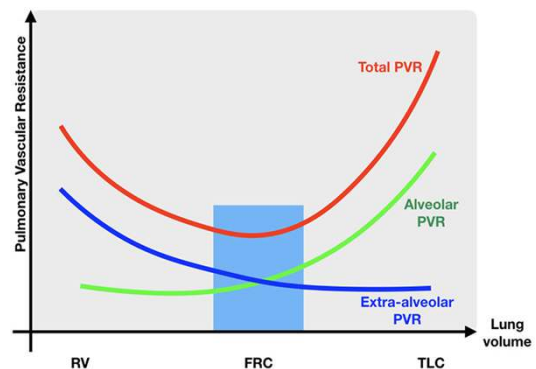
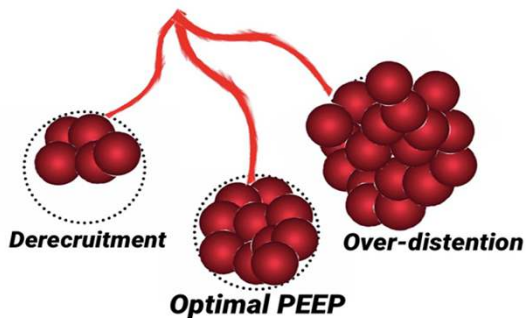
2. Optimizing Pulmonary Blood Flow

Maintain Forward Flow to ensure appropriate VQ Matching

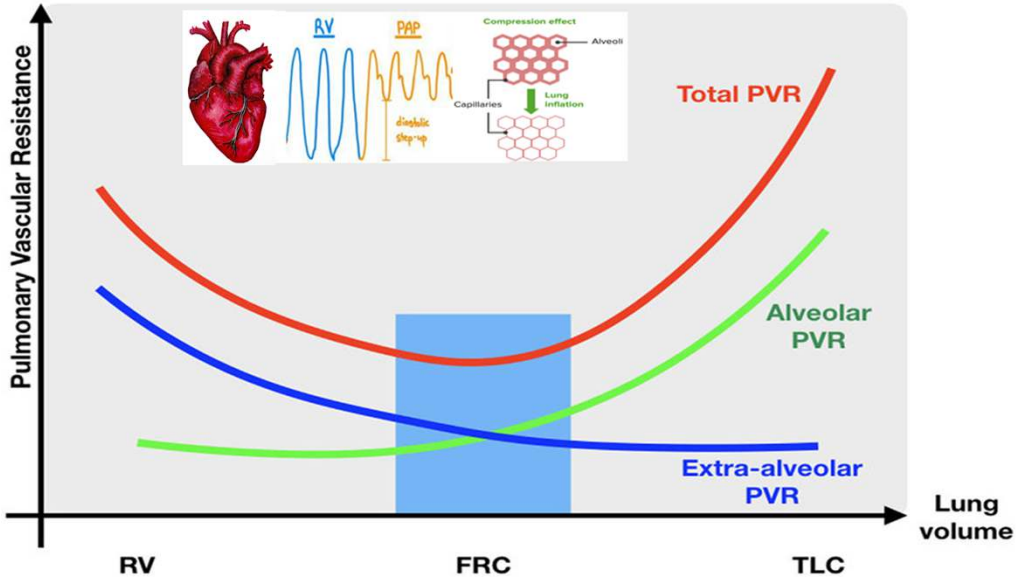
What is PEEP? Positive End Expiratory Pressure

PEEP is the pressure maintained in the airways at end-expiration to prevent alveolar collapse, Improves Oxygenation and FRC by increasing the alveolar surface area, enhancing ventilation-perfusion (VQ) mismatch.

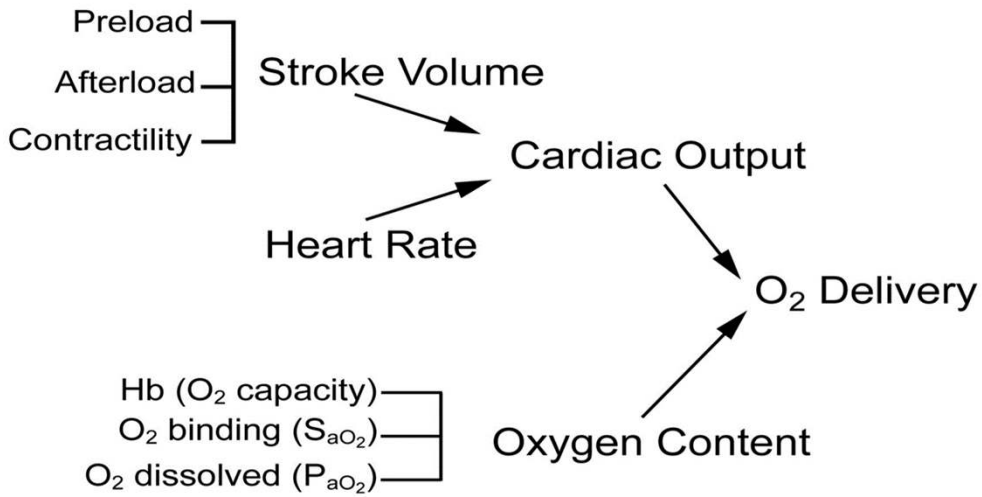
Optimal PEEP is essential to maintain forward pulmonary blood flow and Hemodynamics



FRC and the RV: Maintaining Forward Flow



The End Goal is always the DO₂: Can PEEP affect the DO₂?



What is Physiological PEEP?

Why is 5 or 0 cmH₂O PEEP considered physiological?
Is 5 cmH₂O PEEP for everyone?



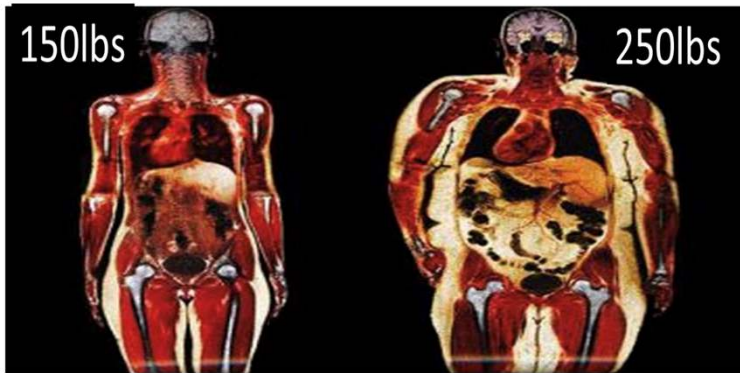
What is Optimal PEEP? Different for everyone

Patient A

PEEP 10
Plateau Pressure <30
Driving Pressure <15
High Recruitability

Patient B

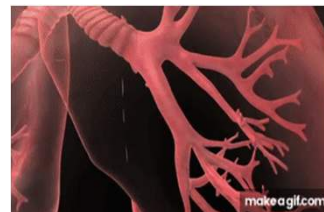
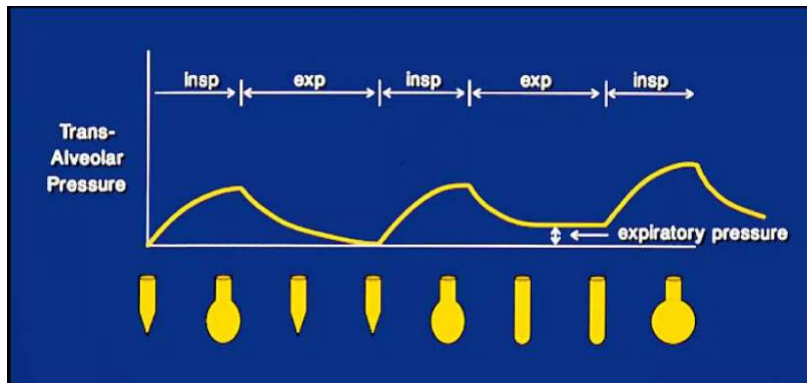
PEEP 10
Plateau Pressure >30
Driving Pressure >15
Low Recruitability



Does PEEP Recruit Alveoli?

Mean Airway Pressure

V_T	RR	T_i	PEEP
-------	----	-------	------



Keeping Airway Pressures Safe

Driving Pressure or Plateau Pressure



Plateau Pressure

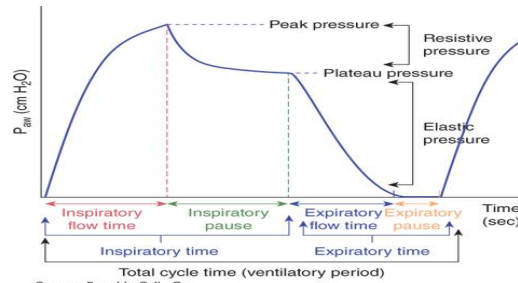


Static Measurement at the end of a full inspiration

Indicates The pressure within the alveoli
Used to trend alveolar compliance

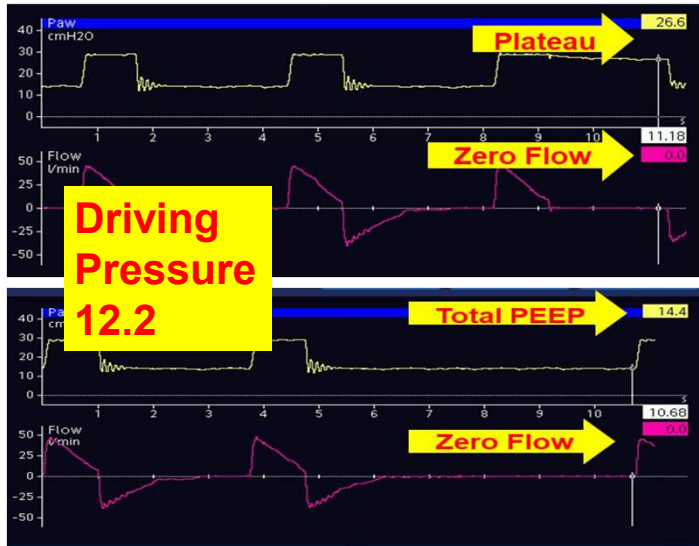
Goal is < 30cmH2O
High = Noncompliant lung

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



Total cycle time (ventilatory period)
Source: Ronaldo Collo Go
Critical Care Examination and Board Review.
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Driving Pressure

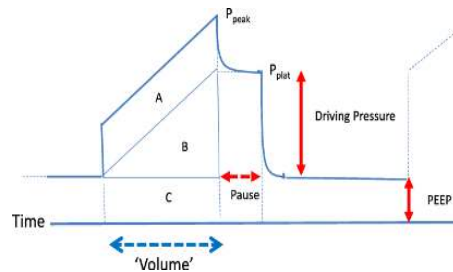


Shearing Force at the end of a full inspiration

Indicates ratio of Vt to CRS

Goal is < 15cmH2O
High = Noncompliant lung

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



What is Driving Pressure?

Passive → Driving Pressure = $P_{plat} - PEEP$

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 guided ventilation

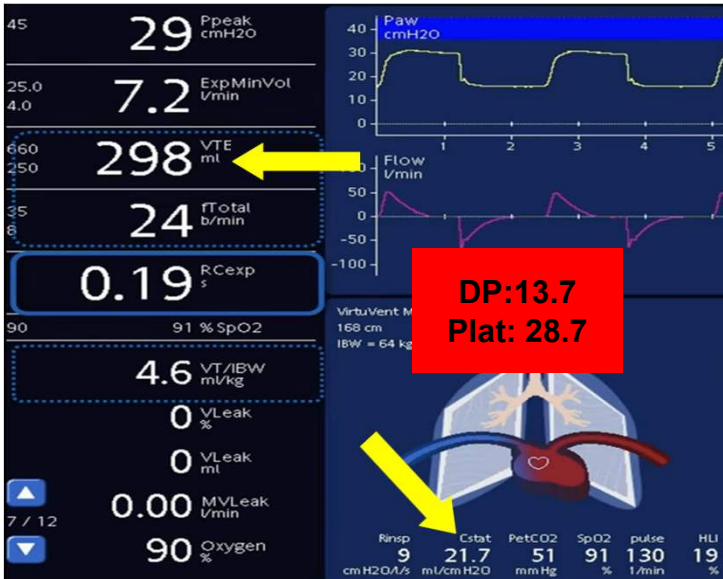
Hyun Joo Ahn,¹ MiHye Park,¹ Jie Ae Kim,¹ Mkyung Yang,¹ Susie Yoon,² Bo Rim Kim,² Jae-Hyon Bahk,² Young Jun Oh,³ and Eun-Ho Lee⁴

Driving pressure is $[P_{plat} - PEEP]$ and is the pressure required for the alveolar opening [17]. Static lung compliance (Cstat) is expressed as $[V_T / (P_{plat} - PEEP)]$. Thus, driving pressure is also expressed as $[V_T / C_{stat}]$. 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.

High driving pressure was also associated with increased mortality in patients receiving pressure support mode ventilation in a recent retrospective cohort study [24].

Passive/Active → Driving Pressure = $\frac{V_T}{C_{ST}}$

Driving Pressure and Estimating Plateau Pressure

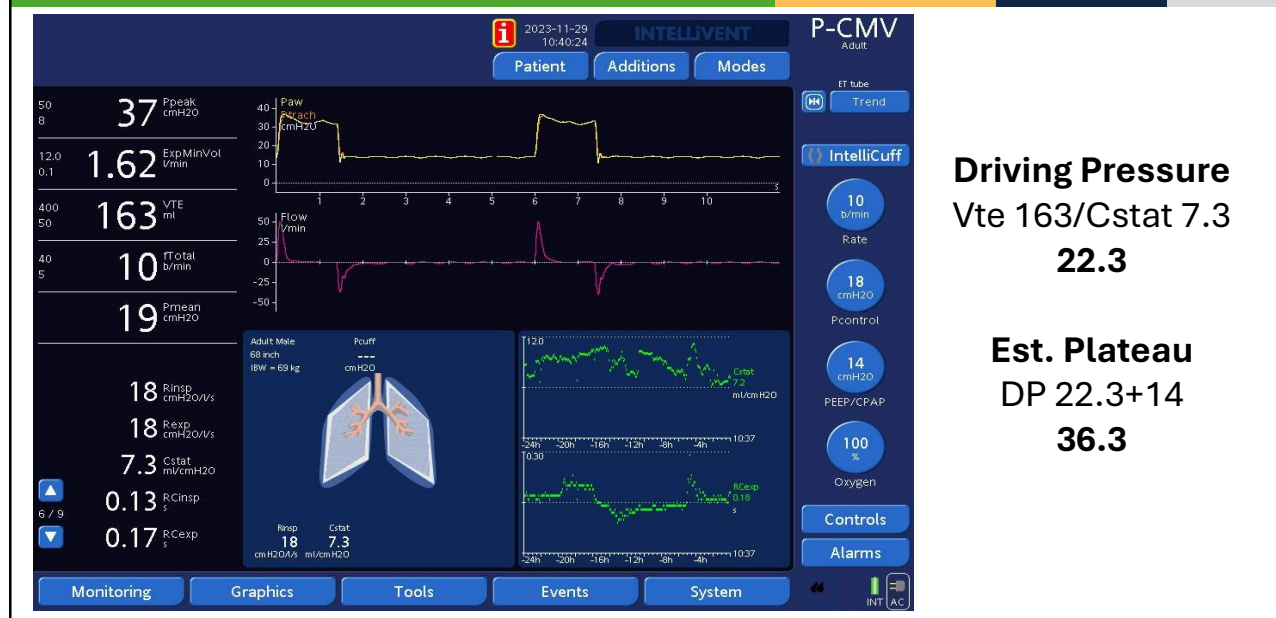


Vte 500ml
Cstat 50ml
 $500/50 = 10$ Driving Pressure
PEEP 5= Plateau 15cmH2O

Vte 300ml
Cstat 15ml
 $300/15 = 20$ Driving Pressure
PEEP 5 = Plateau 25cmH2O

Vte 800ml
Cstat 32ml
 $800/32 = 25$ Driving Pressure
PEEP 5 = Plateau 30cmH2O

Screen Assessment



Driving Pressure
Vte 163/Cstat 7.3
22.3

Est. Plateau
DP 22.3+14
36.3

Titrate PEEP or VT?

[Korean J Anesthesiol.](#) 2020 Jun; 73(3): 194–204.

Published online 2020 Feb 26. doi: [10.4097/kja.20041](https://doi.org/10.4097/kja.20041)

PMCID: PMC7280884

PMID: [32098009](https://pubmed.ncbi.nlm.nih.gov/32098009/)

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 Lee](#)⁴

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Usually, the reduction of VT would decrease driving pressure, but only until the point where reduction of VT does not bring alveolar collapse.

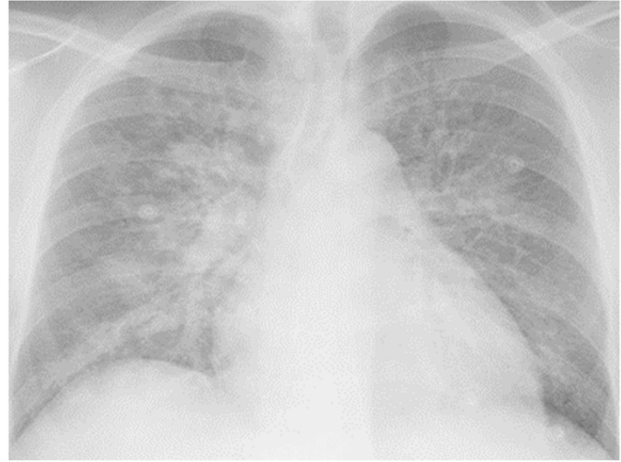
How much Functional Aerated Lung does your patient have?

The Importance of the CXR

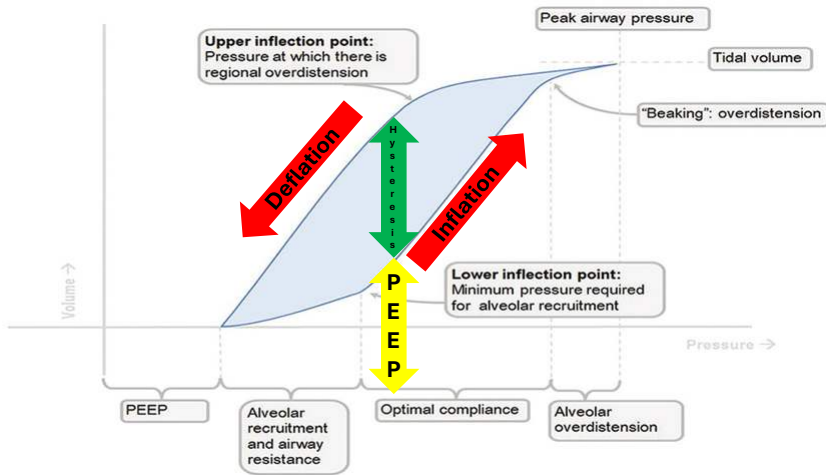
**Driving Pressure >15cmH2O
Decrease VT**



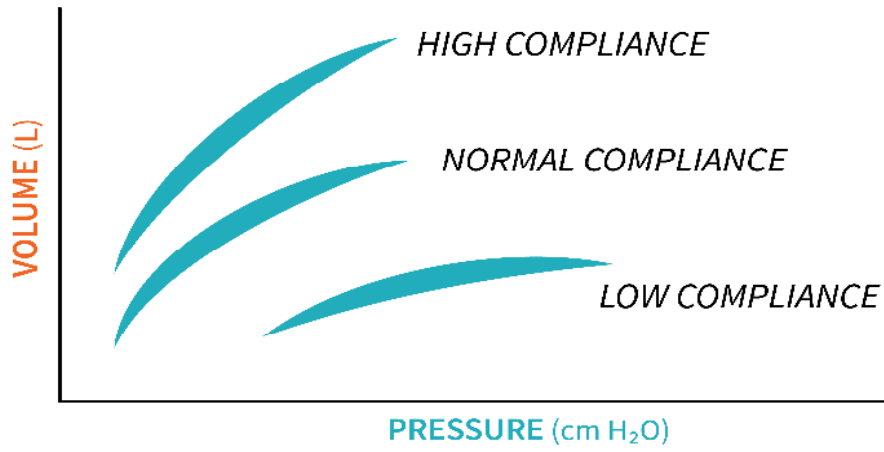
**Driving Pressure >15cmH2O
Increase PEEP**



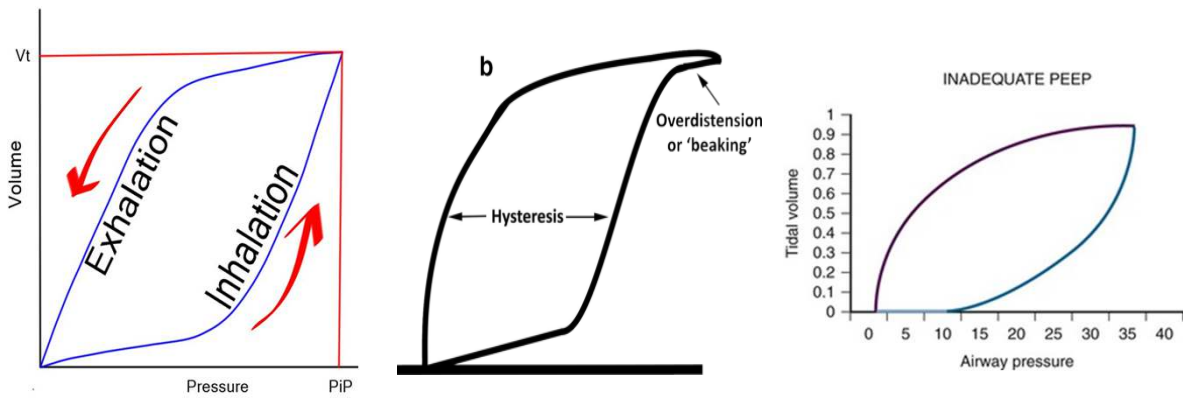
PV Loop Review



The Degrees of the PV Loop

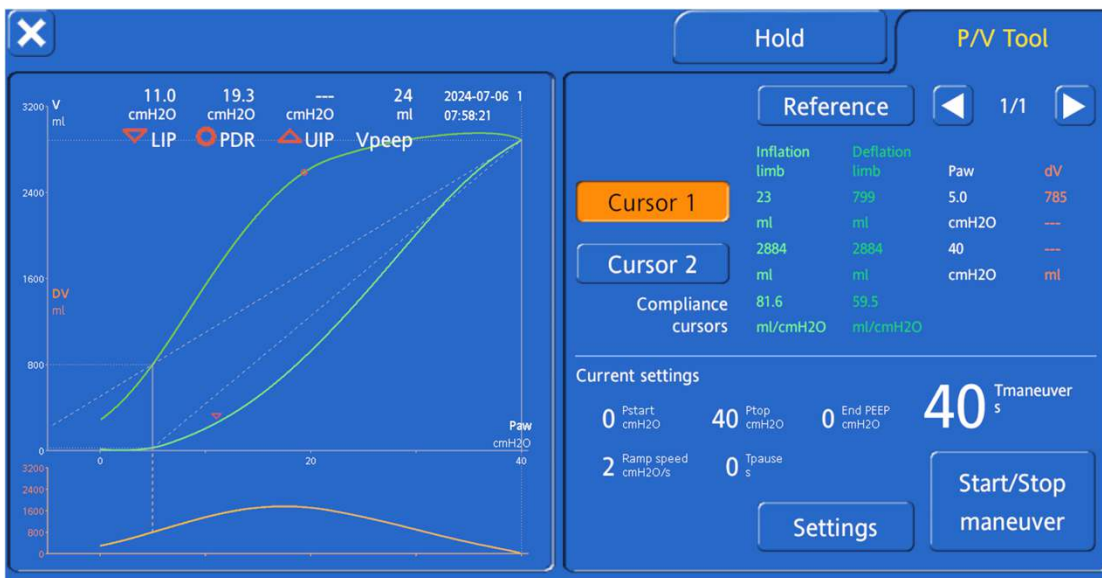


Optimizing VT/PEEP

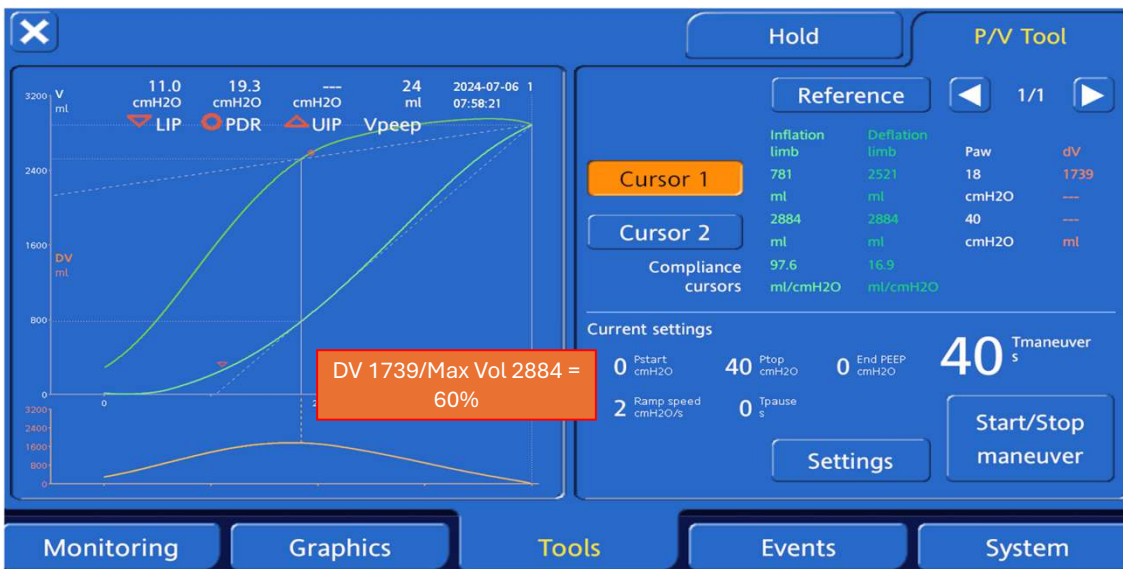


**Global pressures
Can be difficult to find inflection points
Guessing Optimal PEEP**

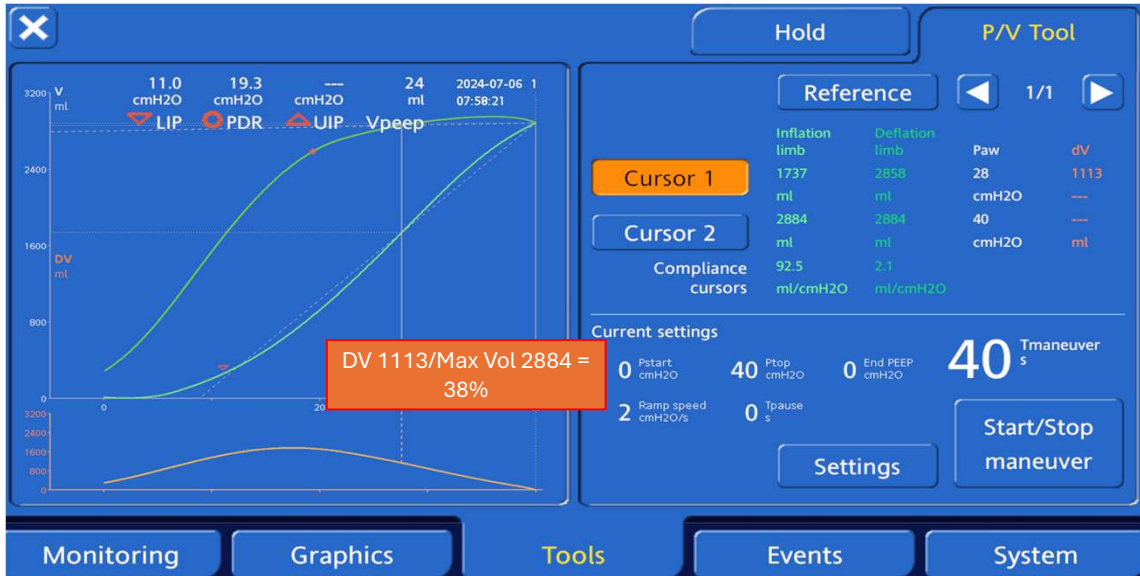
Recruitable PV Loop: Hysteresis and Optimal PEEP?



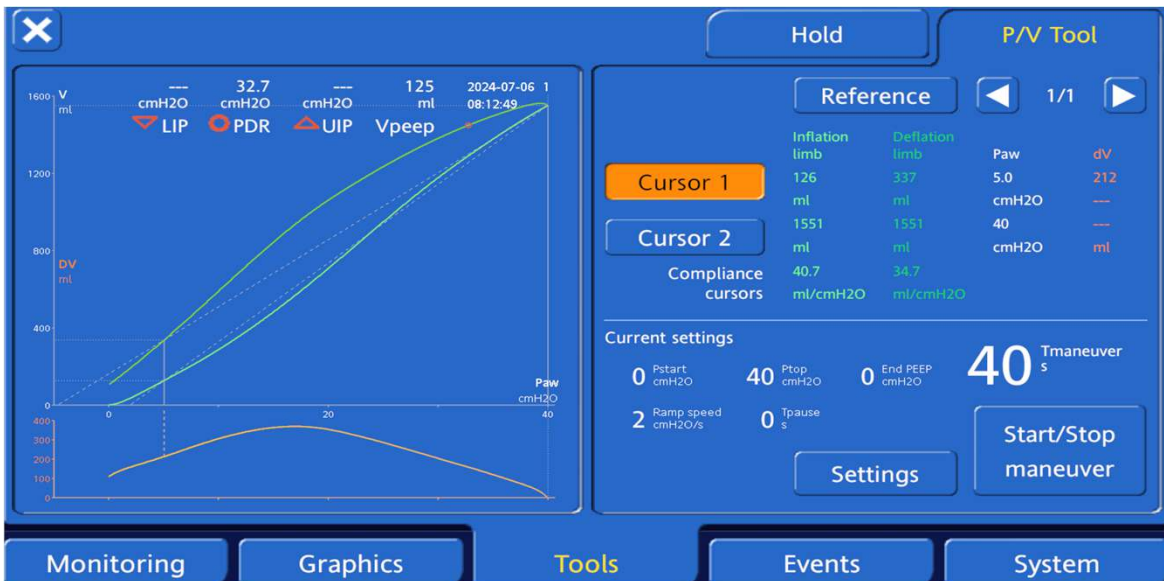
Recruitable PV Loop: Hysteresis and Optimal PEEP?



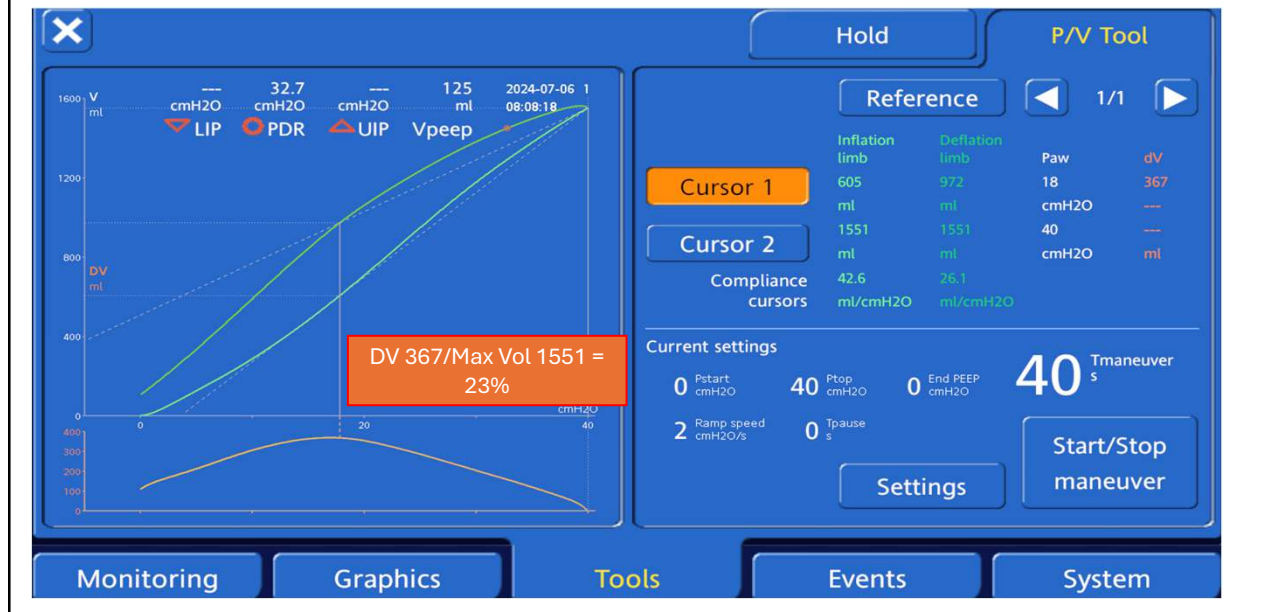
Recruitable PV Loop: Hysteresis and Optimal PEEP?



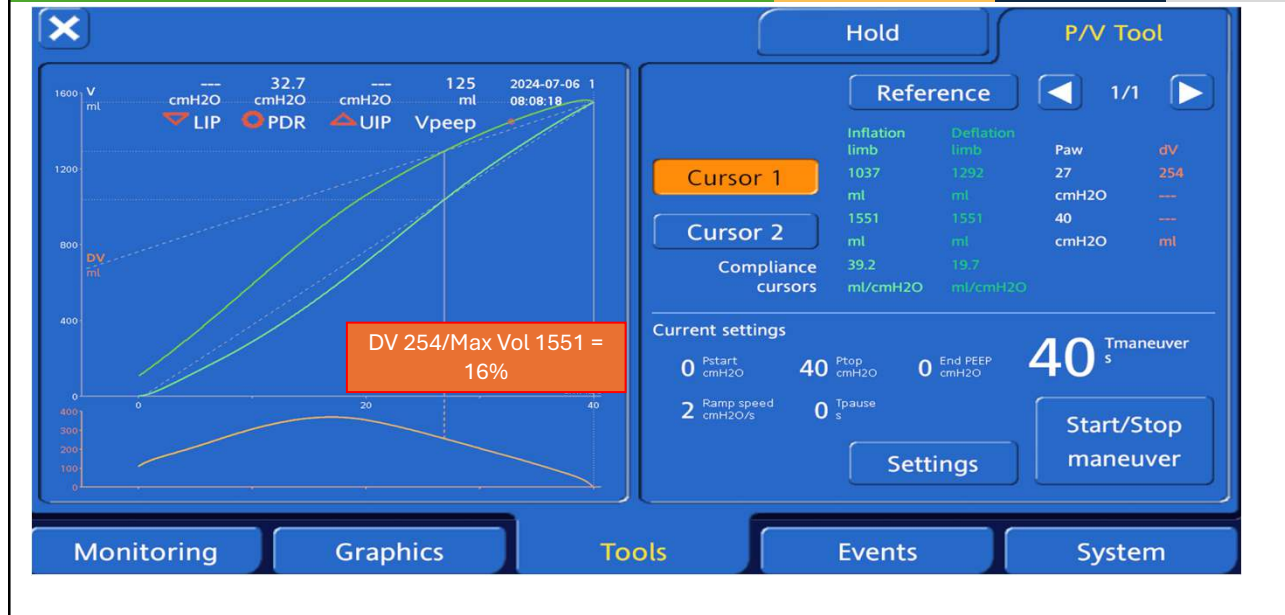
Non-Recruitable PV Loop: Hysteresis and Optimal PEEP?



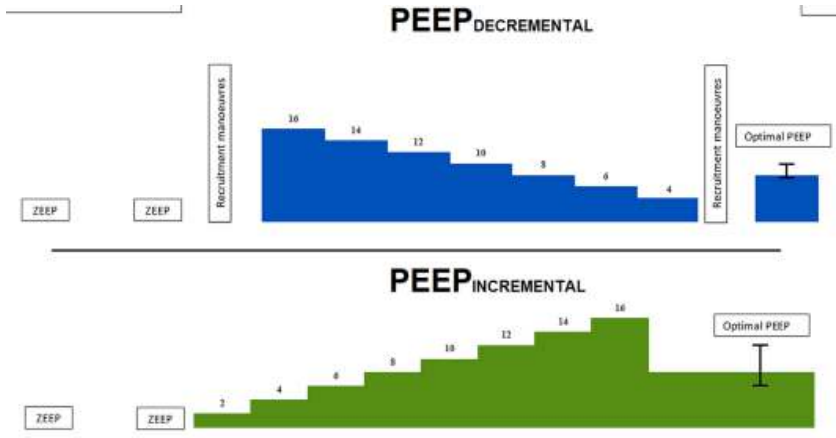
Non-Recruitable PV Loop: Hysteresis and Optimal PEEP?



Non-Recruitable PV Loop: Hysteresis and Optimal PEEP?



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

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

Lower PEEP/higher FiO2

FiO₂	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

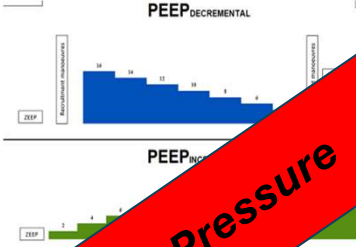
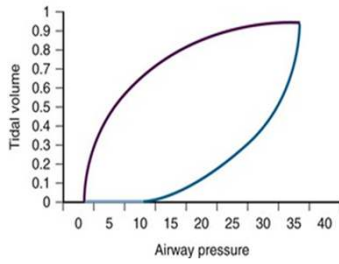
FiO₂	0.7	0.8	0.9	0.9	0.9	1.0
PEEP	14	14	14	16	18	18-24

Higher PEEP/lower FiO2

FiO₂	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

FiO₂	0.5	0.5-0.8	0.8	0.9	1.0	1.0
PEEP	18	20	22	22	22	24

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



Positioning Variability of Pleural Pressures

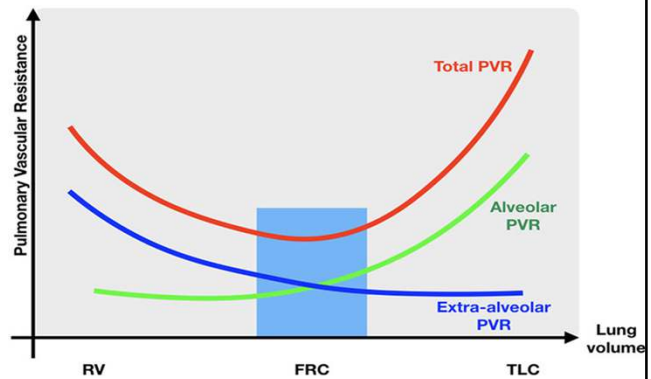
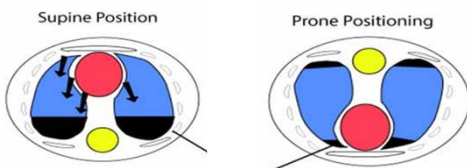
Weight of Mediastinum and Abdomen pressure

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



Partitioning the Respiratory System from Global Pressures

Effect of Esophageal Pressure-Guided Positive End-Expiratory Pressure on Survival from Acute Respiratory Distress Syndrome: A Risk-Based and Mechanistic Reanalysis of the EPVent-2 Trial

August 2021 American Journal of Respiratory and Critical Care Medicine 204(10)
 August 2021 204(10)
 DOI: 10.1164/ajrccm.202009-3559OC

J. Intensive Care Med. 2019 Sep; 34(9): 82012-82017
 doi: 10.1177/088506661987331

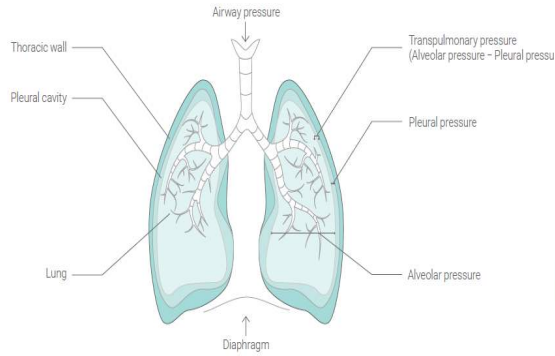
PMCID: PMC6826349
 PMID: 31652013

Positive-end expiratory pressure titration and transpulmonary pressure: the EPVENT 2 trial

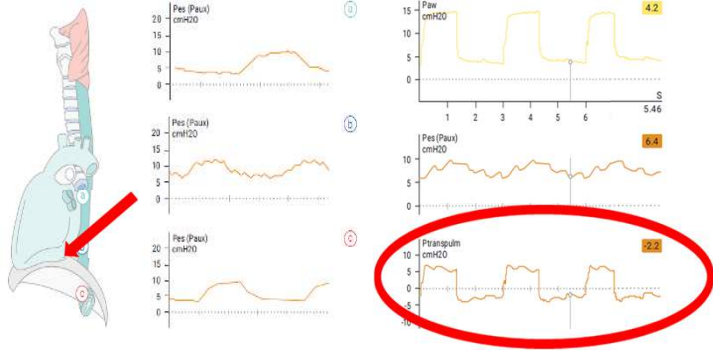
Elamake-Talib¹, Louis-Marie Galoppin^{2,3}, Nicolas Touss^{2,3}, Carole Schreiber^{2,3}, Laurent Ansaud^{1,4} and Claude Guerin^{1,4}

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Airway Pressures ≠ Functioning Lungs



Contractility of the heart is Variable Avoid Negative Pressure Swings



Esophageal Manometry: Transpulmonary Pressures

Inspiratory Hold



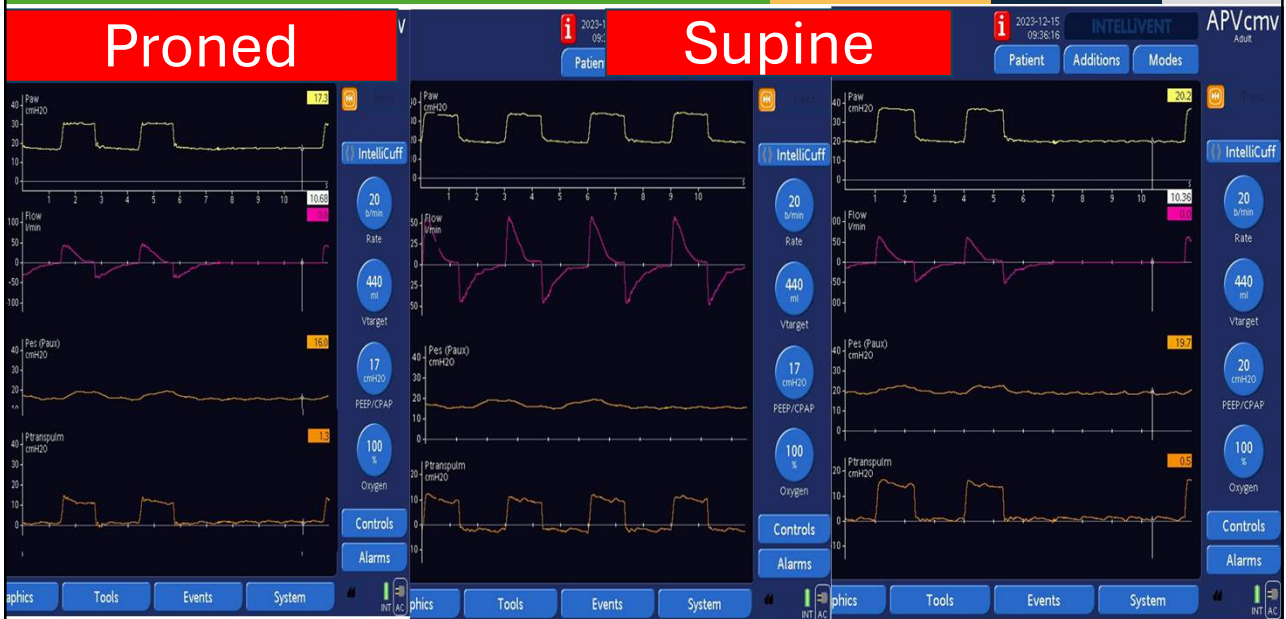
Expiratory Hold



Transpulmonary Pressure: Expiratory Hold



Transpulmonary Pressure: Prone to Supine



Summary

No one way is better than another

They all have Pros and Cons

Optimal PEEP is based on the patient's presenting condition/Habitus

Use the method you know and what is safe for your patient

