PEEP: Can We Reach Consensus?

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PEEP: Can We Reach Consensus?

Objectives: participant will be able to

1. name two key people in the history of PEEP
2. list at least 6 independent variables while using PEEP
3. list at least 6 dependent variables while using PEEP
4. explain why optimization of PEEP remains unclear
5. describe the Cochrane Library

What do we think we know?

On-line search “Positive End-Expiratory Pressure:

results in about 9,900,000 results (0.46 secs)

(This presentation is about PEEP with regard primarily to ARDS)

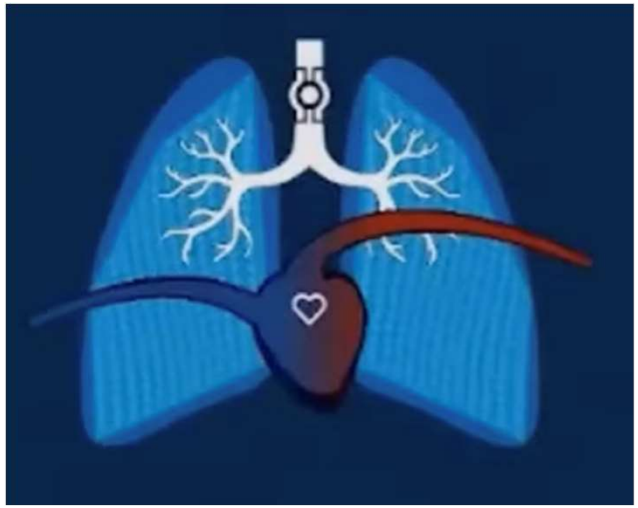
Cochrane Library Reviews: 67 reviews

cochranelibrary.com

Variables Involved with PEEP: Here is the problem…….

Independent Variables

PEEP level
Peak Inspiratory Pressure
F_IO_2
Tidal volume
Inspiratory flowrate
Inspiratory time
Expiratory Time
Respiratory Rate
Mode of Ventilation
Hemoglobin?
Level of Sedation
PEEP valve resistance
Body position



Dependent Variables

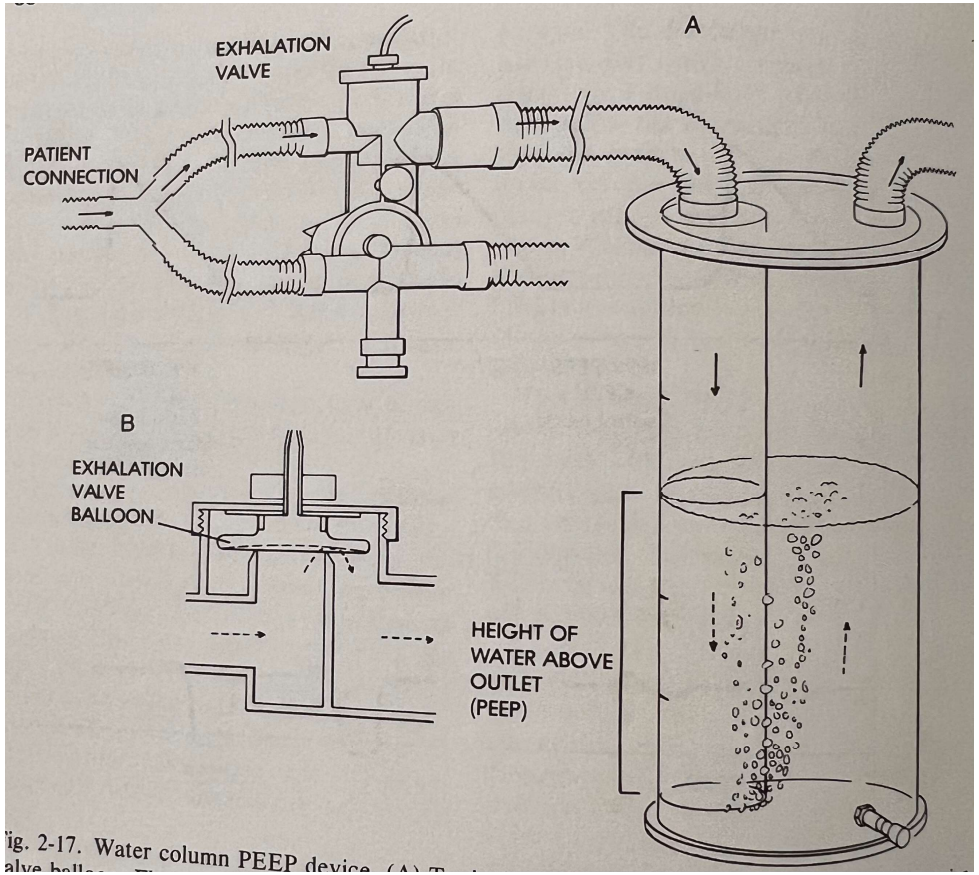
R to L intrapulmonary shunt
Lung/Thoracic Compliance
Expiratory resistance
Static compliance
P/F Ratio
SpO_2
PaO_2
SaO_2
S_VO_2/P_VO_2 (mixed venous)
Pulmonary Artery Pressure
Mean Airway Prressure
Blood Pressure
Auto-PEEP
Transpulmonary Pressure
Deadspace Ventilation
Intra Cranial Pressure
Lung Barotrauma
Ventilator Length of Stay
Survival

Let’s look at one independent variable we seldom think about :

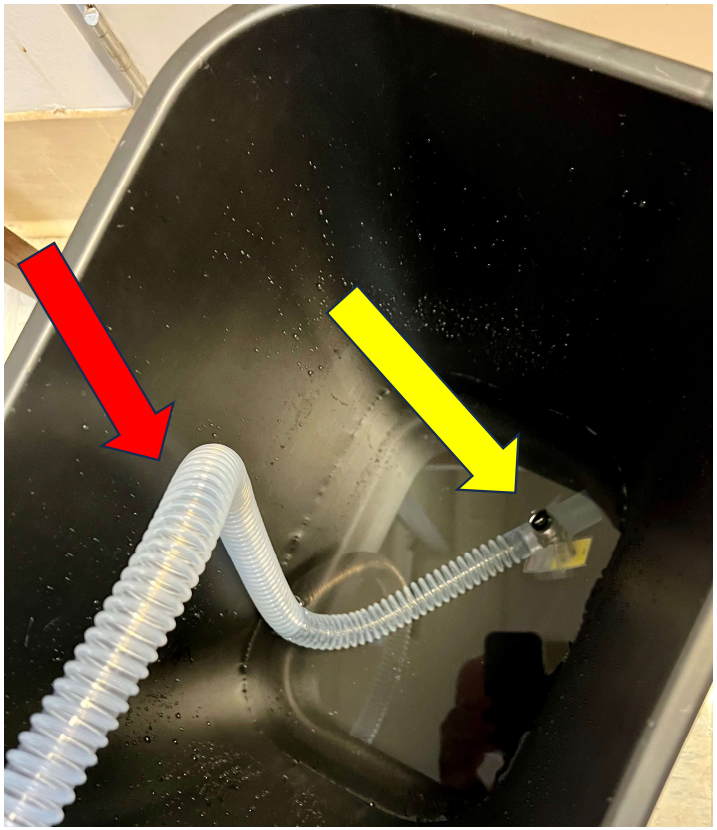
the ventilator’s PEEP valve resistance

Early PEEP Generating Devices

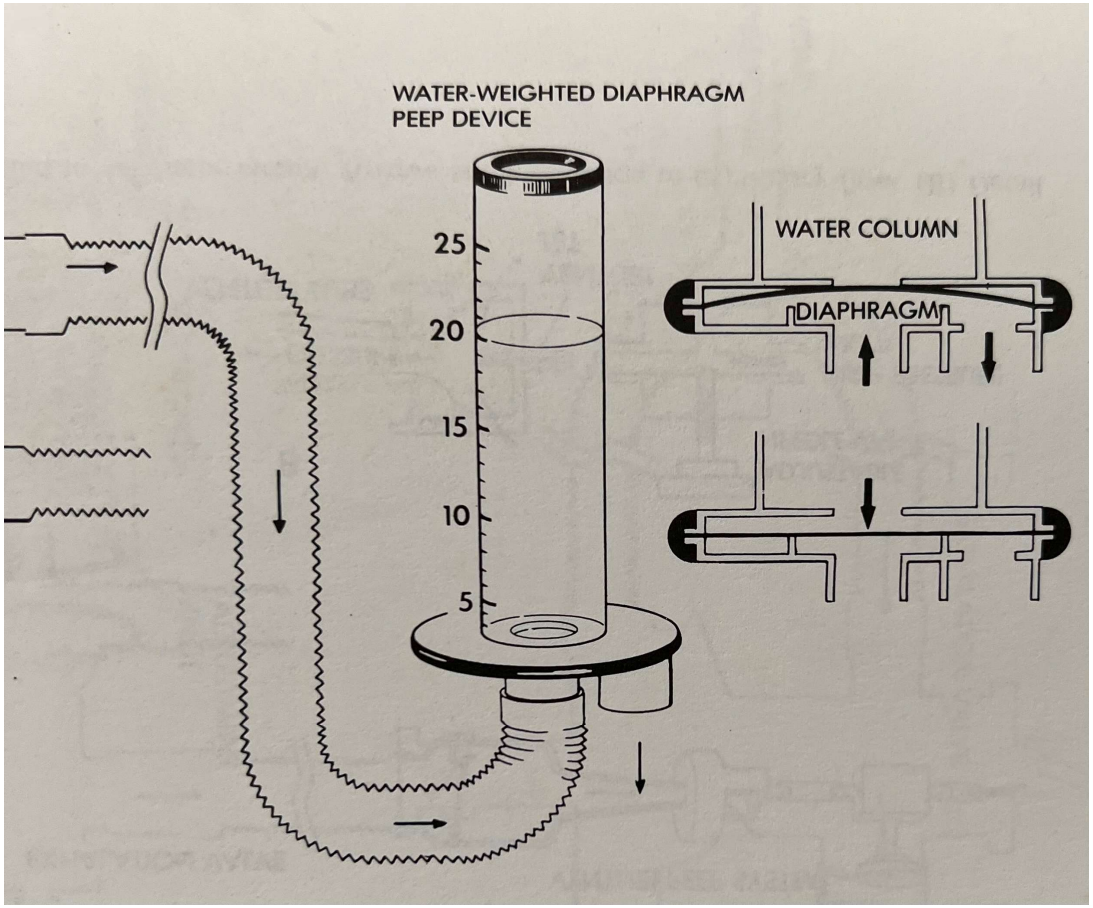
Underwater PEEP



ig. 2-17. Water column PEEP device.



PEEP Generating Devices



Water Column PEEP

PEEP Generating Devices

Large surface area
PEEP valve
Lower Resistance

Marini JJ, Culver BH, Kirk W; **Flow Resistance of Exhalation Valves and Positive End-Expiratory Pressure Devices Used in Mechanical Ventilation;** American Review of Respiratory Disease, Volume 131, 6, 1985

PEEP Generating Devices

Spring Generated PEEP
Higher Resistance

Marini JJ, Culver BH, Kirk W; **Flow Resistance of Exhalation Valves and Positive End-Expiratory Pressure Devices Used in Mechanical Ventilation;** American Review of Respiratory Disease, Volume 131, 6, 1985

PEEP Generating Devices

?

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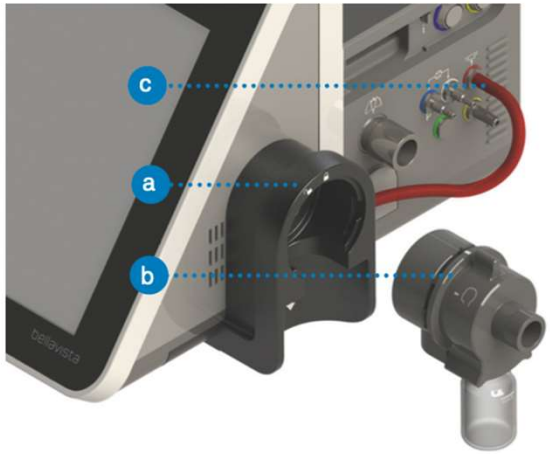


Marini JJ, Culver BH, Kirk W; **Flow Resistance of Exhalation Valves and Positive End-Expiratory Pressure Devices Used in Mechanical Ventilation;** American Review of Respiratory Disease, Volume 131, 6, 1985

An Official American Thoracic Society/European Society of Intensive Care Medicine/Society of Critical Care Medicine Clinical Practice Guideline: Mechanical Ventilation in Adult Patients with Acute Respiratory Distress Syndrome. Eddy Fan, Lorenzo Del Sorbo, Ewan C. Goligher, Carol L. Hodgson, Laveena Munshi, Allan J. Walkey, Neill K. J. Adhikari, Marcelo B. P. Amato, Richard Branson, Roy G. Brower, Niall D. Ferguson, et al. 2017

SBT

Summary of the evidence

Higher versus lower PEEP strategies were evaluated in eight RCTs, including 2,728 patients (21, 22, 59–64). Mean ± SD PEEP was 15.1 ± 3.6 versus 9.1 ± 2.7 cm H_2O in the higher and lower PEEP groups on Day 1, respectively. Our primary analysis excluded two trials that did not use LTV in the lower PEEP control groups (21, 22). There was no significant difference in mortality for patients receiving higher versus lower PEEP (six studies, 2,580 patients; RR, 0.91; 95% CI, 0.80–1.03; moderate confidence) (59–64). Higher PEEP strategies were not associated with significant differences in barotrauma, new organ failure, or VFDs as compared with a lower PEEP strategy (moderate confidence). Oxygenation (Pa_{O2}/Fi_{O2} ratio) was significantly higher in patients randomized to higher PEEP (61 mm Hg higher; 95% CI, 46–77 mm Hg). However, for our recommendation, we also considered evidence from an IPDMA of three large RCTs of higher versus lower PEEP (65). In this study, patients with moderate or severe ARDS ($Pa_{O2}/Fi_{O2} \leq 200$) randomized to higher PEEP had significantly lower mortality (adjusted RR, 0.90; 95% CI, 0.81–1.00), with no significant effect among patients with mild ARDS (adjusted RR, 1.29; 95% CI, 0.91–1.83; $P = 0.02$ for comparison with moderate/severe ARDS subgroup).

Recommendation

We suggest that adult patients with moderate or severe ARDS receive higher rather than lower levels of PEEP (conditional recommendation, moderate confidence in effect estimates)

PEEP Recommendation- ATS, ESIC, SCCM - 2017

We suggest that adult patients with moderate or severe ARDS receive higher rather than lower levels of PEEP (conditional recommendation, moderate confidence in effect estimates).

In patients with ARDS (n=1892), there were 324 hospital deaths (34.1%) in the higher PEEP group and 368 (39.1%) in the lower PEEP group (adjusted RR, 0.90; 95% CI, 0.81-1.00; *P* = .049)

Metanalysis of
Data from 2299 individual patients in 3 trials

Briel M, Meade M, Mercat A, Brower RG, Talmor D, Walter SD, Slutsky AS, Pullenayegum E, Zhou Q, Cook D, *et al*. Higher vs lower positive end-expiratory pressure in patients with acute lung injury and acute respiratory distress syndrome: systematic review and meta-analysis. *JAMA*2010;303:865–873.

What do we think we know?

Physiologic PEEP (all vent patients get 5 PEEP)

Tobin MJ, Extubation and the Myth of "Minimal Ventilator Settings"
American Journal of Respiratory and Critical Medicine, Vol 85,Is 4, Feb 2012

Early PEEP (start PEEP before the ARDS gets worse)

Pepe PE, Hudson LD,Carrico CJ, Early application of positive end-expiratory pressure in patients at risk for the ARDS. NEngl J Med 1984 Aug 2;311(5):281-6.

"early application of PEEP at 8 cmH_2O in high-risk patients had no effect on the incidence of the ARDS or other, associated complications."

Don't interrupt PEEP, (especially at higher levels)

An even larger ventilator patient management question:

What do we <u>really</u> know about mechanical ventilation?

"SBT and our real knowledge of mechanical ventilation"

Spontaneous Breathing Trial is the consensus best method of ventilator discontinuation.

"As long as SBT is the best way for us to know if a patient is ready to come off the ventilator, I think we have to admit that we really don't know what we are doing" Ron Sanderson

Brief PEEP HISTORY

CPPB - Barach - 1938

Barach AL, Martin J, Eckman M. Positive pressure respiration and its application to the treatment of acute pulmonary edema. Ann Intern Med 1938;12:754-95.

PEEP - Ashbaugh and Petty -1967

Ashbaugh DG, Bigelow DB, Petty TL, Levine BE.
Acute respiratory distress in adults. *Lancet* 1967;2:319–323

12 patients, “PEEP appeared to have value for ARDS”

Brief History of PEEP

CPAP - Gregory - 1971

Gregory G.A., Kitterman J.A., Phibbs R.H., Tooley W.H., Hamilton W.K. Treatment of the idiopathic respiratory-distress syndrome with continuous positive airway pressure. *N Engl J Med* 1971; 284: 1333–40

High PEEP - John B. Downs -1977

Douglas ME, Downs JB, Pulmonary Function Following Severe Acute Respiratory Failure and High Levels of Positive End-Expiratory Pressure Chest 71:18-23, 1977 80% survival, 43/54 (20% mortality) 25 to 55 cmH_2O PEEP.

Kirby RR, Downs JB, Civetta JM, Modell JH, Dannemiller, FJ, Klein EF, Hodges M,
High level positive end expiratory pressure (PEEP) in acute respiratory insufficiency
Chest 1975 Feb;67(2):156-63.

Brief History of PEEP

Auto–PEEP, Intrinsic–PEEP, Occult PEEP, Inadvertent PEEP "Air Trapping" – Marini JJ and Pepe PE -1982

I think we agree that when detected auto-PEEP should be eliminated by various means of reducing expiratory airway resistance or increasing expiratory time.

The key here is if the ventilator does not measure and report Auto-PEEP, we must be alert and aware of Auto-PEEP. Also, ventilators are not yet perfect at detecting Auto-PEEP. The flow/time curve in ventilator graphics has helped a great deal.

Pepe PE, Marini JJ, Occult positive end-expiratory pressure in mechanically ventilated patients with airflow obstruction: the auto-PEEP effect. Am Rev Respir Dis 1982;**126**(1):166–170.

Brief PEEP HISTORY

PEEP Effects by CT scan – Gattinoni et al - 1988

Gattinoni L, Presenti A, Bombino M, Baglioni S, Rivolta F, Rossi G, Gumagalli R, Marcolin R, Mascheroni R, et al
Relationships between lung computed tomographic density, gas exchange, and PEEP in acute respiratory failure,
Anesthesiology 1988 Dec;69(6):824-32.

(5,10,15 cmH_2O PEEP) increasing expansion and recruitment) (need >45 cmH_2O PEEP)
"open lung strategy are not satisfied using PEEP up to 15 cmH_2O and plateau pressure up to 30 cmH_2O.
For an effective open lung strategy, higher pressures are required."

Gattinoni L, Pelosi P, Crotti S, Valenze F. Effects of positive end-expiratory pressure on regional distribution of tidal volume and recruitment in adult respiratory distress syndrome. Am J Respir Crit Care Med 1995;151:1807-1814

APRV - John B. Downs -1988

Garner W, Downs JB, Stock MC, Rasanen J, Airway Pressure Relief Ventilation (APRV) A Human Trial
Chest 94:779-781, 1988

Brief PEEP HISTORY

Open lung concept – Lachmann B, Sjostrand, Amato ….. – 1992-3

Lachmann, B. Open up the lung and keep the lung open. *Intensive Care Med* **18**, 319–321 (1992)

Brief PEEP HISTORY

ARDS Clinical Network - 2000

The Acute Respiratory Distress Syndrome Network. Ventilation with lower tidal volumes as compared with traditional tidal volumes for acute lung injury and the acute respiratory distress syndrome. N Engl J Med, 2000;342:1301-1308

Found advantage to low tidal volumes using Assist-Control mode ventilation

Brief PEEP HISTORY

NIH NHLBI ARDS Clinical Network
Mechanical Ventilation Protocol Summary

OXYGENATION GOAL: PaO_2 55-80 mmHg or SpO_2 88-95%

Use a minimum PEEP of 5 cm H_2O. Consider use of incremental FiO_2/PEEP combinations such as shown below (not required) to achieve goal.

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

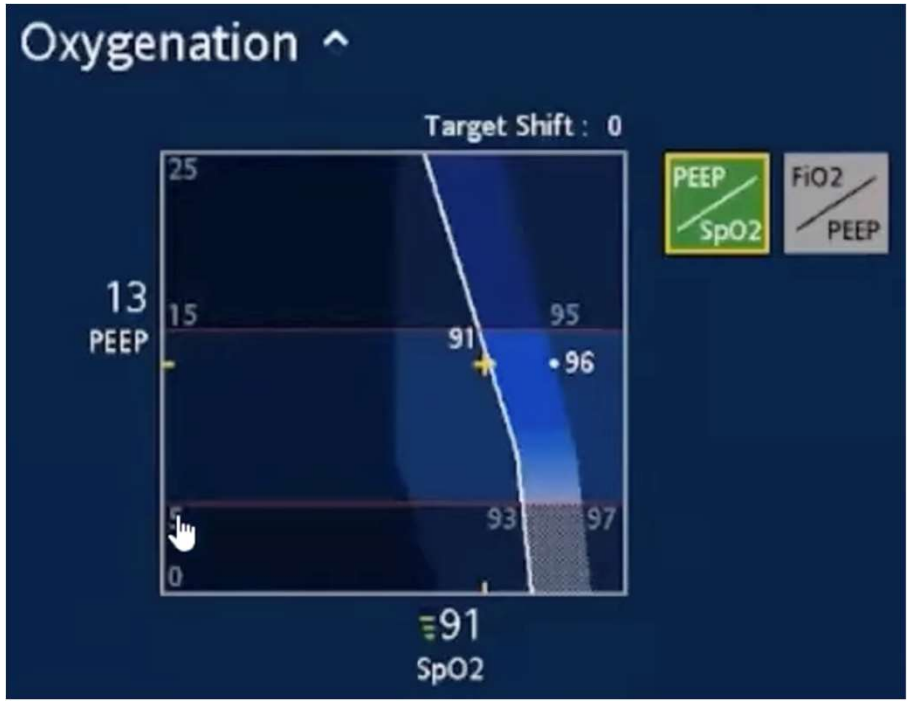
FiO_2	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5
PEEP	5	8	10	12	14	14	16	16

FiO_2	0.5	0.5-0.8	0.8	0.9	1.0	1.0
PEEP	18	20	22	22	22	24

The National Heart, Lung, and Blood Institute ARDS Clinical Trials Network. Higher versus lower positive end-expiratory pressures in patients with the acute respiratory distress syndrome. N Engl J Med2004;351:327-336

Automate PEEP/F_IO_2 titration

Available only on
Hamilton Medical ventilators?



Beyond the ARDSNet Protocol……this is where those who know and understand, perform; and those who don't fail.

What happens at a ventilator rate of 40/min. and PIP of 60 when the P_aCO_2 is 60 Torr.?
"PERMISSIVE HYPERCAPNIA"

What happens on 25 cmH_2O PEEP and 100% oxygen when the PaO_2 is 40 Torr. and the S_PO_2 is 75%?
PERMISSIVE HYPOXIA/ANOXIA?????

Palliative care???

OPTIMAL PEEP - 1970 - 2023

There are a number of methods suggested to determine the optimum PEEP setting,
all of which have pros and cons:

- adjust using a sliding scale of F_IO_2 requirements (e.g. ARDSNet Ventilation Strategy)
- perform recruitment maneuver/s (e.g. Open Lung Approach).
- set PEEP according to pressure-volume loop analysis
- adjust PEEP to maximize static compliance (Cstat)
- adjust PEEP to optimize driving pressure
- adjust PEEP to minimize P_aCO_2-$ETCO_2$ gradient (dead space)
- guided by pulmonary computed tomography (CT)
- adjust PEEP to lowest intra-pulmonary shunt (Q_S/Q_T)
- esophageal balloon directed estimation of pleural pressures to calculate transpleural pressure
- guided by use of Electrical Impedance Tomography (EIT)
- let the automated ventilator titrate the PEEP with clinician guidance

Conclusion:

DO:

Understand as much as possible about pulmonary physiology and mechanics

Measure and calculate QS/QT and deadspace ventilation

Measure and think about the patient's L/T compliance and Expiratory Resistance

Implement ventilator management quality control projects, LOS if nothing else.

Conclusion:

DO:

If you have enough resources purchase excellent ventilators & use advanced features

Consider using APRV as a preferred mode of ventilation

Stand next to the bed, critically think, and focus on the ventilator/patient interface.

Use automation wisely and whenever possible

If not ..... ARDSNet Protocol or buy automated ventilators


PEEP: Can We Reach Consensus?
Not Yet……


Questions?