Should Every Patient Receive 6 ml/kg? What Evidence Supports Low Tidal Volume

Aaron Light DHSc, RRT-ACCS
Program Director
Ozarks Technical Community College

We all know where this came from

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*

ARDSnet 6ml/kg Trial

- The experimental group (6 ml/kg) demonstrated a 31% mortality versus a 40% in 12 ml/kg group
- Breathing without assistance after 28 days was higher (65.7%) versus (55%)
- Number of days without failure of nonpulmonary organs was higher (15) versus (11)

- The Acute Respiratory Distress Syndrome Network. (2000). Ventilation with lower tidal volumes as compared with traditional tidal volumes for acute lung injury and the acute respiratory distress syndrome. *New England Journal of Medicine, 342*(18), 1301-1308.

Demographics of the study

	Low VT	Traditional VT
Age (yr)	51 ± 17	52 ± 18
Female (%)	40	41
Race		
White	75	71
Black	16	19
Hispanic	5	7
Other or unknown	4	3
APACHE III score	81 ± 28	84 ± 28
PaO2/FiO2	138 ± 64	134 ± 58

The Acute Respiratory Distress Syndrome Network. (2000). Ventilation with lower tidal volumes as compared with traditional tidal volumes for acute lung injury and the acute respiratory distress syndrome. *New England Journal of Medicine*, *342*(18), 1301-1308.

Demographics of the study

	Low VT	Traditional VT
Minute Volumes	13.4 ± 4.3	12.7 ± 4.3
Lung Injury (%)		
Pneumonia	33	36
Sepsis	27	26
Aspiration	15	14
Trauma	13	9
Other Causes	10	11
Multiple transfusions	2	3

The Acute Respiratory Distress Syndrome Network. (2000). Ventilation with lower tidal volumes as compared with traditional tidal volumes for acute lung injury and the acute respiratory distress syndrome. *New England Journal of Medicine*, *342*(18), 1301-1308.

Patients were excluded if:

- they were younger than 18 years of age
- they had participated in other trials within 30 days before the first three criteria were met
- they were pregnant
- they had increased intracranial pressure, neuromuscular disease, sickle cell disease, or severe chronic respiratory disease

Patients were excluded if:

- they weighed more than 1 kg per centimeter of height
- they had burns over more than 30 percent of their body-surface area
- they had other conditions with an estimated 6-month mortality rate of more than 50 percent
- they had undergone bone marrow or lung transplantation
- they had chronic liver disease


YOU GET 6 ML/KG
EVERYONE GETS 6 ML/KG
makeameme.org

however …

Was 12 ml/Kg Traditional?

- Study found that 24 hospitals and 74 medical and surgical ICU's of the ARDS Network between 1996-1999 used an:

average VT of 10.3 ml/kg

Thompson et al. 2001. Chest

So was 6ml/kg good or was 12/ml kg bad?

- Stewart et al. 1998 – Vt's of 7.2ml/kg vs 10.8 ml/kg. PIP's were 23.6 cmH2O vs 34 cmH2O (all means of Vt and PIP's)
  - Mortality 30% vs 28% pvalue of 0.72
- Brochard et al. 1998 – Vt's of 7.2 ml/kg vs 10.6 ml/kg. Ppl were 25 cmh2O vs 32 cmH2O
  - we found that a deliberate reduction in tidal volume to achieve an end-inspiratory plateau pressure around 25 cm H2O **did not appear to have a significant impact on morbidity and mortality,** as compared with a more conventional ventilatory strategy where normocapnia was achieved with tidal volumes in the range of 10 to 11 ml/kg and plateau pressures already below 35 cm H2O.

So was 6ml/kg good or was 12/ml kg bad?

- Brower et al. 1999 – 7.3 ml/kg vs 10.2 ml/kg. Ppl were 24.9 cmH2O vs 30.6.
  - Similar PEEP table as ARDSnet
  - No encouraging trends with small tidal volumes in the proportion of patients who achieved reversal of respiratory failure (RRF), time to RRF, or mortality before hospital discharge

- Amato et al. 1998 – 6ml/kg vs 12 ml/kg.
  - They used drastically different PEEPs', 16 cmH2O on the low VT group and 9 cmH2O in the high Vt group. Ppl's were 30 cmH2O vs 37 cmH2O. This one did show a difference in outcomes. But I ask, was the lung protective arm of the study good or was the "conventional" arm bad?

Original Investigation | CARING FOR THE CRITICALLY ILL PATIENT

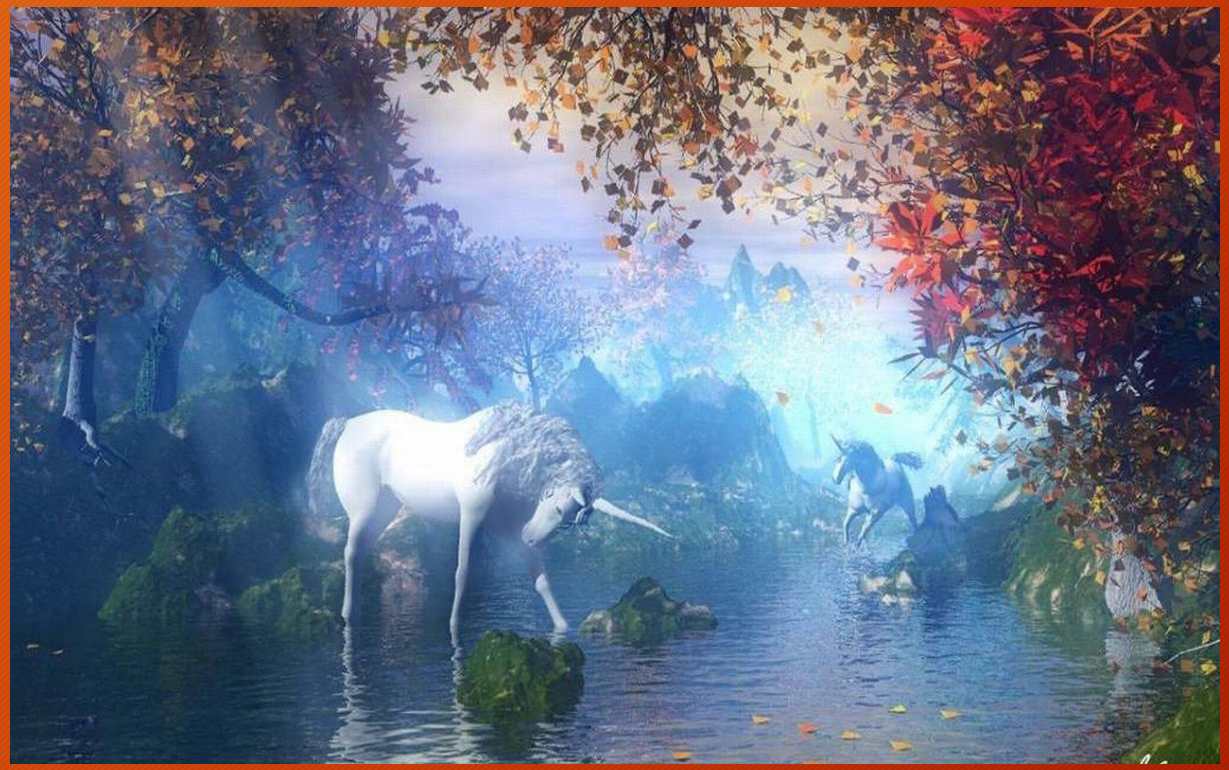
Epidemiology, Patterns of Care, and Mortality for Patients With Acute Respiratory Distress Syndrome in Intensive Care Units in 50 Countries

Giacomo Bellani, MD, PhD; John G. Laffey, MD, MA; Tài Pham, MD; Eddy Fan, MD, PhD; Laurent Brochard, MD, HDR; Andres Esteban, MD, PhD; Luciano Gattinoni, MD, FRCP; Frank van Haren, MD, PhD; Anders Larsson, MD, PhD; Daniel F. McAuley, MD, PhD; Marco Ranieri, MD; Gordon Rubenfeld, MD, MSc; B. Taylor Thompson, MD, PhD; Hermann Wrigge, MD, PhD; Arthur S. Slutsky, MD, MASc; Antonio Pesenti, MD; for the LUNG SAFE Investigators and the ESICM Trials Group

- ICU Mortality 34%, similar to ARDSnet
- Average Vt's 7.6 ml/kg
- Average PEEP 8.4 cmH2O

- *JAMA*. 2016;315(8):788-800.

Is 6ml/Kg Magical?



ARDS Mortality

- Almost every “new” strategy over the past 20 years for ARDS produces a mortality of 30-40%

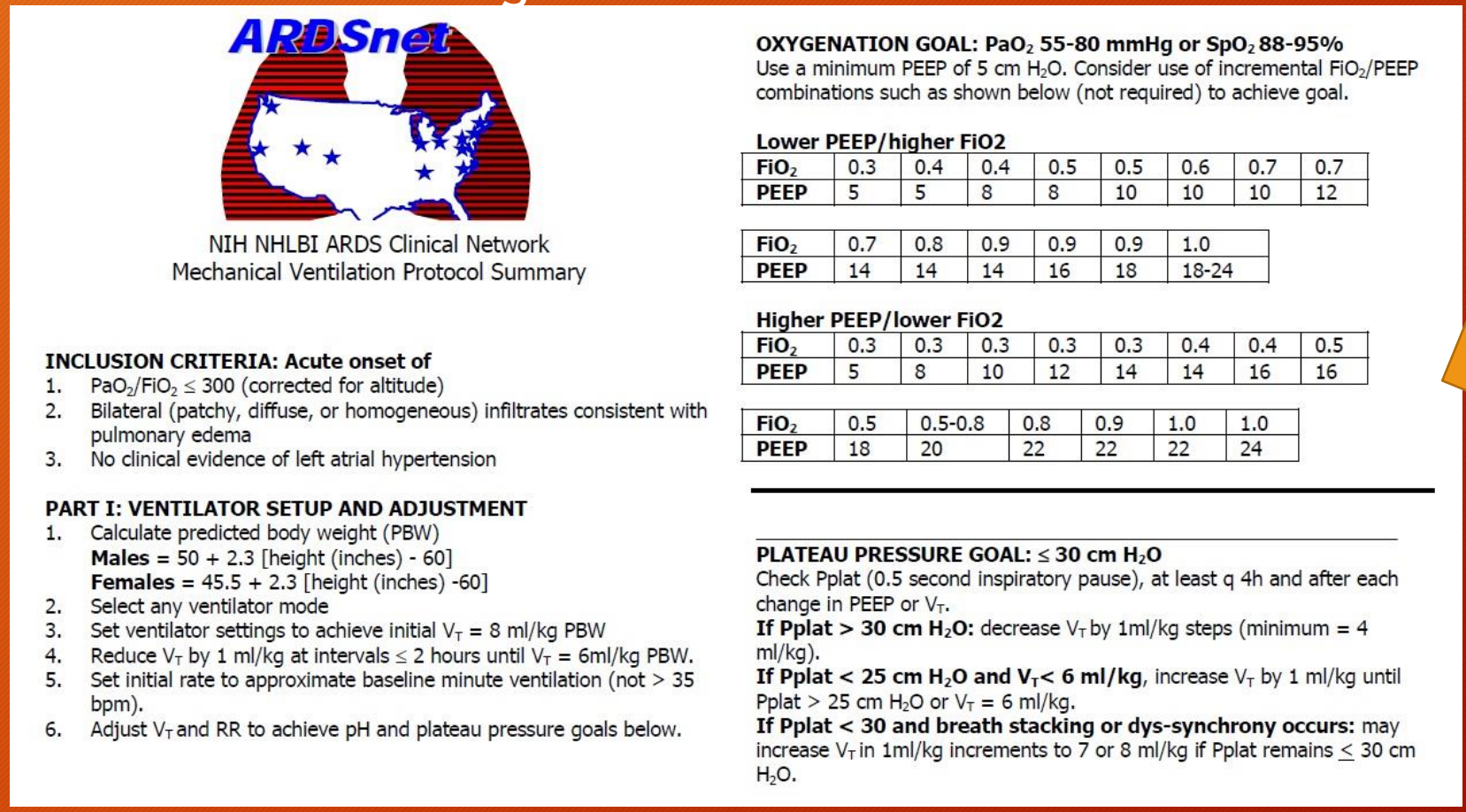
Mortality for ARDS LTV groups in the 2000's

Study	ARDSnet	LOV	EXPRESS	ALIEN	OSCAR	OSCILLATE
Year	2000	2008	2008	2011	2012	2012
Mortality	31%	40.4%	31.2%	47%	41%	35%


What do we do now?

Why do we only look at VT?

- Does it have to be 6ml/kg?



ARDSnet

NIH NHLBI ARDS Clinical Network
Mechanical Ventilation Protocol Summary

INCLUSION CRITERIA: Acute onset of

1. $PaO_2/FiO_2 \leq 300$ (corrected for altitude)
2. Bilateral (patchy, diffuse, or homogeneous) infiltrates consistent with pulmonary edema
3. No clinical evidence of left atrial hypertension

PART I: VENTILATOR SETUP AND ADJUSTMENT

1. Calculate predicted body weight (PBW)
   Males = 50 + 2.3 [height (inches) - 60]
   Females = 45.5 + 2.3 [height (inches) -60]
2. Select any ventilator mode
3. Set ventilator settings to achieve initial V_T = 8 ml/kg PBW
4. Reduce V_T by 1 ml/kg at intervals ≤ 2 hours until V_T = 6ml/kg PBW.
5. Set initial rate to approximate baseline minute ventilation (not > 35 bpm).
6. Adjust V_T and RR to achieve pH and plateau pressure goals below.

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
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FiO_2	0.5	0.5-0.8	0.8	0.9	1.0	1.0
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PLATEAU PRESSURE GOAL: ≤ 30 cm H_2O
Check Pplat (0.5 second inspiratory pause), at least q 4h and after each change in PEEP or V_T.
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If Pplat < 30 and breath stacking or dys-synchrony occurs: may increase V_T in 1ml/kg increments to 7 or 8 ml/kg if Pplat remains ≤ 30 cm H_2O.

A forgotten part about ARDSnet

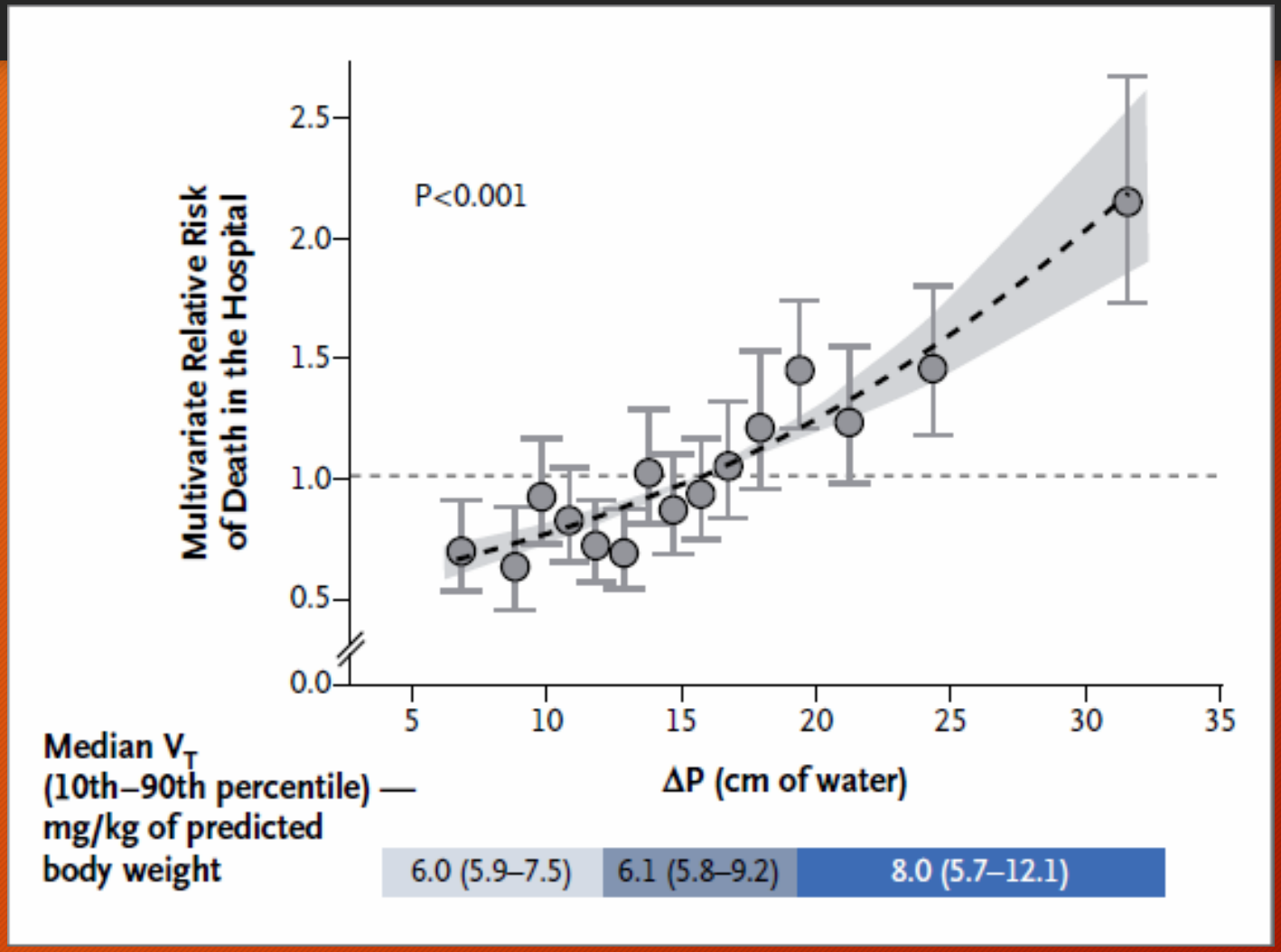
Driving Pressure and Survival in the Acute Respiratory Distress Syndrome

Marcelo B.P. Amato, M.D., Maureen O. Meade, M.D., Arthur S. Slutsky, M.D., Laurent Brochard, M.D., Eduardo L.V. Costa, M.D., David A. Schoenfeld, Ph.D., Thomas E. Stewart, M.D., Matthias Briel, M.D., Daniel Talmor, M.D., M.P.H., Alain Mercat, M.D., Jean-Christophe M. Richard, M.D., Carlos R.R. Carvalho, M.D., and Roy G. Brower, M.D.

- Looked at 3562 patients from 9 different studies
- Individual changes in VT or PEEP after randomization were not independently associated with survival; they were associated only if they were among the changes that led to reductions in ΔP

N Engl J Med 2015;372:747-55

N Engl J Med 2015;372:747-55



Does it have to be 6ml/kg to be Lung Protective Ventilation?

- Limiting Vt to 4-8ml/kg
- Applying moderate to high levels of PEEP
- Plateau pressures to <30 cmH2O
- Driving pressures <15-18 cmh2O

Villar, Blanco, Kacmarek (2016) Curr Opin Crit Care 22:1-6
Petrucci, De Feo (2013) Cochrane Database of Systematic Reviews. Issue 2
Amato et al. (2015) NEJM; 372:747-55

How Much PEEP?

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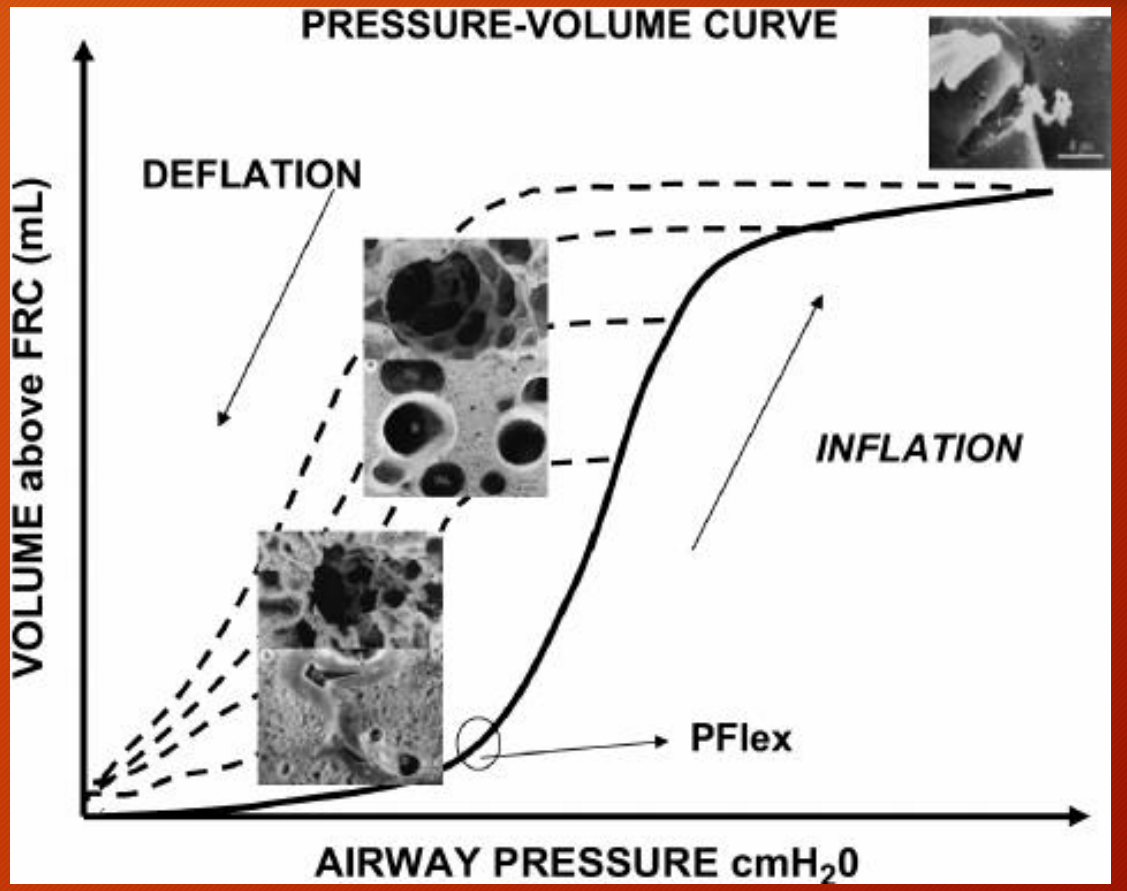
How Much PEEP?

- Pflex plus 1



Current Opinion in Critical Care 11(1):18-28 · March 2005

How much PEEP?

- **Decremental PEEP**
- **Following the lung-recruitment maneuver, PEEP was set at 20 cm H2O and then the FIO2 was decreased until the oxygen saturation (measured via pulse oximetry [SpO2]) was 90–94%. PEEP was then decreased in 2-cm H2O steps until the SpO2 dropped below 90%.**

- Girgis, Hamed, Khater, Kacemarek. Respir Care 2006;51(10):1132–1139

How much PEEP?

- **Setting PEEP based on best Cs (Optimal PEEP)**
- Based on best PaO2 without decreasing CO (Best PEEP)
- Based on trans pulmonary pressure
- Based on….

What do all these PEEP strategies have in common?

- No changes in mortality
- Only improvements in Oxygenation

- Could make a connection between delta p study and best Cs, but no data to support.

There is no evidence to suggest that...

S

1.

2.

3.

4.

5.

6.

Table 3. The Berlin Definition of Acute Respiratory Distress Syndrome

	Acute Respiratory Distress Syndrome
Timing	Within 1 week of a known clinical insult or new or worsening respiratory symptoms
Chest imaging[a]	Bilateral opacities—not fully explained by effusions, lobar/lung collapse, or nodules
Origin of edema	Respiratory failure not fully explained by cardiac failure or fluid overload Need objective assessment (eg, echocardiography) to exclude hydrostatic edema if no risk factor present
Oxygenation[b]	
Mild	200 mm Hg $<$ Pa_{O_2}/F_{IO_2} $\leq$ 300 mm Hg with PEEP or CPAP $\geq$5 cm H_2O[c]
Moderate	100 mm Hg $<$ Pa_{O_2}/F_{IO_2} $\leq$ 200 mm Hg with PEEP $\geq$5 cm H_2O
Severe	Pa_{O_2}/F_{IO_2} $\leq$ 100 mm Hg with PEEP $\geq$5 cm H_2O

Abbreviations: CPAP, continuous positive airway pressure; F_{IO_2}, fraction of inspired oxygen; Pa_{O_2}, partial pressure of arterial oxygen; PEEP, positive end-expiratory pressure.

[a] Chest radiograph or computed tomography scan.

[b] If altitude is higher than 1000 m, the correction factor should be calculated as follows: [Pa_{O_2}/F_{IO_2} × (barometric pressure/760)].

[c] This may be delivered noninvasively in the mild acute respiratory distress syndrome group.

Hess. Respir Care 2015;60(11):1688-1704


FORD

Personalize

- FiO2 requirements
- CXR changes
- Compliance changes
- WOB changes
- Total PEEP Changes
- Ppl changes

What about Recruitment Maneuvers? I like those

- 20 cmH2O of CPAP for 20 sec
- 40 cmH2O of CPAP for 40 sec
- 20 of PEEP with 20 of PC, 1:1 I:E ratio for 3 min
- Open Lung tool on Hamilton or Servoi

Summary and Recommendations: Recruitment Maneuvers

1. Evidence is lacking that the use of recruitment maneuvers improves patient outcomes.
2. Alveolar recruitment is desirable if it can be achieved safely, but there is variable potential for recruitment among patients with ARDS.
3. A stepwise recruitment maneuver is preferred over sustained inflation.
4. Complications of recruitment such as hypotension and desaturation are common but temporary; complications such as barotrauma appear to be rare.
5. If a recruitment maneuver is effective, sufficient PEEP is necessary to maintain the recruitment.
6. Evidence is not sufficient to recommend the routine use of recruitment maneuvers as standard practice.

Hess. Respir Care 2015;60(11):1688–1704

Does Mode Make a Difference?


FORD

Does Mode Make a Difference?

- Adjust mode to fit patient needs.
- Know the advantages and disadvantages of the modes and how they interact with the patient.

PRVC Example

- Patient presents with increased WOB, accessory muscle use, and high FiO2 requirements.
- Mode: PRVC (APV, VC-AC with autoflow, PC-AC with VG, VC+)
- Settings: VT 450 ml (6ml/kg), RR 20, PEEP 12 cmH2O, IT 1 sec, FiO2 95%.
- Measurements: PIP 16 cmH2O, Ppl unable, actual rate 30, SpO2 89%, VT exhaled 550 ml.

PRVC Example

- Patient wanting a higher VT than what is set, so
  - Vent decreases PIP to target lower VT
  - Results in an increase in WOB
  - Results in a decrease Mean AW pressure
  - All resulting in low SpO2
- Vent is doing on what we asked it to do, but it is all wrong for this patient.

PRVC Example

- So what do we do?
- Option 1 – sedate and paralyze the patient

- Option 2 – get them out of a volume targeted mode

I thought the trend was to NOT paralyze patients

Alhazzani *et al. Critical Care* 2013, **17**:R43
http://ccforum.com/content/17/2/R43

RESEARCH Open Access

Neuromuscular blocking agents in acute respiratory distress syndrome: a systematic review and meta-analysis of randomized controlled trials

Waleed Alhazzani[1*], Mohamed Alshahrani[2], Roman Jaeschke[1,3], Jean Marie Forel[4], Laurent Papazian[4], Jonathan Sevransky[5] and Maureen O Meade[1,3]

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- Short term infusion (48 hours) of paralytic reduces mortality of ARDS patients, and lowers risk of barotrauma
- No change in length of mechanical ventilation or ICU acquired weakness

Ok, so is proning making a come back too?

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., Arnaud Gacouin, M.D., Thierry Boulain, M.D., Emmanuelle Mercier, M.D., Michel Badet, M.D., Alain Mercat, M.D., Ph.D., Olivier Baudin, M.D., Marc Clavel, M.D., Delphine Chatellier, M.D., Samir Jaber, M.D., Ph.D., Sylvène Rosselli, M.D., Jordi Mancebo, M.D., Ph.D., Michel Sirodot, M.D., Gilles Hilbert, M.D., Ph.D., Christian Bengler, M.D., Jack Richecoeur, M.D., Marc Gainnier, M.D., Ph.D., Frédérique Bayle, M.D., Gael Bourdin, M.D., Véronique Leray, M.D., Raphaele Girard, M.D., Loredana Baboi, Ph.D., and Louis Ayzac, M.D., for the PROSEVA Study Group*

Proning

- Ventilation in the prone position is recommended for the first week in moderate to severe ARDS patients

- A total of 237 patients were assigned to the prone group, and 229 patients were assigned to the supine group. The 28-day mortality was 16.0% in the prone group and 32.8% in the supine group ($P<0.001$).

A Comprehensive Review of Prone Position in ARDS

Richard H Kallet MSc RRT FAARC

- survival is enhanced when patients are managed with
  - a smaller tidal volume (≤8 mL/kg)
  - higher PEEP (10–13 cm H2O)
  - and longer duration of PP sessions (>10–12 h/session).

- Respir Care 2015;60(11):1660–1687

Proning Problems

- The incidence of complications did not differ significantly between the groups, except for the incidence of cardiac arrests, which was higher in the supine group.

- Multiple studies have reported an increased risk of pressure ulcers in the prone group
- Taccone et al 2009 reported an increased rate of airway obstruction, transient desaturation, vomiting, increased vasopressor needs, loss of venous access, displacement of endotracheal tubes, and the need for increased neuromuscular blockers with prone positioning

Wasn’t this a presentation about VT?

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If Pplat < 30 and breath stacking or dys-synchrony occurs: may increase V_T in 1ml/kg increments to 7 or 8 ml/kg if Pplat remains $\leq$ 30 cm H_2O.

How do you determine height?

- Count tiles on the floor?
- Carry a measuring tape?
- Ask relatives?
- Bring a Carnie to work day?

A PRELIMINARY COMPARISON OF DELIVERED TIDAL VOLUME AND ARDSNET RECOMMENDED TIDAL VOLUME AS DETERMINED BY IDEAL BODY WEIGHT IN MECHANICALLY VENTILATED PATIENTS

Susan R. Whiddon, Randall Baker, Christen Adcock, Amanda Hadden, Robin Smith; Respiratory Therapy, Medical College of Georgia, Augusta, GA

- found that 40% of the patients were ventilated at tidal volumes of

> 6ml/kg IBW, and 10% of the patients were being ventilated at tidal volumes of <6ml/kg

A COMPARISON BETWEEN PATIENTS HEIGHTS RECORDED IN THE ELECTRONIC MEDICAL RECORD AND THE PATIENTS ACTUAL MEASURED HEIGHTS: THE IMPACT ON THE SETTING OF TIDAL VOLUME

Donald L. Bellerive, Scott Kopec, Rachel Carragher, Luanne Hills, Scott Leonard, Earl Dyer, Pam Leclaire, Larry Owens, Paul Alger, Patrick Dowd, Sharon Pare, Patricia Lemire, Thomas Canedy, Darlene Levasseur, Thomas Collins, Kathy McLane, Debbie Hendrickson; Respiratory Care, UMass Memorial Health Care, Worcester, MA

- Heights recorded in the patient's record are inaccurate nearly 80% of the time.
- Recorded heights tend to be higher than actual heights leading to the use of larger than required tidal volumes. These larger tidal volumes based on inaccurately recorded heights can potentially result in worsening acute lung injury and a higher mortality in patients with ARDS or ALI

ASSESSING METHODS FOR ESTIMATING HEIGHT IN RECUMBENT ADULTS

Randall Baker, Susan R. Whiddon, Simmons Catherine, Aleksandr Gulchuk, Verna-Virginia Lehockey; Respiratory Therapy, Medical College of Georgia, Augusta, GA

Forearm Length demonstrated the least bias regardless of patient's position or gender and may be ideal method for estimating height and calculating ideal body weight in the

Comparison of Usual and Alternative Methods to Measure Height in Mechanically Ventilated Patients: Potential Impact on Protective Ventilation

Azadeh Bojmehrani Eng MSc, Maude Bergeron-Duchesne, Carmelle Bouchard Inh, Serge Simard MSc, Pierre-Alexandre Bouchard Inh, Abel Vanderschuren MD, Erwan L'Her MD PhD, and François Lellouche MD PhD

- In comparison with the reference method, estimating the height visually and using the tape measure were less accurate than both lower leg and forearm measurement methods

- Respir Care 2014;59(7):1025–1033.

Height Estimation from Ulna Length

Height (in)	Men (<65 years)	76.38	75.98	75.2	74.41	73.62	72.84	72.44	71.65	70.87	70.08	69.29	68.9	68.11	67.32
	Men (>65 years)	73.62	73.22	72.44	71.65	71.26	70.47	70.08	69.29	68.9	68.11	67.32	66.93	66.14	65.75
	Ulna length (cm)	32	31.5	31	30.5	30	29.5	29	28.5	28	27.5	27	26.5	26	25.5
Height (in)	Women (<65 years)	72.44	72.05	71.65	70.87	70.47	69.69	69.29	68.9	68.11	67.72	66.93	66.54	66.14	65.35
	Women (>65 years)	72.44	72.05	71.65	70.47	70.08	69.29	68.9	68.11	67.32	66.93	66.14	65.35	64.96	64.17

Height (in)	Men (<65 years)	66.54	65.75	65.35	64.57	63.78	62.99	62.21	61.81	61.02	60.24	59.45	58.66	58.27	57.48
	Men (>65 years)	64.96	64.17	63.78	62.99	62.6	61.81	61.45	60.63	59.84	59.45	58.66	58.27	57.48	57.09
	Ulna length (cm)	25	24.5	24	23.5	23	22.5	22	21.5	21	20.5	20	19.5	19	18.5
Height (in)	Women (<65 years)	64.96	64.17	63.78	63.39	62.6	62.21	61.45	61.02	60.63	59.84	59.45	59.06	58.27	57.87
	Women (>65 years)	63.39	62.99	62.21	61.45	61.02	60.24	59.84	59.06	58.27	57.87	57.09	56.69	55.91	55.12

How to obtain ulna length

1) Ask subject to bend an arm (left side if possible), palm across chest, fingers pointing to opposite shoulder.
2) Using tape measure, measure the length in centimeters (cm) to the neasrest 0.5 cm between the point of the elbow and the mid-point of the prominent bone of the wrist
3) Use table above to convert ulna length (cm) to height (in)

Summary

1. 6ml/kg is NOT magical
   - 4-8ml/kg is the general recommendation for VT
   - Need to use ulnar length to assess patient height
2. Monitor Ppl and total PEEP
   - Keep delta P's under 15 cmH2O
3. Tirelessly assess your patient for ARDS. Recognition and action is key.

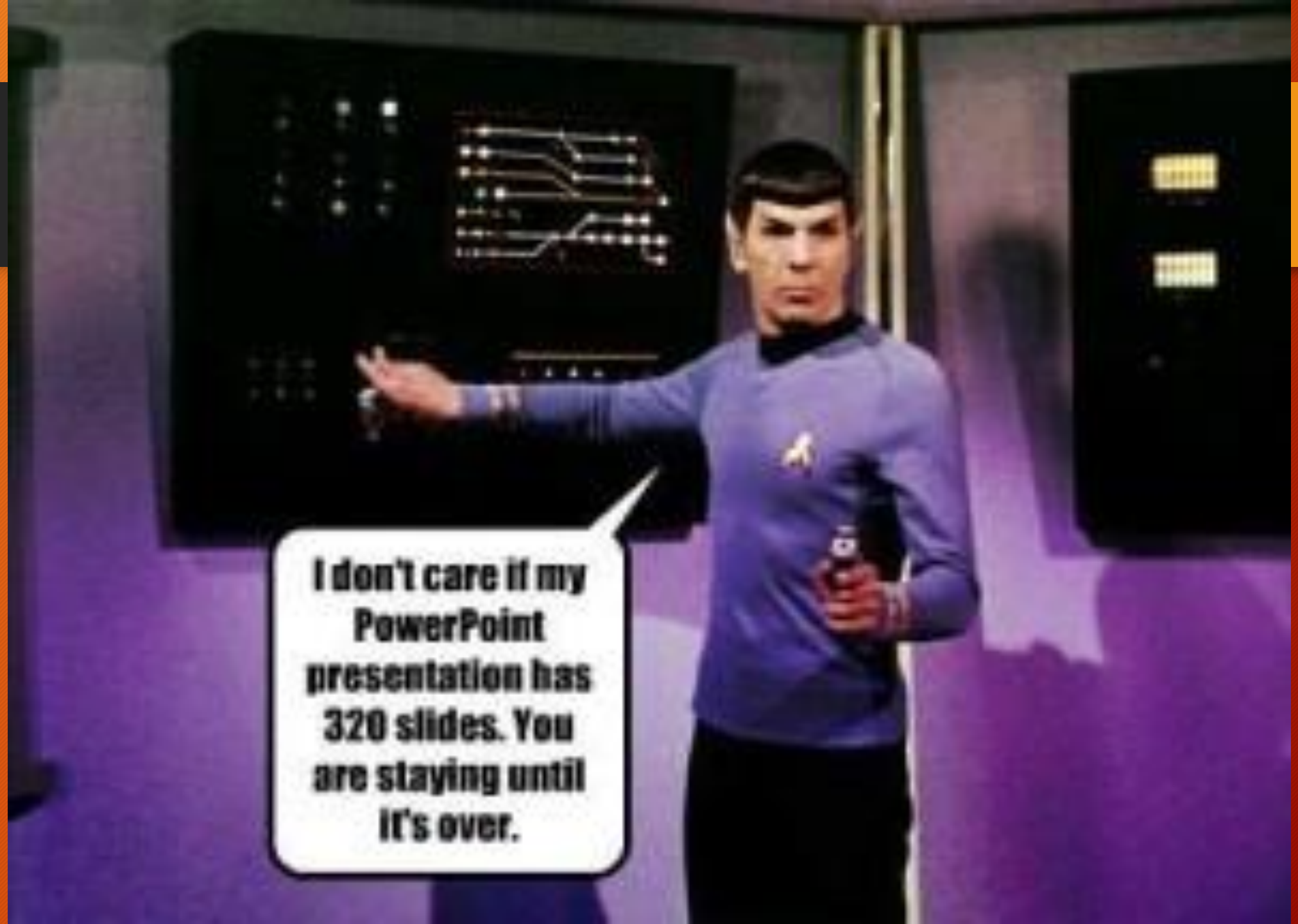
Summary

1. Personalize your PEEP strategy for the patient
2. Personalize the mode for the patient

3. Neuromuscular blockages for the first 48 hours is recommended

4. Proning for moderate to severe ARDS is recommended

5. A knowledgeable bedside clinician makes the biggest difference!


I don't care if my PowerPoint presentation has 320 slides. You are staying until it's over.