Safely Ventilating the Sick Lung in 2022

Mike Dougherty RRT-NPS

Disclosure/Who Is This Guy?

- Currently employed by Getinge as Critical Care Territory Manager (Servo Ventilators)
- Draeger 2008-2015
- Fisher and Paykel 2004-2008
- Lankenau Hospital RRT
  - Clinical Coordinator 2002-2004
  - RRT 1997-2002

Goals and Objectives

* Discuss some Core Principles of Ventilation relevant to mechanical ventilation moving forward.
* Compare and Contrast High MAP strategies of ventilation.
* Familiarize clinicians with some of the key papers impacting ventilation strategy today.

Pressure vs Volume Ventilation

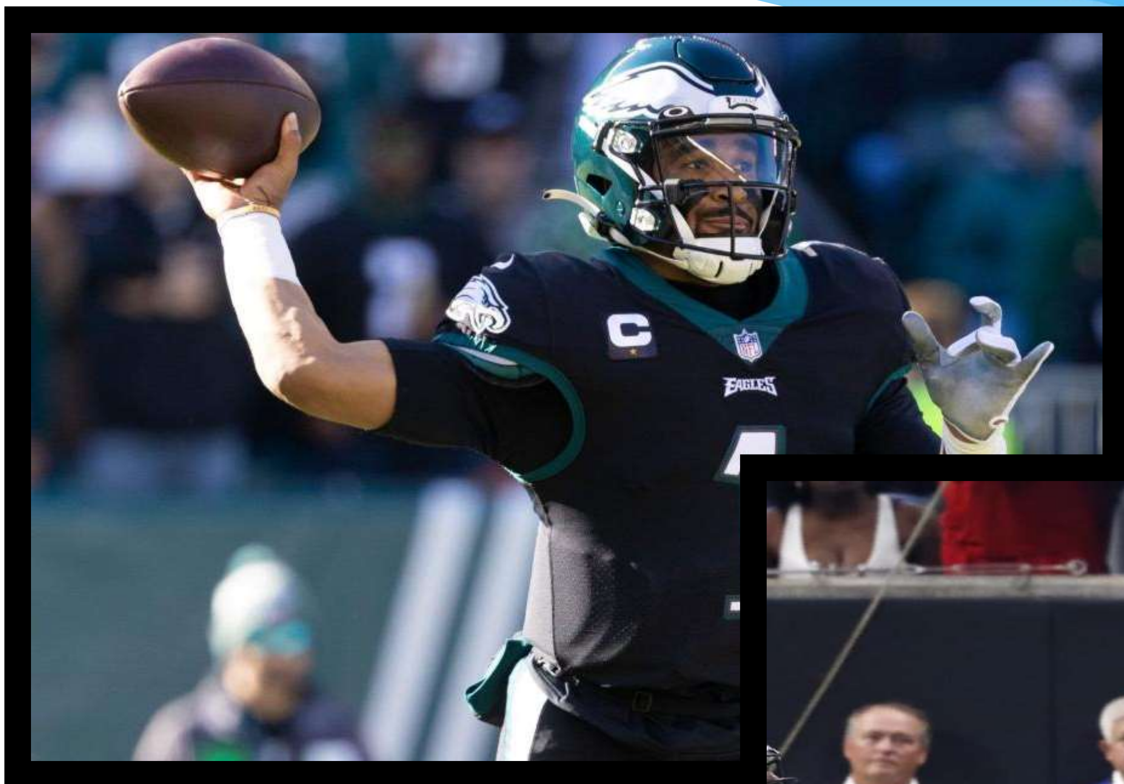
* Volume: Set Flow, variable pressure

  RR/VT/FIO2/Peep 10/500/60 +5

* Pressure: Set pressure, variable flow and tidal volume.

  RR/PIP/Peep/FIO2/I time 10 20/5 60 1.2 I time

Volume Ventilation



The Ball is your VT. You decide how fast to throw it.

Pressure Ventilation

The balloon is your vt. Your primary concern is not to hurt the catchers hand, the balloon may not arrive in the way you intended.

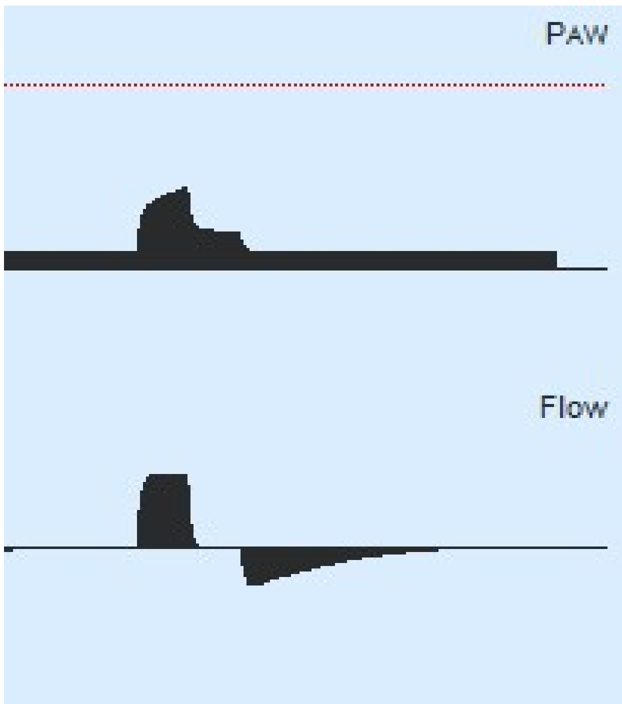
PRVC
25
PRESSURE cmH₂O
-3
50
FLOW l/min
-50
500
VOLUME ml
0
Ppeak
40
22
cmH₂O
RR
30
5
12
b/min
VTe
386
ml
Cdyn
22.4
ml/cmH₂O
O₂ conc.
70
PEEP
5.0
RR
12
Tidal volume
400

Volume and Pressure

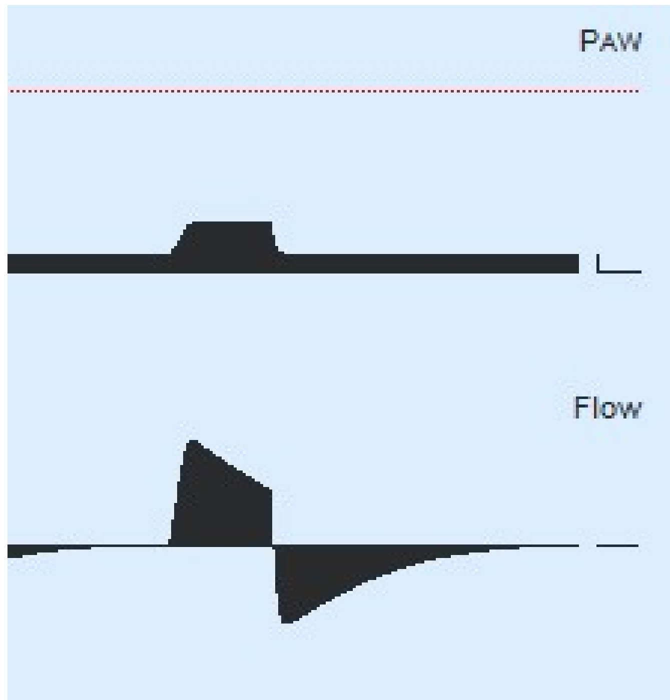
PRVC

Pressure

Plateau Pressure



Fixed Flow Volume



Pressure

2011 Respiratory Care Journal January 2011

- Page 83
- Patient Ventilator Interactions: Optimizing Conventional Ventilation Modes
- ***Pressure Control Volume Assured Ventilation***
- Dr Catherine Sassoon MD Long Beach, CA
- Dr Neil MacIntyre MD Duke University, NC
- Richard Kallet MSc RRT

1. ***"CS "In my experience it seems to be a better mode than just plain pressure control ventilation"***
2. ***Dr Neil MacIntyre "We kind of like Pressure Regulated Volume Control"***
3. ***Richard Kallet RRT "We have all but outlawed it at San Francisco General Hospital.***

Dual Mode Commentary From Kallet

1. "In a 6 month period I found 4 patients in overt shock with a peak pressure of 12".
2. The Rule of thumb is if your peak pressure on someone who is very sick is less than 20, you need to take a closer look".
3. If your peak pressures on a dual mode are in the mid 20s to 30s, I don't have a problem with it at all

Paraphrased for length complete text page 84 Jan 2011 Resp Care

* "It's a clinician problem, in that a lot of times the clinician is not recognizing that there's a problem going on"

Richard Kallet 2011

Bedside Approach

1. PIP
2. MAP (PMean)


PRVC
25
PRESSURE cmH₂O
-3
50
FLOW l/min
-50
450
VOLUME ml
0
Ppeak
40
21
cmH₂O
PEEP
15
5.0
2
cmH₂O
Pmean
8
cmH₂O
RR
30
15
5
b/min
I:E
1 : 3.4
O₂ conc.
100
%
VTe
394
ml
VTi
409
ml
MVe
40.0
5.9
1.5
l/min
Cdyn
24.5
ml/cmH₂O
VT/PBW
6.4
ml/kg
O₂ conc.
100
PEEP
5.0
RR
15
Tidal volume
400

PBW 61 kg
15:47
18-09-17
>45 min
PRVC
STANDBY
MODES
ALARM LIMITS
MANEUVERS
VIEWS
NAVA
DISCONNECTION /SUCTION
TRENDS & LOGS
14 PRESSURE cmH2O
-2
45 FLOW l/min
-45
500 VOLUME ml
0
Ppeak 40 10 cmH2O
PEEP 15 2 4.9 cmH2O
Pmean 7 cmH2O
RR 45 5 19 b/min
I:E 1 : 1.9
O2 conc. 70 %
VTe 576 ml
VTi 562 ml
MVe 40.0 2.5 10.1 l/min
Cdyn 132.7 ml/cmH2O
VT/PBW 9.5 ml/kg
100 O2 BOOST
O2 conc. 70
PEEP 5.0
RR 12
Tidal volume 400

What Do You Do?

Traditional Volume Ventilation?

Issue is that the patient is demanding a higher volume, limiting the volume will result in severe asynchrony.

You can do it, but you will need to apply heavy sedation

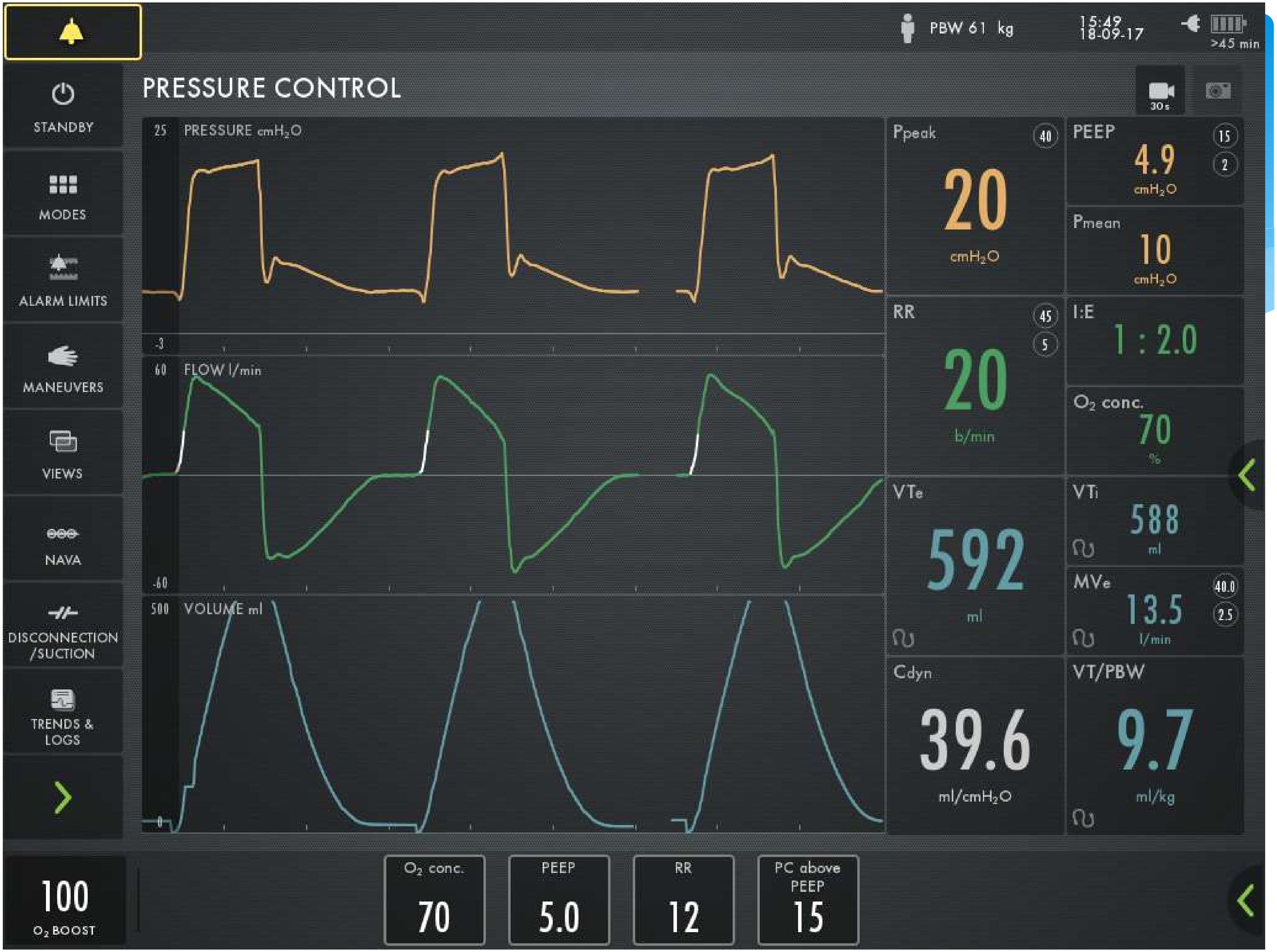
What Do You Do Part 2

Pressure Ventilate

Set Pressure to 20, you will then achieve a higher MAP.

Note Driving pressure

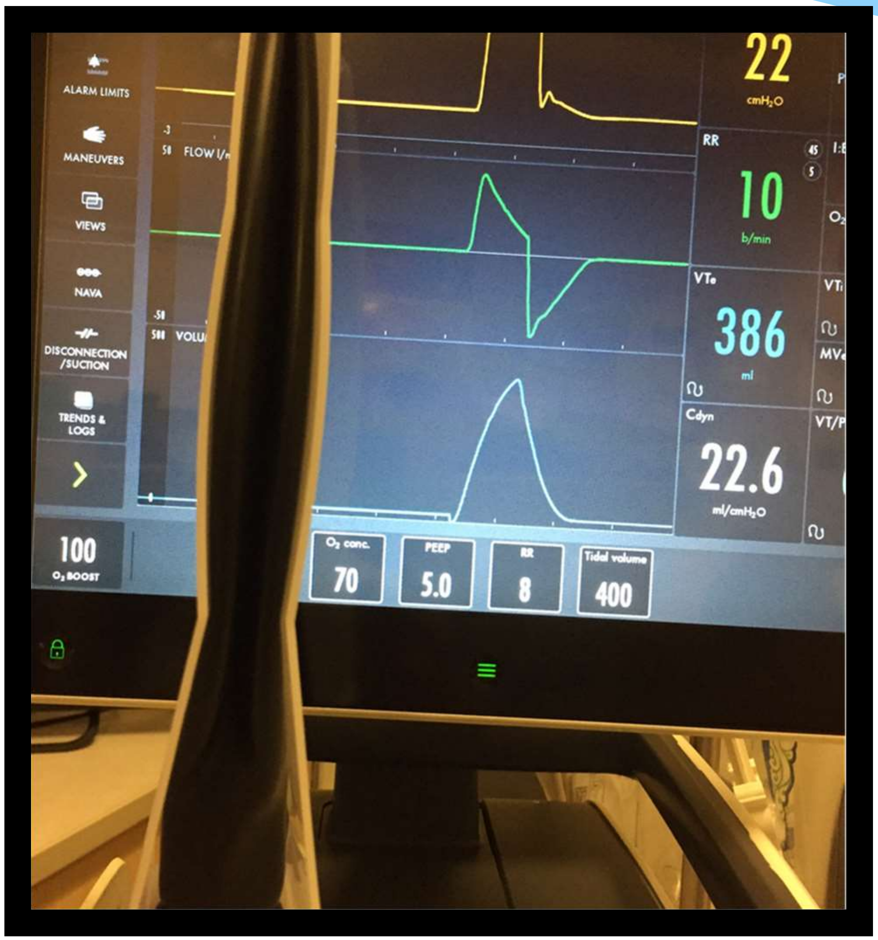
Note tidal volumes because they are variable

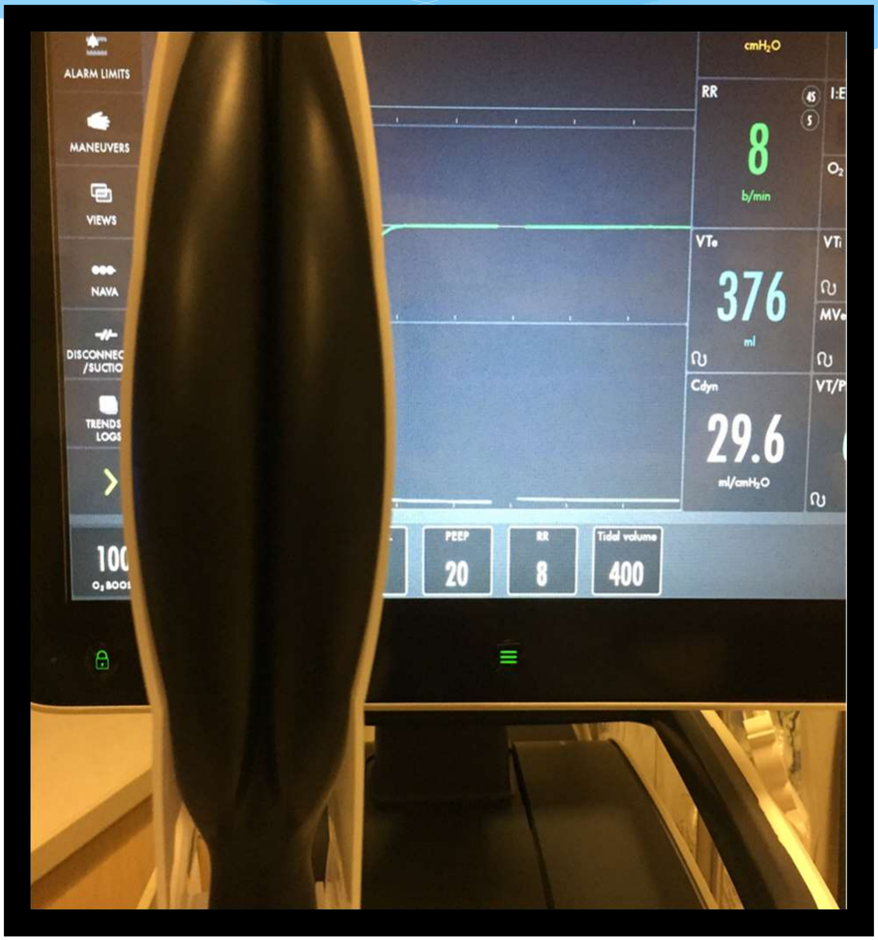

PBW 61 kg
15:49
18-09-17
>45 min
PRESSURE CONTROL
30 s
STANDBY
MODES
ALARM LIMITS
MANEUVERS
VIEWS
NAVA
DISCONNECTION /SUCTION
TRENDS & LOGS
25 PRESSURE cmH2O
-3
60 FLOW l/min
-60
500 VOLUME ml
0
Ppeak 40
20
cmH2O
PEEP 15 2
4.9
cmH2O
Pmean
10
cmH2O
RR 45 5
20
b/min
I:E
1 : 2.0
O2 conc.
70
%
VTe
592
ml
VTi
588
ml
MVe 40.0 2.5
13.5
l/min
Cdyn
39.6
ml/cmH2O
VT/PBW
9.7
ml/kg
100
O2 BOOST
O2 conc.
70
PEEP
5.0
RR
12
PC above PEEP
15

Option 3 2022

* Increase Peep (10-12cmh2O)
* Check Driving Pressure

Peep is Volume

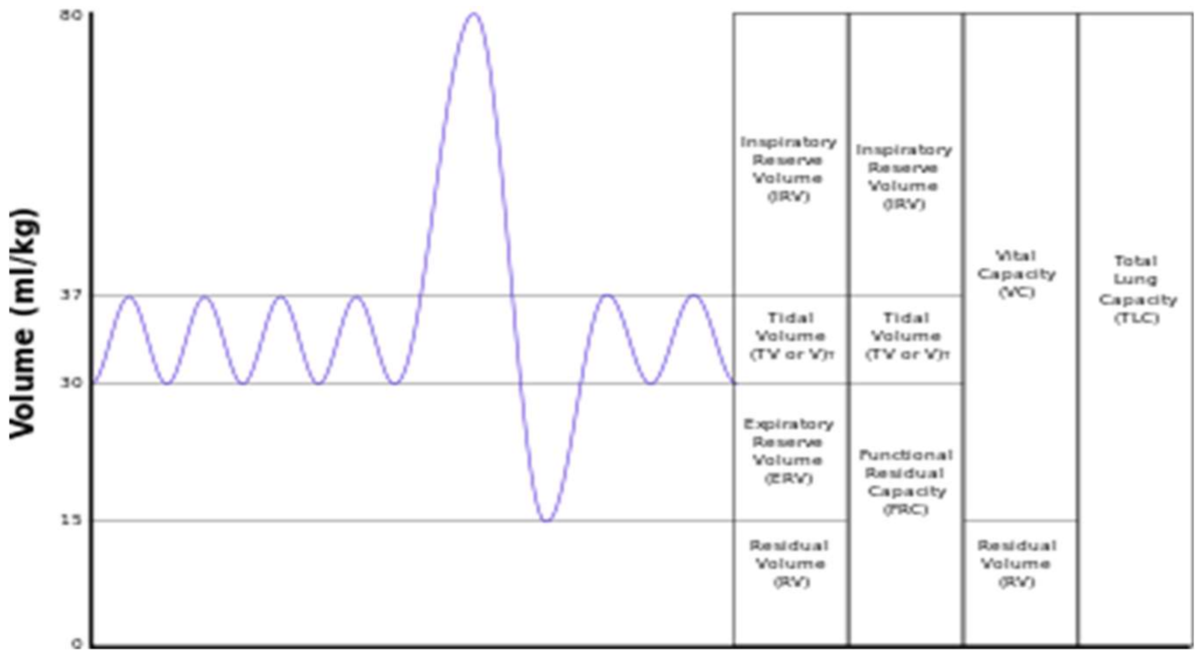




Peep and FRC

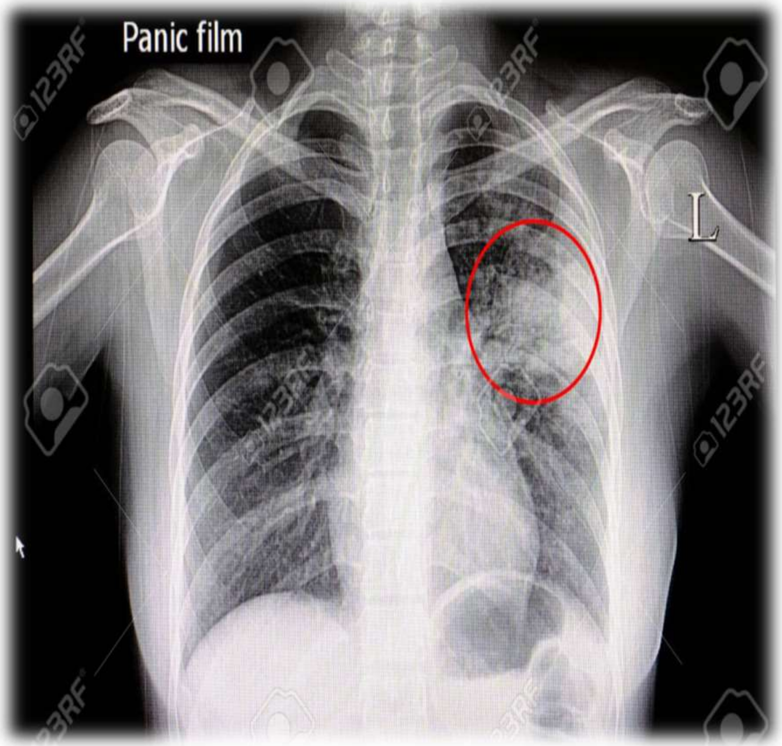
FRC

70 kg/154lb male IBW
VT = 6cc-8cc **420-560**
Functional Residual Capacity
FRC = 35ml/kg **2450ml**



Peep Needed?

L Mid lobe Pneumonia



ARDS

Ardsnet VT Goal 6ml/kg
What About Peep?

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

Mec

INCLUSION CRI
1. $PaO_2/FiO_2 \le 3$
2. Bilateral (patc pulmonary ed
3. No clinical evi

PART I: VENTILA
1. Calculate pred
   Males = 50 -
   Females = 4
2. Select any ve
3. Set ventilator
4. Reduce V_T by
5. Set initial rate bpm).
6. Adjust V_T and

High or Low Peep? 2004

Higher versus Lower Positive End-Expiratory Pressures in Patients with the Acute Respiratory Distress Syndrome

The National Heart, Lung, and Blood Institute ARDS Clinical Trials Network*

N Engl J Med 2004; 351:327-336

Conclusions

These results suggest that in patients with acute lung injury and ARDS who receive mechanical ventilation with a tidal-volume goal of 6 ml per kilogram of predicted body weight and an end-inspiratory plateau-pressure limit of 30 cm of water, clinical outcomes are similar whether lower or higher PEEP levels are used.

High vs Low Peep? 2017

In conclusion, we have performed an updated meta-analysis of clinical trials comparing higher PEEP to lower PEEP strategies among patients with ARDS

Conclusions: Use of higher PEEP is unlikely to improve clinical outcomes among unselected patients with ARDS.

Walkey, Del Sorbo, Hodgson, et al.: PEEP in ARDS
AnnalsATS Volume 14 Supplement 4| October 2017

What Does it all Mean?

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

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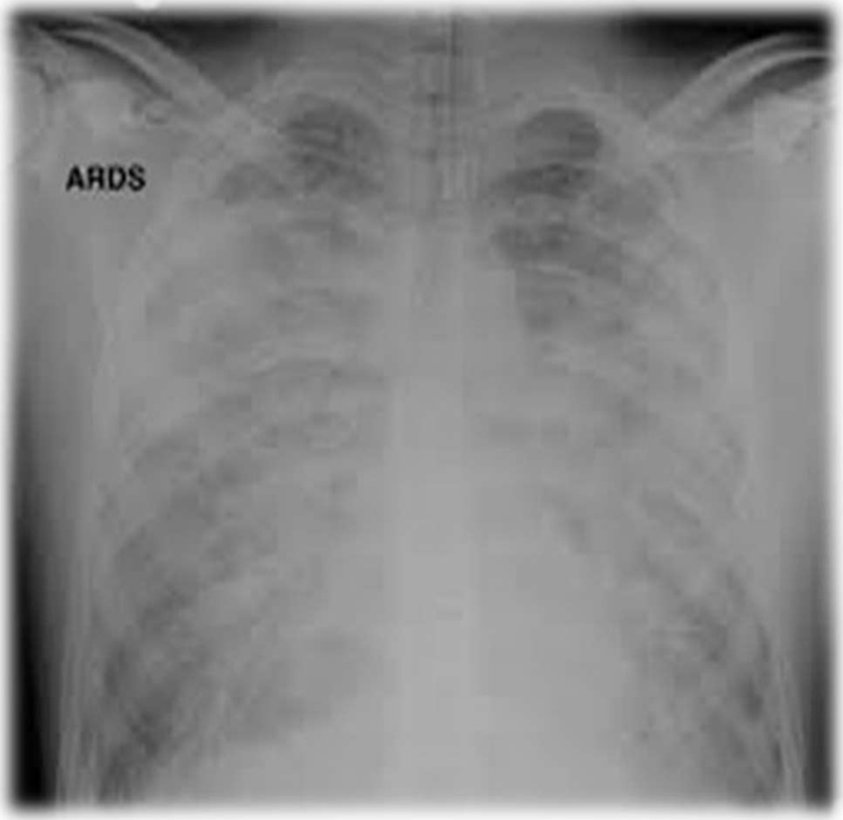


How Do You Set PEEP?

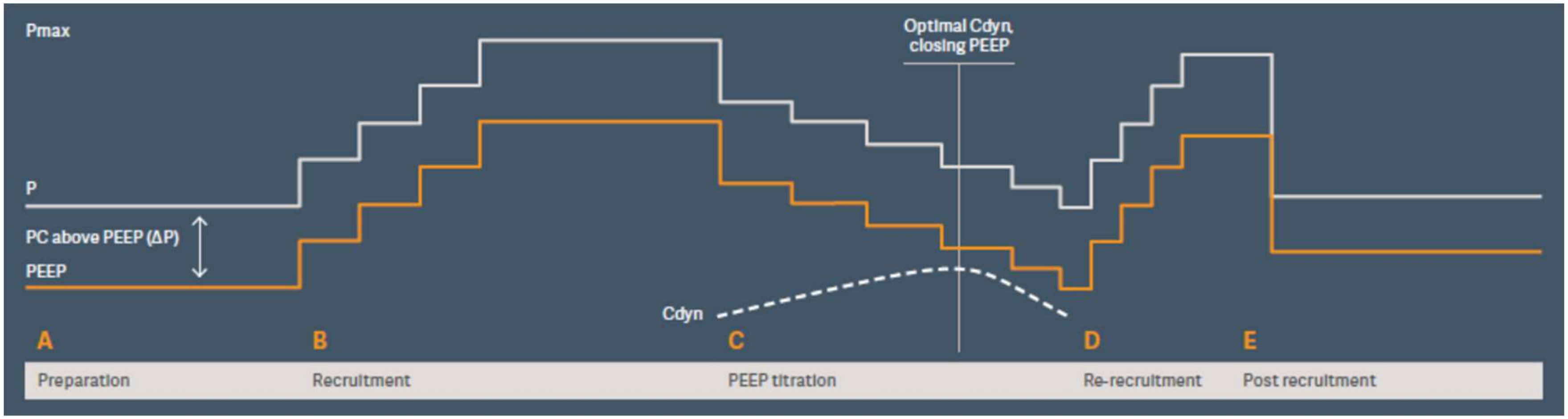
“Open Lung Concept”

- The “open lung concept” was a proposal to use recruitment manoeuvres followed by higher PEEP to reduce atelectrauma and shear-stress
- Critical Care 1992 “Open up the lung and keep the lung open”

Process

* Recruitment phases

1. Recruitment
2. PEEP titration
3. Re-recruitment
4. Post-recruitment



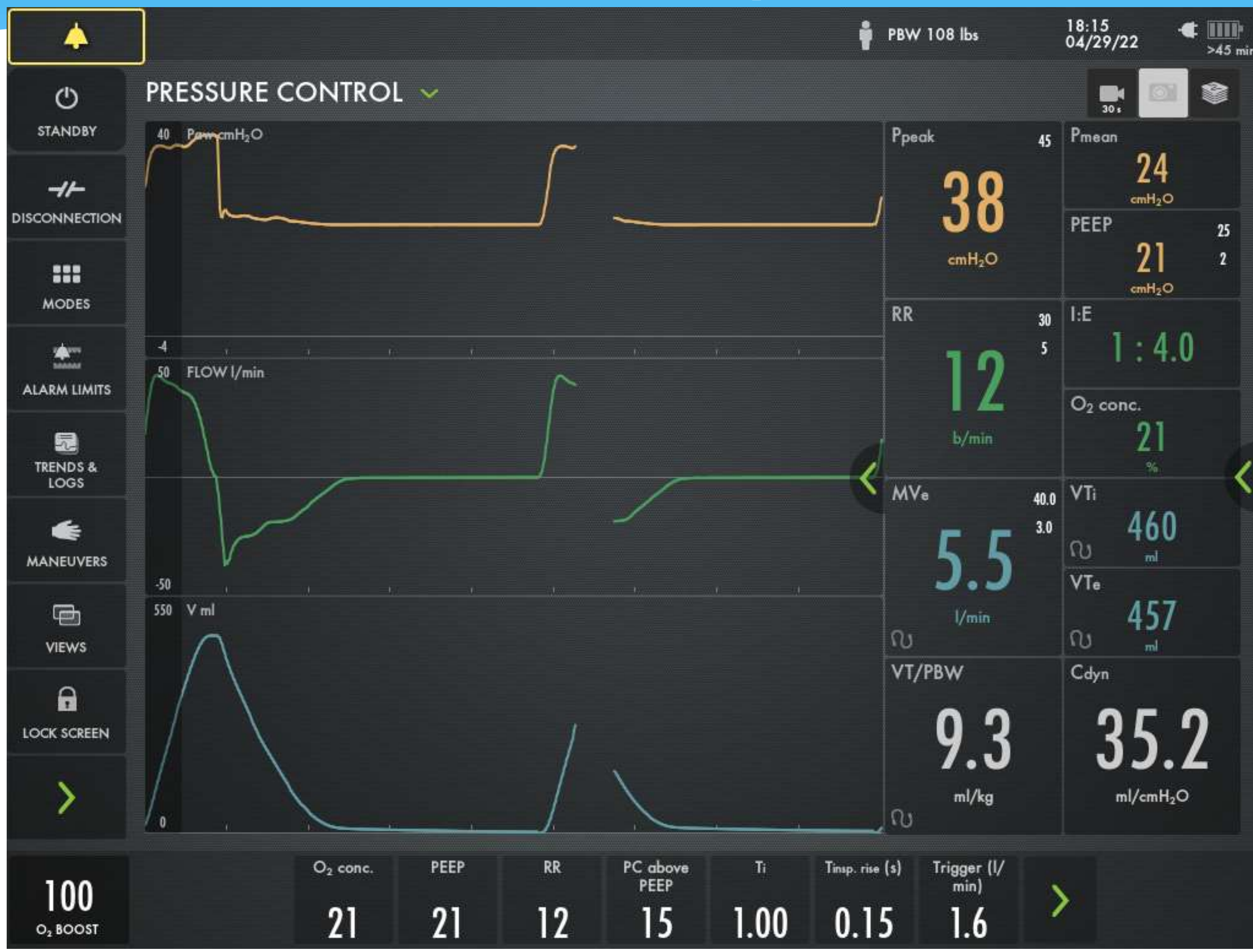
Determine Best Peep

- Switch Patient to Pressure Control
- Set PIP 15 Titrate for appropriate volumes
- *Modified Recruitment adverse method. Start at low level work up to 25 than verify on way down*
- Allow at least 3-5 Breaths per level
- Note Volume and Compliance

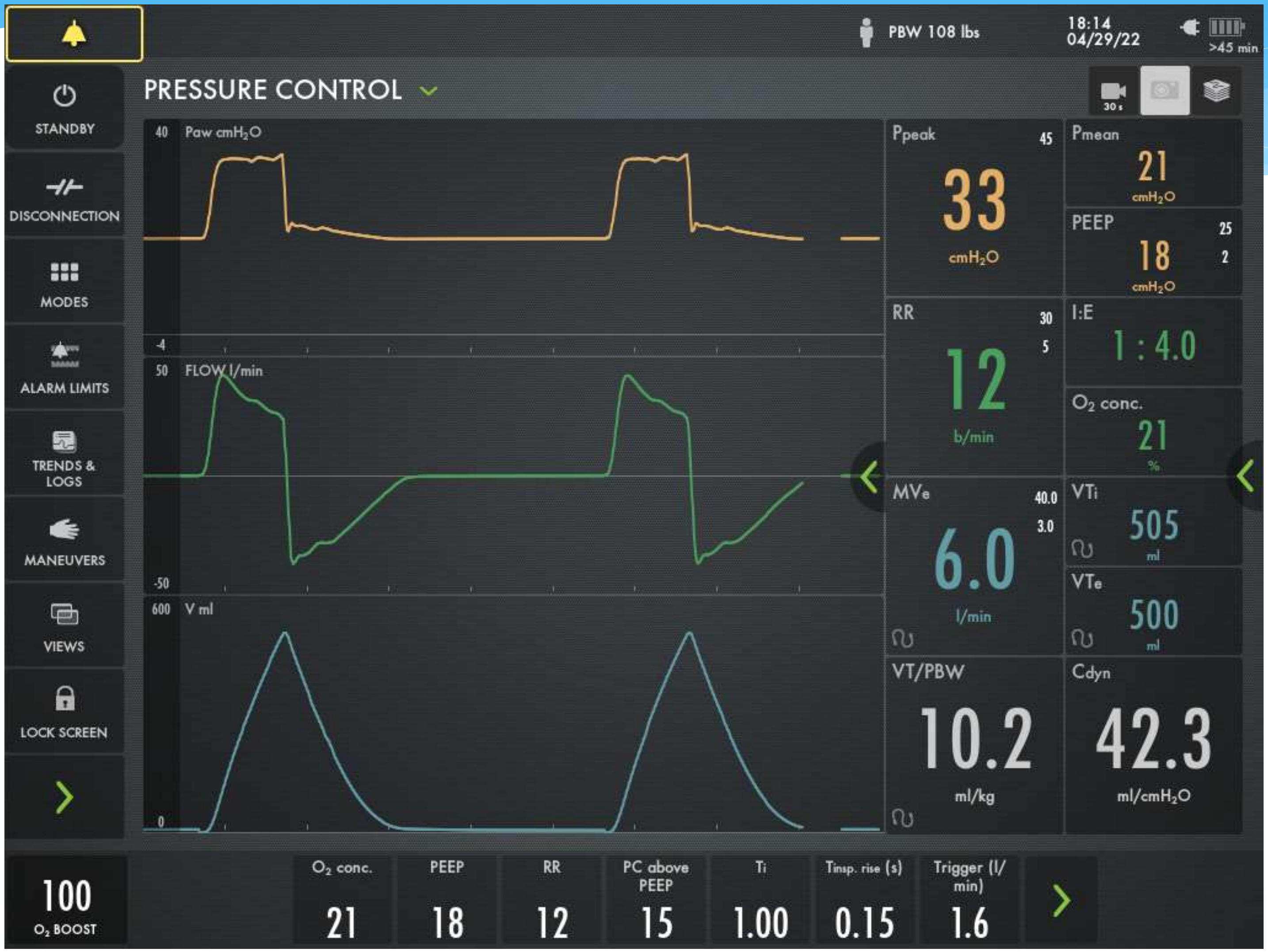
Patient Cannot Be Spontaneously Breathing

Best Peep
25 Peep

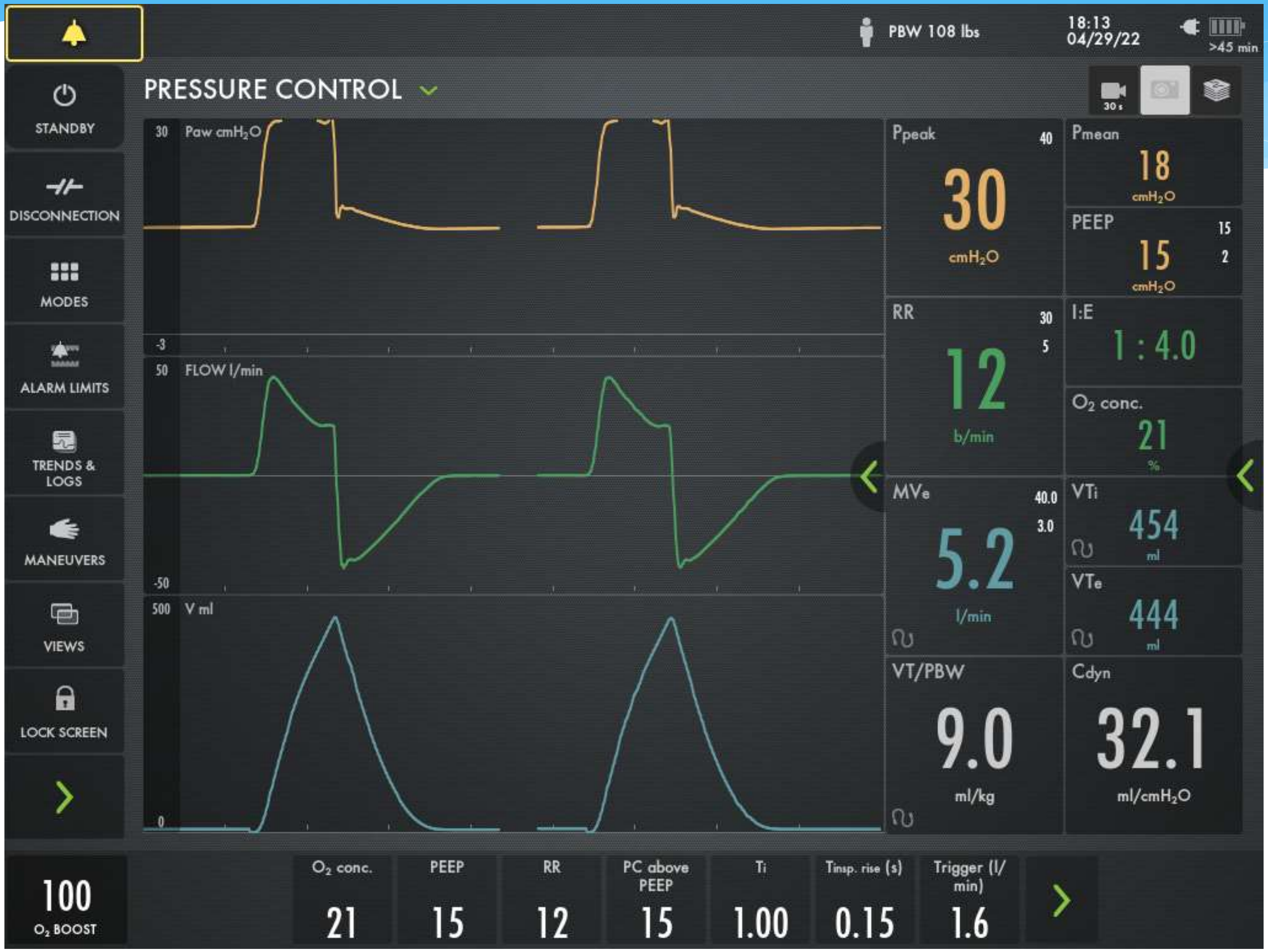
Best Peep
21 Peep



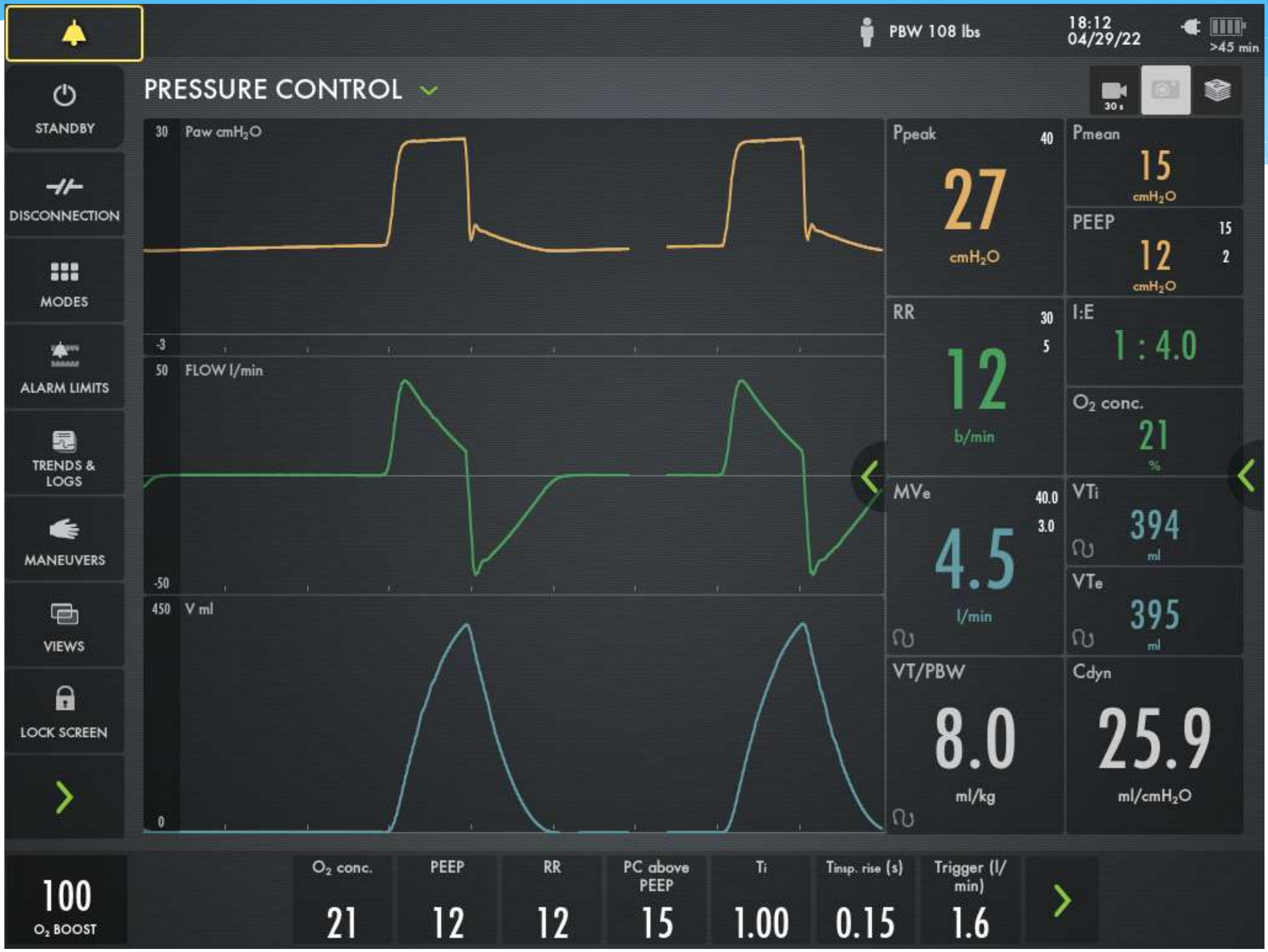
Best Peep
18 Peep

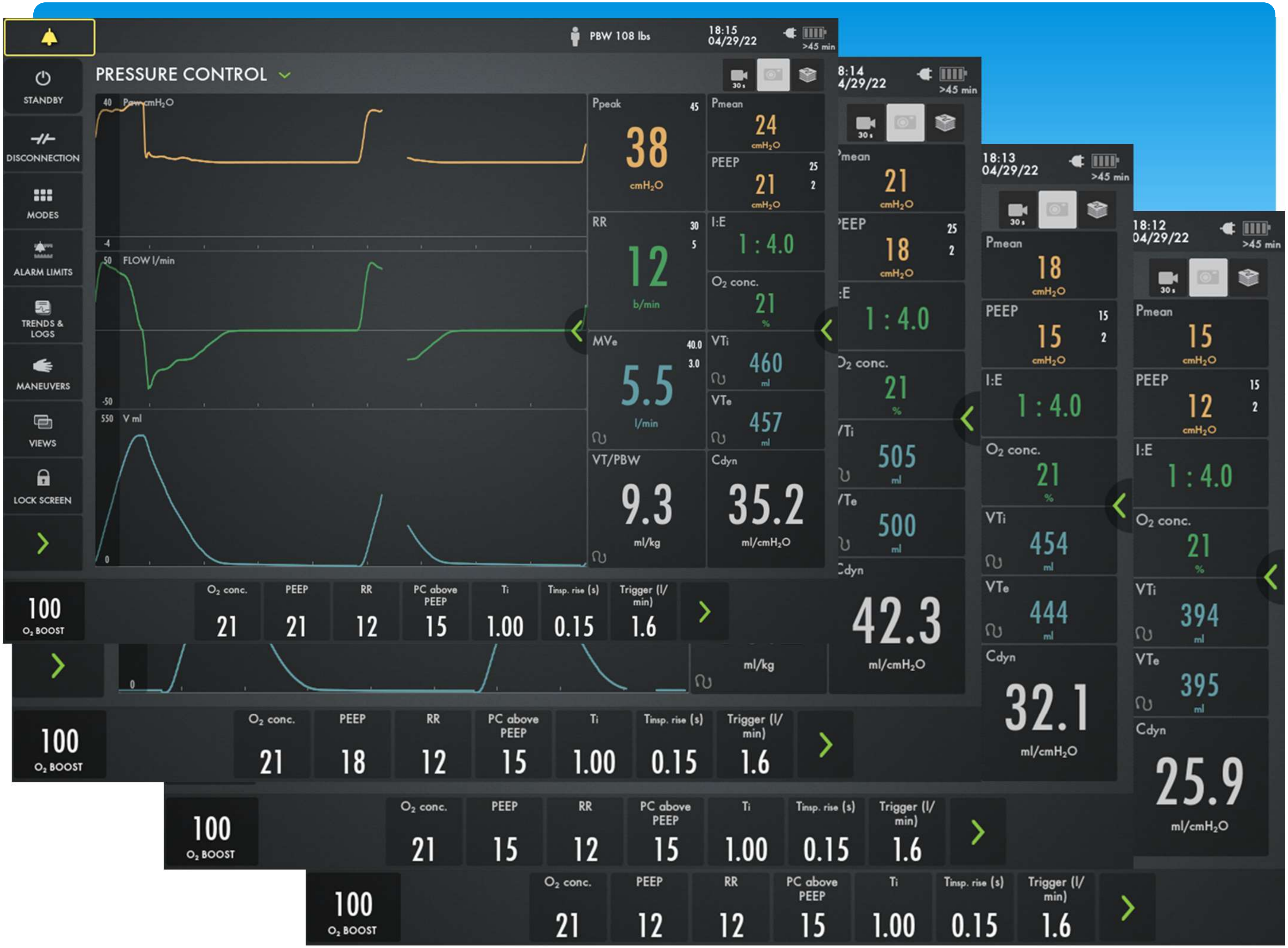


Best Peep
15 Peep



Best Peep
12 Peep





PBW 108 lbs
18:15
04/29/22
>45 min
PRESSURE CONTROL
STANDBY
DISCONNECTION
MODES
ALARM LIMITS
TRENDS & LOGS
MANEUVERS
VIEWS
LOCK SCREEN
Paw cmH₂O
FLOW l/min
V ml
Ppeak 45
38 cmH₂O
Pmean
24 cmH₂O
PEEP 25 2
21 cmH₂O
RR 30 5
12 b/min
I:E
1 : 4.0
O₂ conc.
21 %
MVe 40.0 3.0
5.5 l/min
VTi
460 ml
VTe
457 ml
VT/PBW
9.3 ml/kg
Cdyn
35.2 ml/cmH₂O
100 O₂ BOOST
O₂ conc. 21
PEEP 21
RR 12
PC above PEEP 15
Ti 1.00
Tinsp. rise (s) 0.15
Trigger (l/min) 1.6
18:14
Pmean 21
PEEP 18
1 : 4.0
O₂ conc. 21
VTi 505
VTe 500
Cdyn 42.3 ml/cmH₂O
O₂ conc. 21
PEEP 18
RR 12
PC above PEEP 15
Ti 1.00
Tinsp. rise (s) 0.15
Trigger (l/min) 1.6
18:13
04/29/22
Pmean 18
PEEP 15
I:E 1 : 4.0
O₂ conc. 21
VTi 454
VTe 444
Cdyn 32.1 ml/cmH₂O
O₂ conc. 21
PEEP 15
RR 12
PC above PEEP 15
Ti 1.00
Tinsp. rise (s) 0.15
Trigger (l/min) 1.6
18:12
04/29/22
Pmean 15
PEEP 12
I:E 1 : 4.0
O₂ conc. 21
VTi 394
VTe 395
Cdyn 25.9 ml/cmH₂O
100 O₂ BOOST
O₂ conc. 21
PEEP 12
RR 12
PC above PEEP 15
Ti 1.00
Tinsp. rise (s) 0.15
Trigger (l/min) 1.6

1) "Conclusions: In patients with established acute respiratory distress syndrome, open lung approach improved oxygenation and driving pressure, without detrimental effects on mortality, ventilator-free days, or barotrauma."

Kacmarek RM, Villar J, Sulemanji D, Montiel R, Ferrando C, Blanco J, Koh Y, Soler JA, Martínez D, Hernández M, Tucci M, Borges JB, Lubillo S, Santos A, Araujo JB, Amato MB, Suárez-Sipmann F; Open Lung Approach Network. Open Lung Approach for the Acute Respiratory Distress Syndrome: A Pilot, Randomized Controlled Trial.

Crit Care Med. 2016 Jan;44(1):32-42. doi: 10.1097/CCM.0000000000001383. PMID: 26672923.

https://pubmed.ncbi.nlm.nih.gov/26672923/

2) "We propose that the open lung concept should be applied in patients with severe ARDS with refractory hypoxemia under the ARDSNet protocol, but only if a patient is a responder to recruitment".

Van der Zee, P., Gommers, D. Recruitment Maneuvers and Higher PEEP, the So-Called Open Lung Concept, in Patients with ARDS. Crit Care 23, 73 (2019). https://doi.org/10.1186/s13054-019-2365-1

https://ccforum.biomedcentral.com/articles/10.1186/s13054-019-2365-1

Amato et al NEJM 2015

The NEW ENGLAND JOURNAL of MEDICINE

SPECIAL ARTICLE

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.,

METHODS: Using a statistical tool known as multilevel mediation analysis to analyze individual data from 3562 patients with ARDS enrolled in nine previously reported randomized trials, we examined ΔP as an independent variable associated with survival. In the m
chang
minim
diseas

CONCLUSIONS We found that ΔP was the ventilation variable that best stratified risk. Decreases in ΔP owing to changes in ventilator settings were strongly associated with increased survival.

would be an index more strongly associated with survival than V_T or PEEP in patients who are not actively breathing.

Research Centre for Biomedical Science, St. Michael's Hospital (A.S.S., L.B.), and the Interdepartmental Division of Critical Care Medicine and Department of Medi-

N Engl J Med 2015;372:747-55.

Driving pressure: a marker of severity, a safety limit, or a goal for mechanical ventilation?

Bugedo et al. Critical Care (2017) 21:199
DOI 10.1186/s13054-017-1779-x

Critical Care

VIEWPOINT Open Access

Driving pressure: a marker of severity, a safety limit, or a goal for mechanical ventilation?

Guillermo Bugedo*, Jaime Retamal and Alejandro Bruhn

Current guidelines for lung-protective ventilation in patients with acute respiratory distress syndrome (ARDS) suggest the use of low tidal volumes (Vt), set according to ideal body weight (IBW) of the patient [1], and higher levels of positive end-expiratory pressure (PEEP) to limit ventilator-induced lung injury (VILI) [2, 3]. However, recent studies have shown that ARDS patients who are ventilated according to these guidelines may still be exposed to forces that can induce or aggravate lung injury [4–6].

Airway driving pressure has received considerable attention after a publication by Amato et al. [7] of a complex and innovative statistical analysis of key randomized clinical trials that tested ventilatory settings in patients with ARDS. The analysis showed that driving pressure, as opposed to Vt and PEEP, was the variable that best correlated with survival in patients with ARDS [7]. Since this article, several authors have replicated this hypothesis in different clinical scenarios, to the point of suggesting that driving pressure may be a goal in itself [8].

In this Viewpoint, we review the physiological meaning of driving pressure, look at the current clinical evidence, and discuss the role of driving pressure when setting the ventilator, considering it more as a safety limit than an objective by itself. This discussion is restricted to patients undergoing controlled mechanical ventilation and without spontaneous breathing efforts. During spontaneous ventilation measurements of driving pressure will underestimate the real distending pressure of the respiratory system and it can, therefore, be misleading [9].

Back to basics: what does driving pressure represent?

After the description of the baby lung concept [10], which revealed a physiologically small lungs in patients with ARDS, several studies in the 1990s tested the hypothesis that limiting Vt or airway pressures during mechanical ventilation might improve the outcome of these patients. In a pioneering single center study, Amato et al. were the first to show a reduction in mortality in this setting using a strategy based on maintaining low inspiratory driving pressures (lower than 20 cmH_2O) along low Vt and high PEEP levels [11]. Shortly after, the large multicenter ARDSnet trial showed a decrease in mortality by nearly 25% in more than 800 patients with ARDS when using 6, instead of 12 mL/kg, IBW, confirming that Vt limitation is a fundamental strategy to improve survival of patients with ARDS [1].

However, some controversy was generated about the best way to titrate Vt: IBW, body surface area, lung size, airway pressures, etc. Going further back, the rationale of limiting Vt emerged from the description of the concept of baby lung, which tells us that in ARDS we are facing physiologically small lungs, and not rigid lungs as previously thought [10]. In Gattinoni et al.'s original study, while oxygenation and shunt were correlated with non-aerated tissue, static lung compliance was strongly correlated with the residual aerated lung volume [12], the volume of the baby lung.

With that being said, driving pressure (DP) is the difference between the airway pressure at the end of inspiration (plateau pressure, P_{pl}) and PEEP [7, 13]. In turn, static compliance of the respiratory system (C_{RS}) is the quotient between Vt and driving pressure. Ergo, by simple arithmetic, driving pressure is the quotient between the Vt and C_{RS} of the patient:

$$DP = P_{pl} - PEEP$$

$$C_{RS} = \frac{Vt}{P_{pl} - PEEP} = \frac{Vt}{DP}$$

$$DP = \frac{Vt}{C_{RS}}$$

Thus, driving pressure represents the Vt corrected for the patient's C_{RS}, and using driving pressure as a safety limit may be a better way to adjust Vt in order to

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Although there is insufficient evidence to suggest a specific cutoff value for driving pressure, **we propose 15 cm H2O**, not as a target, but as a safety limit.

"we suggest adjusting ventilatory support with traditional protective parameters, Vt 6–8 mL/kg IBW and moderate PEEP levels, and adjusting them according to driving pressure, which should ideally be below 15 cm H2O"

Bugedo et al. Critical Care (2017) 21:199

Driving pressure: a marker of severity, a safety limit, or a goal for mechanical ventilation?

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Critical Care

VIEWPOINT Open Access

Driving pressure: a marker of severity, a safety limit, or a goal for mechanical

"Driving pressure may be a valuable tool to set PEEP. Independent of the strategy used to titrate PEEP**, changes in PEEP levels should consider the impact on driving pressure,** besides other variables such as gas exchange and hemodynamics [3, 32, 33].

A decrease in driving pressure after increasing PEEP will necessarily reflect recruitment and a decrease in cyclic strain. On the contrary, an increase in driving pressure will suggest a non-recruitable lung"

objective by itself. This discussion is restricted to patients undergoing controlled mechanical ventilation and without spontaneous breathing efforts. During spontaneous ventilation measurements of driving pressure will underestimate the real distending pressure of the respiratory system and it can, therefore, be misleading [9].

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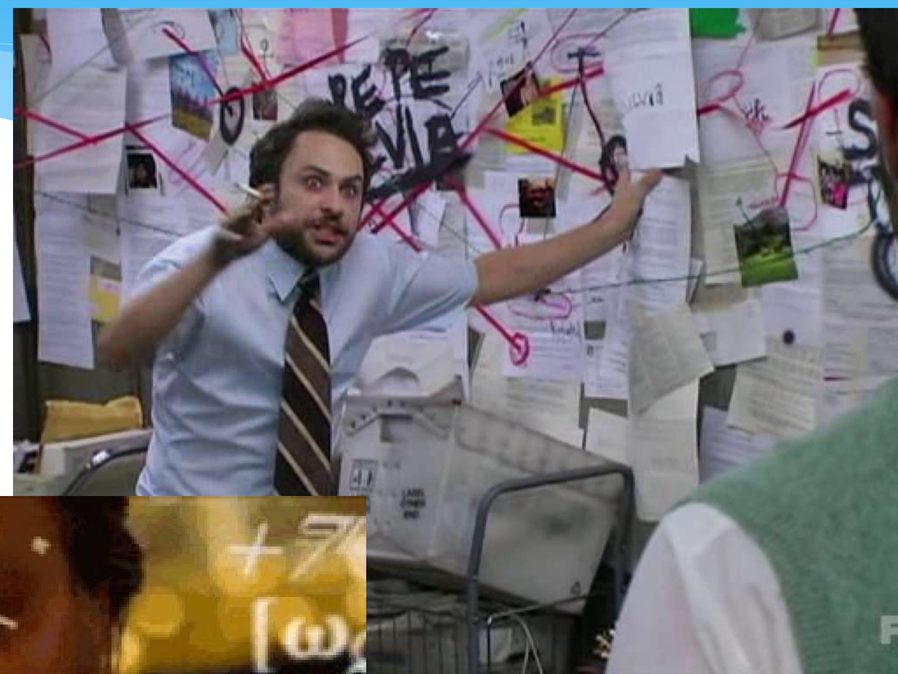
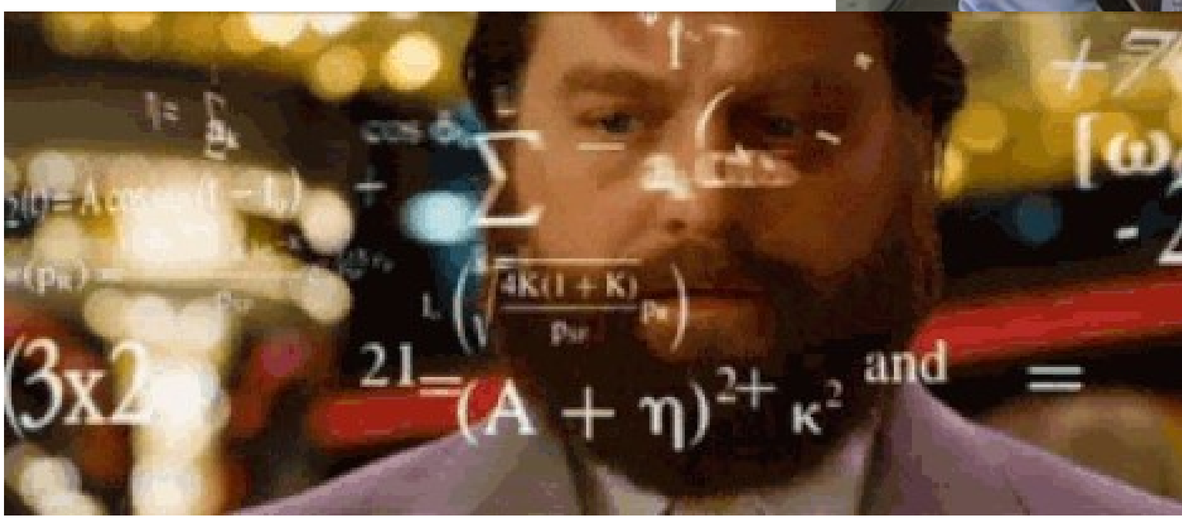
Bugedo et al. Critical Care (2017) 21:199

Driving Pressure

How Do you Calculate?





Driving Pressure

Plateau – Peep = Driving pressure (ΔP)

22 – 7 = 15

Driving Pressure

Driving Pressure 12

Driving Pressure 16

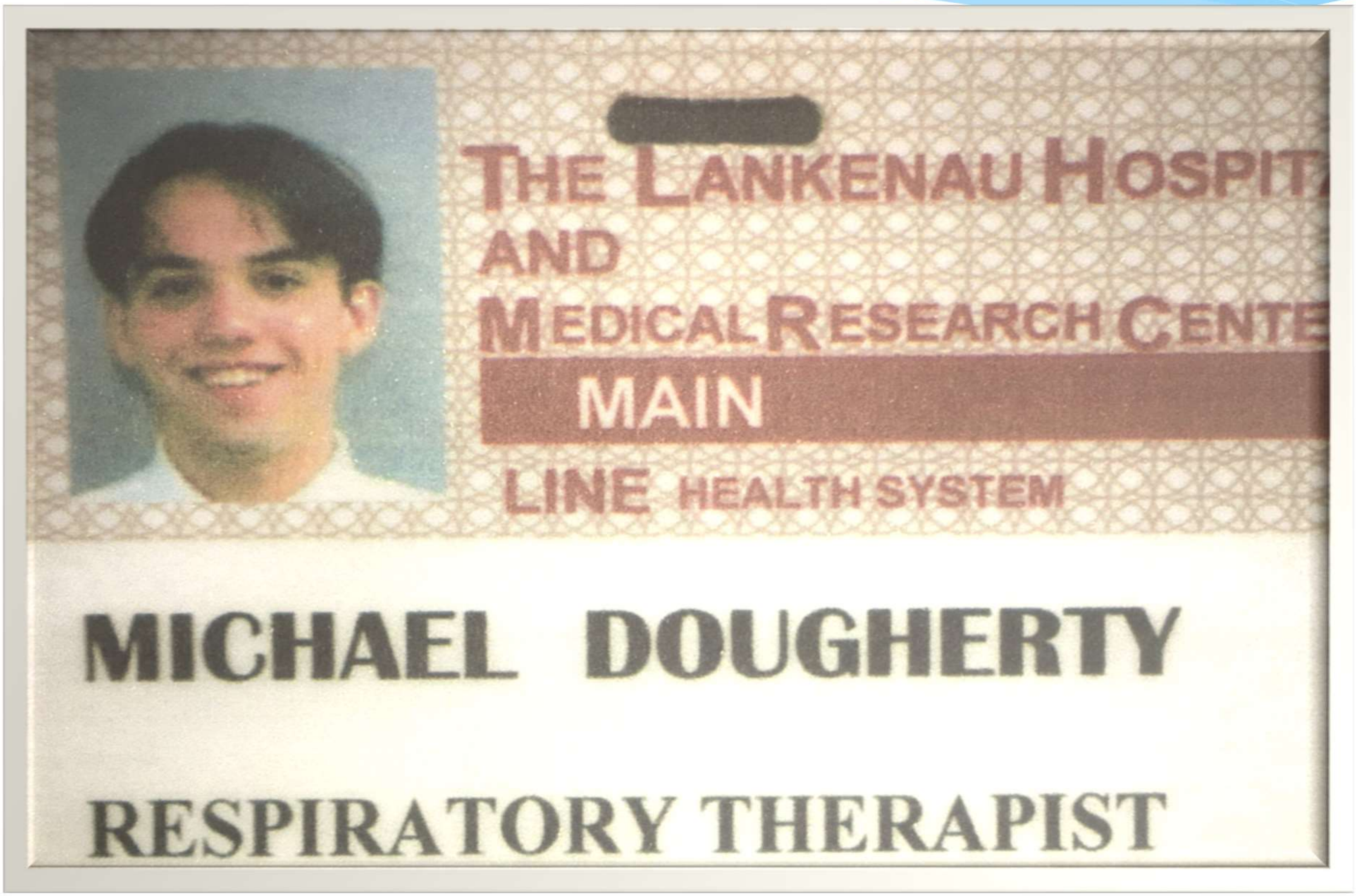
Servo-U 2.1
Pdrive (Driving Pressure) – new numerical value

APRV? Peep? HFO? Inverse I:E

High MAP Strategies

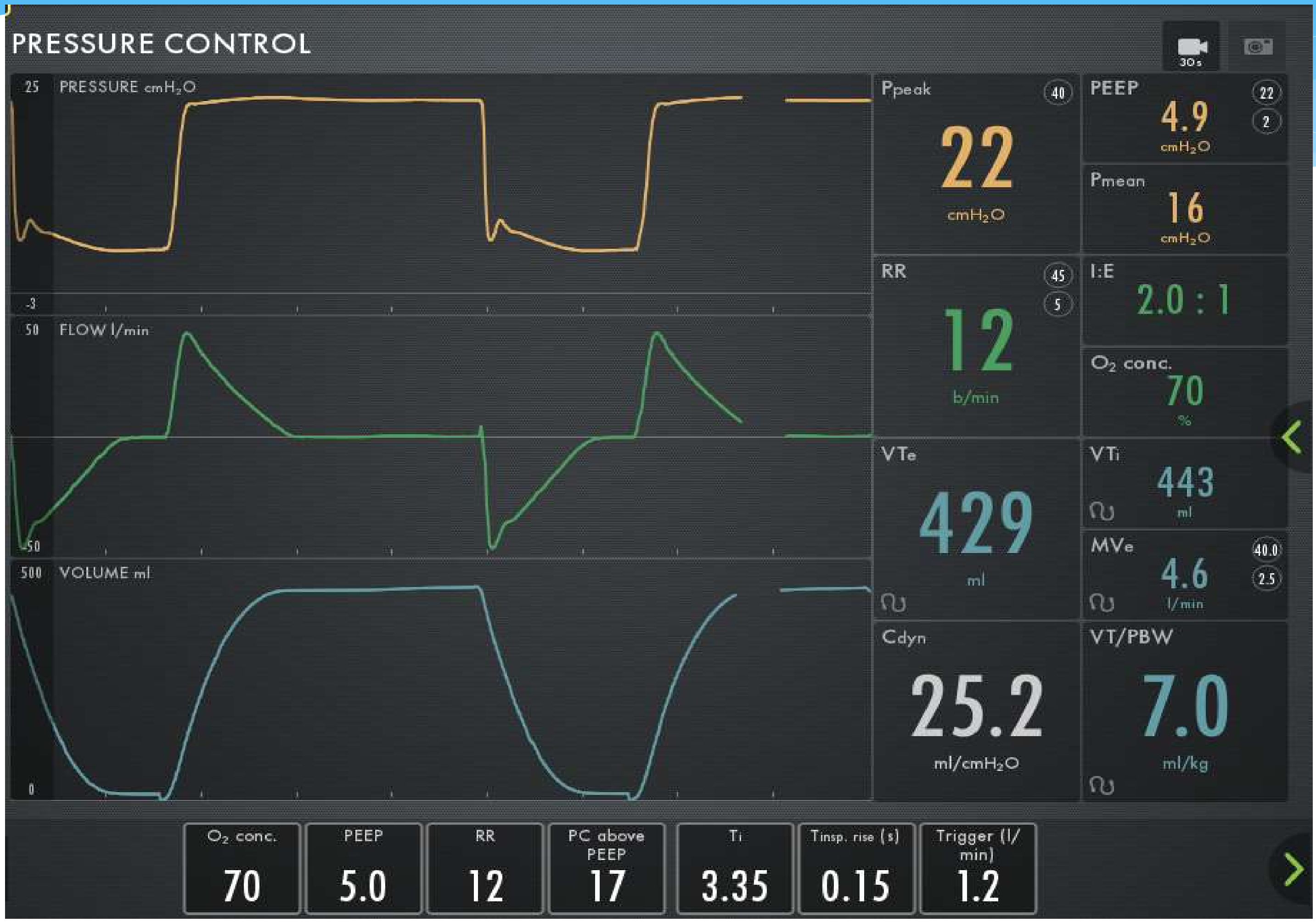
Let’s Go Back to the 90s

1997


THE LANKENAU HOSPIT
AND
MEDICAL RESEARCH CENTE
MAIN
LINE HEALTH SYSTEM
MICHAEL DOUGHERTY
RESPIRATORY THERAPIST

A Long Time Ago…

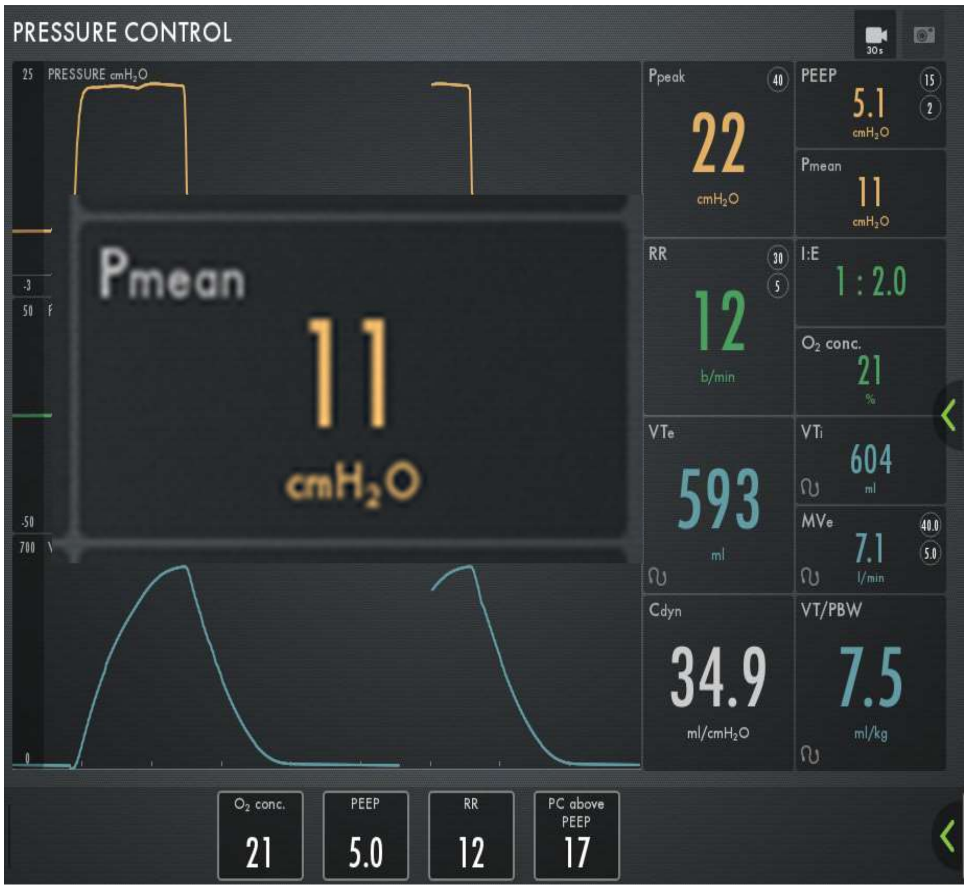
Inverse I:E



PRESSURE CONTROL
25 PRESSURE cmH2O
-3
50 FLOW l/min
-50
500 VOLUME ml
0
Ppeak 40
22
cmH2O
PEEP 22 2
4.9
cmH2O
Pmean
16
cmH2O
RR 45 5
12
b/min
I:E
2.0 : 1
O2 conc.
70
%
VTe
429
ml
VTi
443
ml
MVe 40.0 2.5
4.6
l/min
Cdyn
25.2
ml/cmH2O
VT/PBW
7.0
ml/kg
O2 conc. 70
PEEP 5.0
RR 12
PC above PEEP 17
Ti 3.35
Tinsp. rise (s) 0.15
Trigger (l/min) 1.2

Traditional vs Inverse I:E
What Changes?

1-2 I:E



2-1 I:E

Inverse I:E Unnatural and uncomfortable

Requires Paralysis and/or heavy sedation

Neuromuscular Blockers in Early Acute Respiratory Distress

Laurent Papazian, M.D., Ph.D., Jean-Marie Forel, M.D., Arnaud Gacouin, M.D et al.

ACURASYS Trial

Multicenter, double-blind trial, 340 patients presenting to the intensive care unit (ICU) with an onset of severe ARDS within the previous 48 hours were randomly assigned to receive, for 48 hours, either cisatracurium besylate (178 patients) or placebo (162 patients).

The primary outcome was the proportion of patients who died either before hospital discharge or within 90 days after study enrollment

Treated with volume assist-control mode of ventilation, tidal volumes of 6-8ml/kg of predicted body weight. Target SpO_2 88-95% or PaO_2 55-80mmHg. FiO_2 and PEEP adjusted according to ARMA trial protocol.

In patients with severe ARDS, early administration of a neuromuscular blocking agent improved the adjusted 90-day survival and increased the time off the ventilator without increasing muscle weakness.

N Engl J Med 2010; 363:1107-1116

2019

No Benefit to Early Neuromuscular Blockade in Moderate-to-Severe ARDS
N Engl J Med 2019 May 19 Slutsky AS and Villar J. N Engl J Med 2019 May 19

More than 1000 patients with moderate-to-severe ARDS (partial pressure of oxygen: fraction of inspired oxygen [$PaO_2:FIO_2$], <150) were randomized to 48 hours of either cisatracurium with deep sedation or light sedation without NMB.

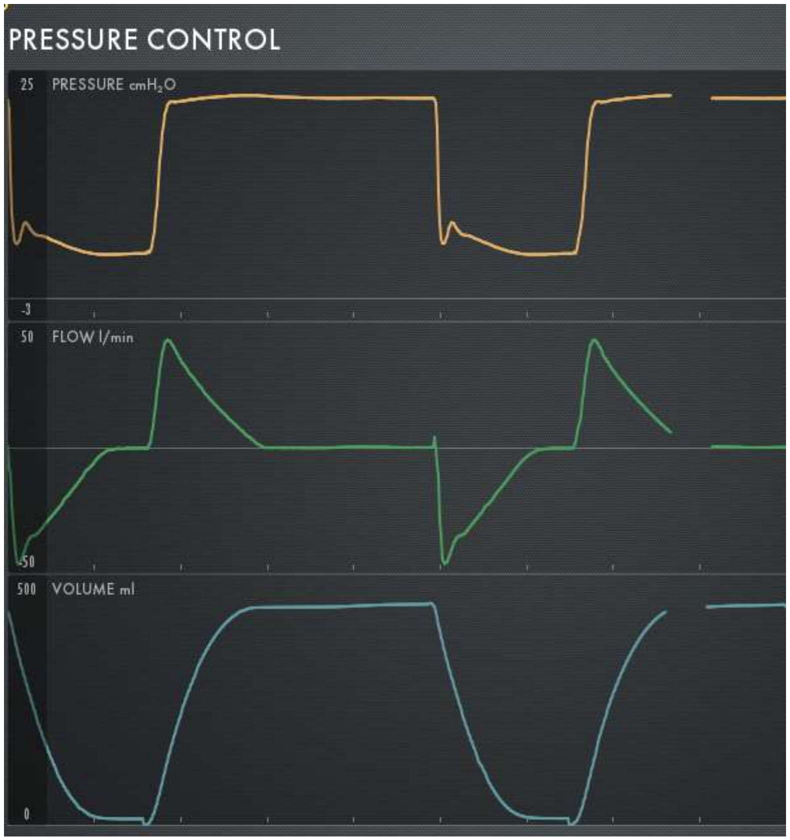
The trial was stopped early for futility. Mortality was quite high (43%) but was not different between groups. Lengths of stay (hospital and intensive care unit) and days free from mechanical ventilation were similar between groups; neuromuscular weakness and patient-reported quality of life at 3, 6, and 12 months also did not differ between groups.

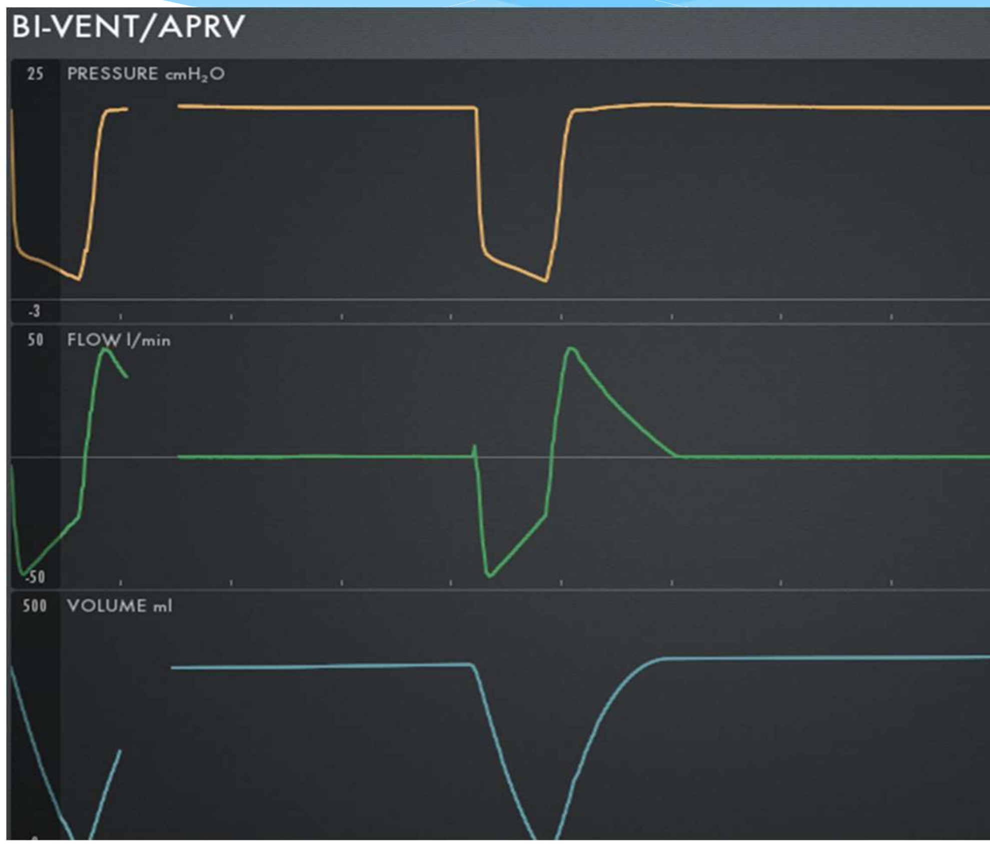
Patients with moderate-to-severe ARDS should not be treated uniformly with early NMB. The editorialists state that NMB still should be considered on an individual basis, particularly for patients with ventilator dyssynchrony.

What Happened to Inverse I:E?

It Became APRV!

Both Are PC With Extended I Time





Airway Pressure Release Ventilation

APRV in 2022

Remains Controversial

1) **“APRV is a mode of mechanical ventilation that has generated enough controversy to fuel a war.”**

Journal ListJ Thorac Disv.10(Suppl 9); 2018

2) **“APRV is the Devil’s Spawn. I'll let that hyperbole be published.”**

Rich Kallet Respiratory Care June 2016

Should Airway Pressure Release Ventilation Be the Primary Mode in ARDS?

3) **Early application of airway pressure release ventilation may reduce the duration of mechanical ventilation in acute respiratory distress syndrome**

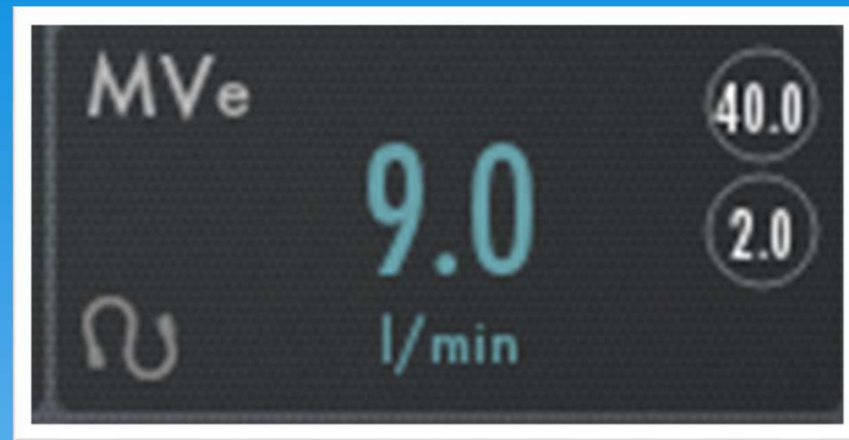
Intensive Care Med. 2017; 43(11): 1648–1659.

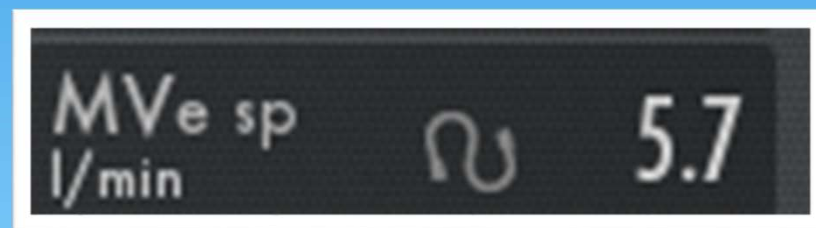
APRV Tips

1. Be aware of spontaneous breathing
2. Note patient's Minute Volume and Spontaneous VE.
3. Make sure you are inverse
4. Get the Time at Peep level right

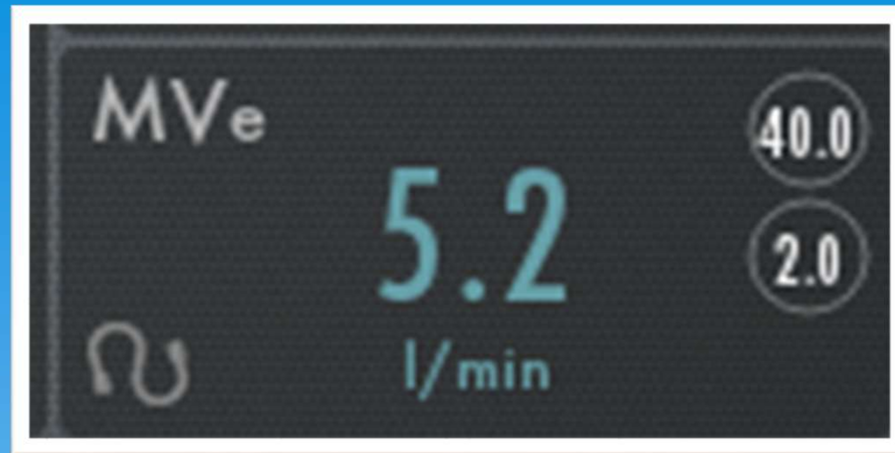
Tip 1: Spontaneous Breathing
Understanding Why APRV Works

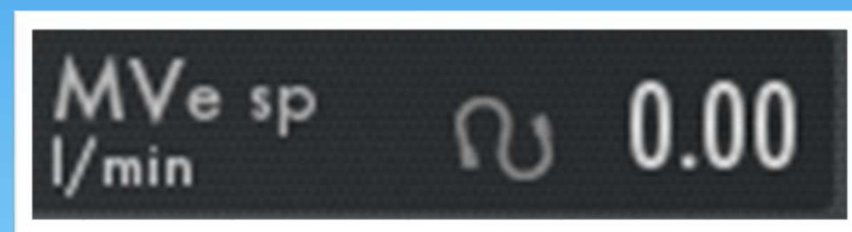

BI-VENT/APRV
PBW 80 kg
PRESSURE cmH2O
FLOW l/min
VOLUME ml
Ppeak
26
cmH2O
PEEP
3.8
Pmean
23
RR
36
b/min
Ti/Ttot
O2 conc.
21
VTe
399
ml
VTi
420
MVe
9.0
l/min
MVe sp/MVe
0.7
VT/PBW
5.0
ml/kg
MVi
RRsp
MVe sp
PEEPtot
Cstatic
E
Re
P 0.1
Tc
O2 conc.
21
PEEP
1.0
Phigh
25
Thigh
4.0
TPEEP
0.60


MVe
9.0
l/min
40.0
2.0


MVe sp
l/min
5.7

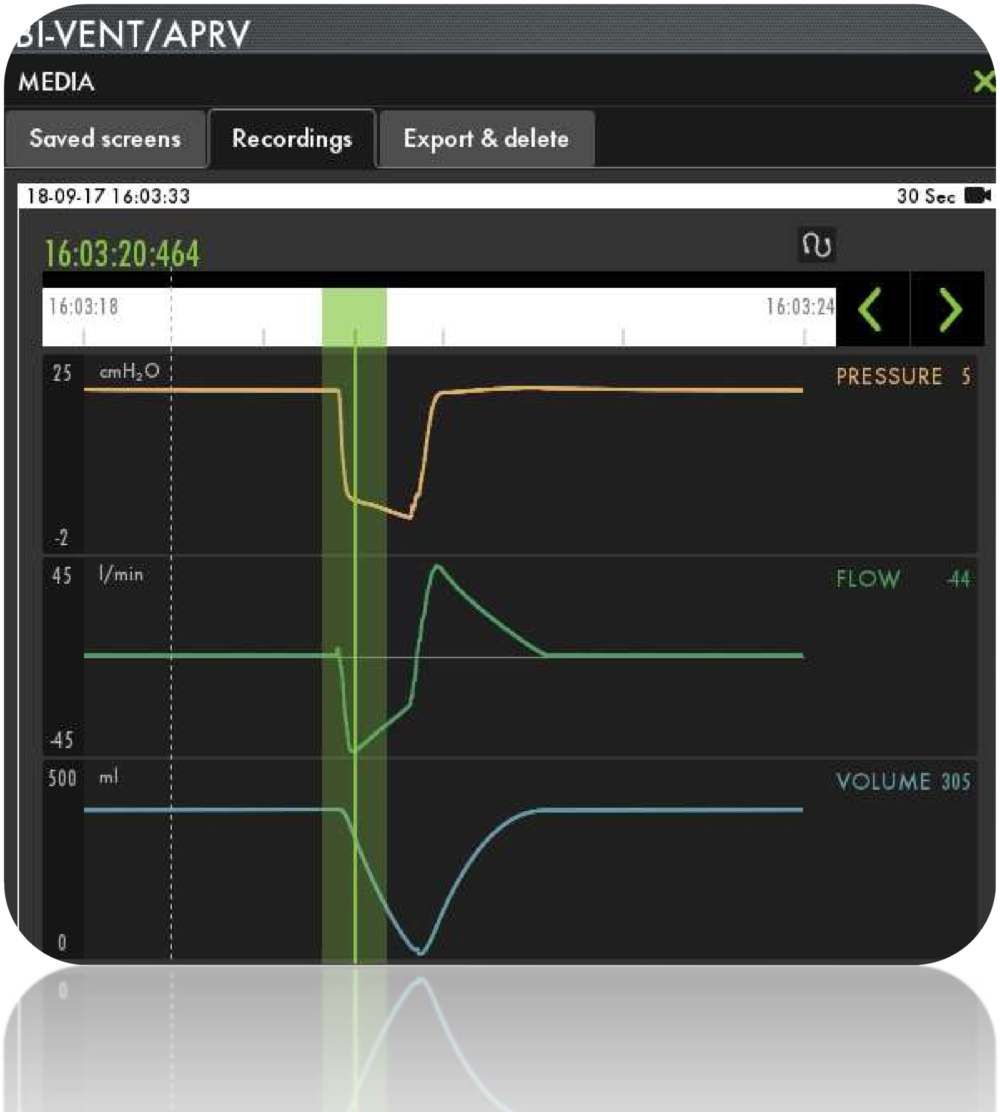

0:18
PBW 80 kg
BI-VENT/APRV
PRESSURE cmH2O
FLOW l/min
VOLUME ml
Ppeak
26
cmH2O
PEEP
4.0
Pmean
23
RR
13
b/min
O2 conc.
21
VTe
401
ml
VTi
429
MVe
5.2
MVe sp/MVe
0.0
VT/PBW
5.0
ml/kg
O2 conc.
21
PEEP
1.0
Phigh
25
Thigh
4.0
TPEEP
0.60


MVe
40.0
5.2
2.0
l/min

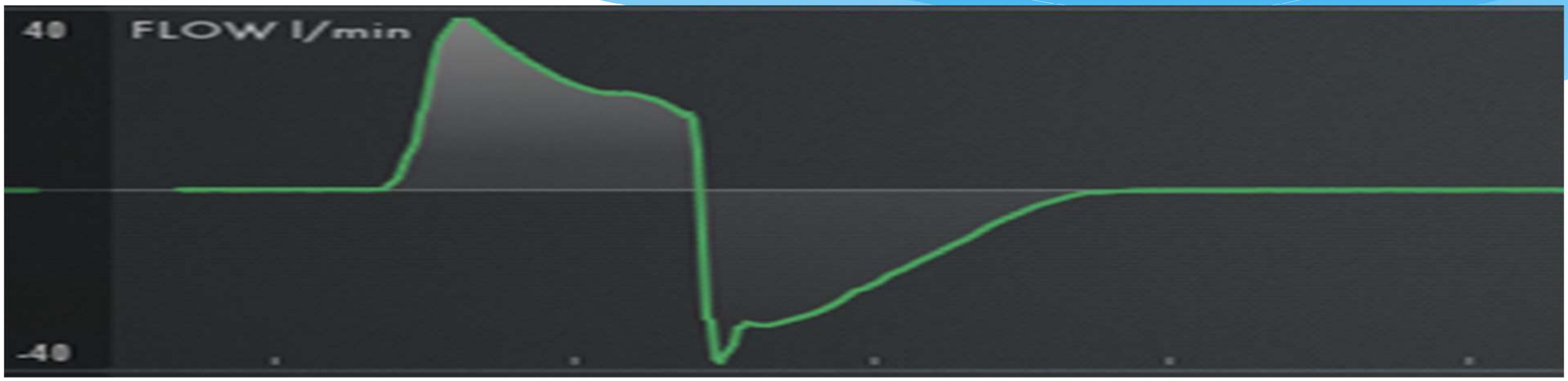

MVe sp
l/min
0.00

Tip 3: Make sure you are inverse

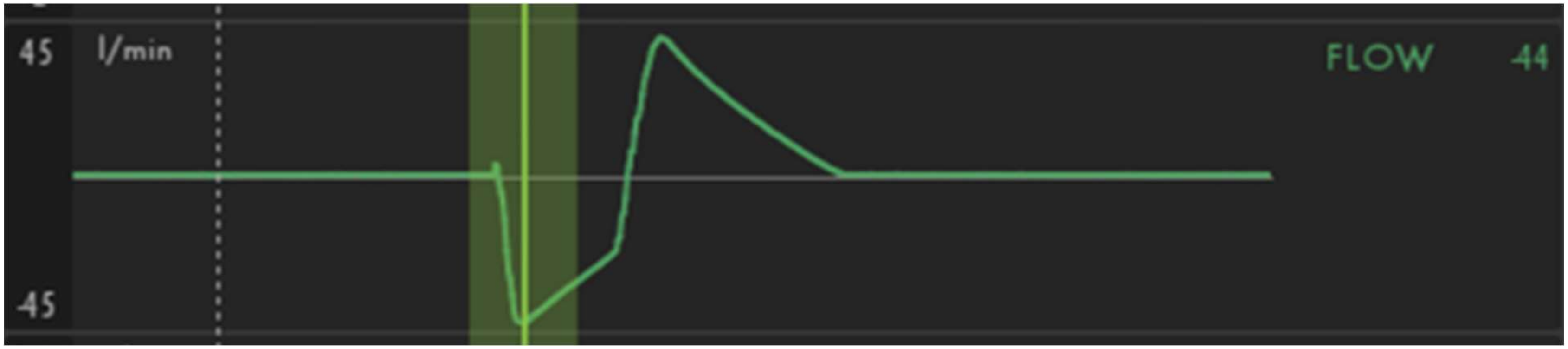
Tip 4 Get the Time at Peep Right



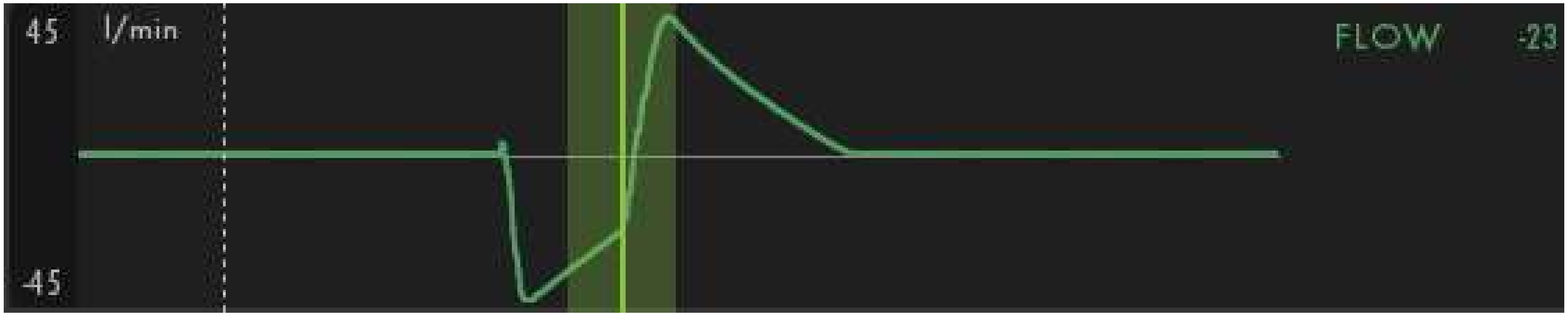
- Note Peak expiratory Flow
- Assure that flow does not return to 0 on exhalation
- Capture between 75-50% of PEF
- Reassess Frequently



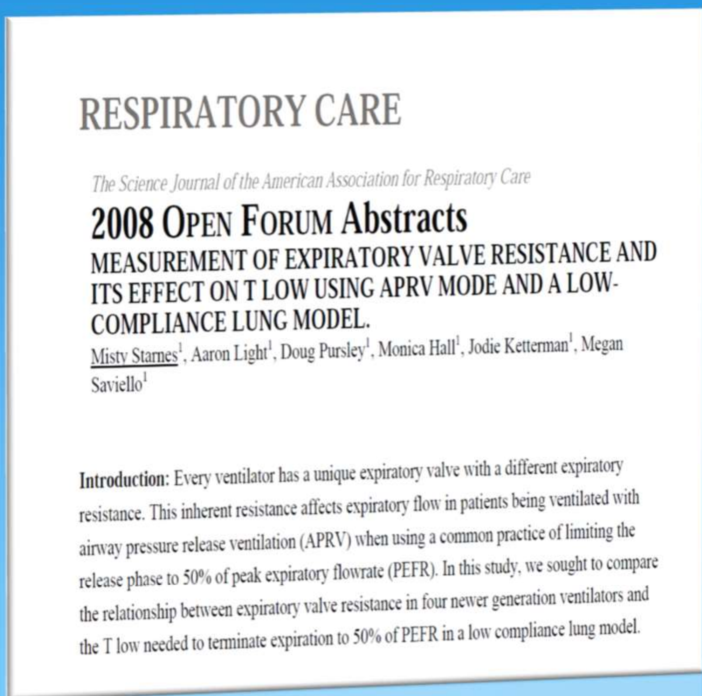
40
FLOW l/min
-40



45
l/min
FLOW
44
-45



45
l/min
FLOW
-23
-45


RESPIRATORY CARE

The Science Journal of the American Association for Respiratory Care

2008 OPEN FORUM Abstracts

MEASUREMENT OF EXPIRATORY VALVE RESISTANCE AND ITS EFFECT ON T LOW USING APRV MODE AND A LOW-COMPLIANCE LUNG MODEL.

Misty Starnes[1], Aaron Light[1], Doug Pursley[1], Monica Hall[1], Jodie Ketterman[1], Megan Saviello[1]

Introduction: Every ventilator has a unique expiratory valve with a different expiratory resistance. This inherent resistance affects expiratory flow in patients being ventilated with airway pressure release ventilation (APRV) when using a common practice of limiting the release phase to 50% of peak expiratory flowrate (PEFR). In this study, we sought to compare the relationship between expiratory valve resistance in four newer generation ventilators and the T low needed to terminate expiration to 50% of PEFR in a low compliance lung model.

2008 OPEN FORUM Abstracts

MEASUREMENT OF EXPIRATORY VALVE RESISTANCE AND ITS EFFECT ON T LOW USING APRV MODE AND A LOWCOMPLIANCE LUNG MODEL.

Misty Starnes, Aaron Light, Doug Pursley, Monica Hall, Jodie Ketterman, Megan Saviello

When we observed the T low needed to achieve 50% of PEFR in our lung model, the results were as follows:

Avea = 0.7 s

840 = 0.63 s

Drager XL = 0.6 s

Servo i = 0.4 s.

http://www.rcjournal.com/abstracts/2008/?id=aarc08_245 12/3/2010

ARDSnet

ARDSnet Low Peep

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

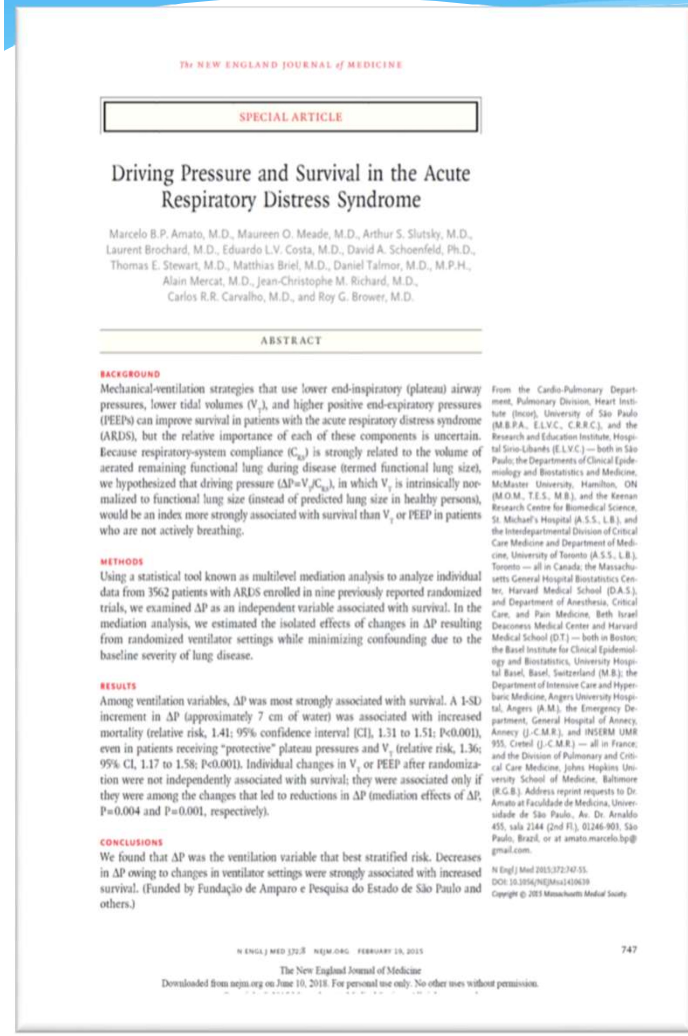
FiO_2	0.5	0.5-0.8	0.8	0.9	1.0	1.0
PEEP	18	20	22	22	22	24

High MAP

PRESSURE CONTROL
BI-VENT/APRV
PRVC
PRVC
PRESSURE cmH2O
FLOW l/min
VOLUME ml
Ppeak
22
cmH2O
PEEP
4.9
Pmean
8
RR
12
b/min
I:E
1 : 4.0
O2 conc.
71
VTe
386
ml
VTi
405
MVe
4.6
l/min
Cdyn
22.4
ml/cmH2O
VT/PBW
6.3
ml/kg
O2 conc.
70
PEEP
5.0
RR
12
Tidal volume
400
PEEP
14
Pmean
16
I:E
1 : 4.0
O2 conc.
71
VTi
411
MVe
4.7
VT/PBW
6.4
2.4
17
72
375
3.1
5.8
4.9
16
2.0 : 1
70
443
4.6
7.0

Homework

Print Out and Take Back This Evidence



The NEW ENGLAND JOURNAL *of* MEDICINE

SPECIAL ARTICLE

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.

ABSTRACT

BACKGROUND

Mechanical-ventilation strategies that use lower end-inspiratory (plateau) airway pressures, lower tidal volumes (V_T), and higher positive end-expiratory pressures (PEEPs) can improve survival in patients with the acute respiratory distress syndrome (ARDS), but the relative importance of each of these components is uncertain. Because respiratory-system compliance (C_{RS}) is strongly related to the volume of aerated remaining functional lung during disease (termed functional lung size), we hypothesized that driving pressure ($\Delta P = V_T/C_{RS}$), in which V_T is intrinsically normalized to functional lung size (instead of predicted lung size in healthy persons), would be an index more strongly associated with survival than V_T or PEEP in patients who are not actively breathing.

METHODS

Using a statistical tool known as multilevel mediation analysis to analyze individual data from 3562 patients with ARDS enrolled in nine previously reported randomized trials, we examined ΔP as an independent variable associated with survival. In the mediation analysis, we estimated the isolated effects of changes in ΔP resulting from randomized ventilator settings while minimizing confounding due to the baseline severity of lung disease.

RESULTS

Among ventilation variables, ΔP was most strongly associated with survival. A 1-SD increment in ΔP (approximately 7 cm of water) was associated with increased mortality (relative risk, 1.41; 95% confidence interval [CI], 1.31 to 1.51; $P<0.001$), even in patients receiving "protective" plateau pressures and V_T (relative risk, 1.36; 95% CI, 1.17 to 1.58; $P<0.001$). Individual changes in V_T 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 (mediation effects of ΔP, $P=0.004$ and $P=0.001$, respectively).

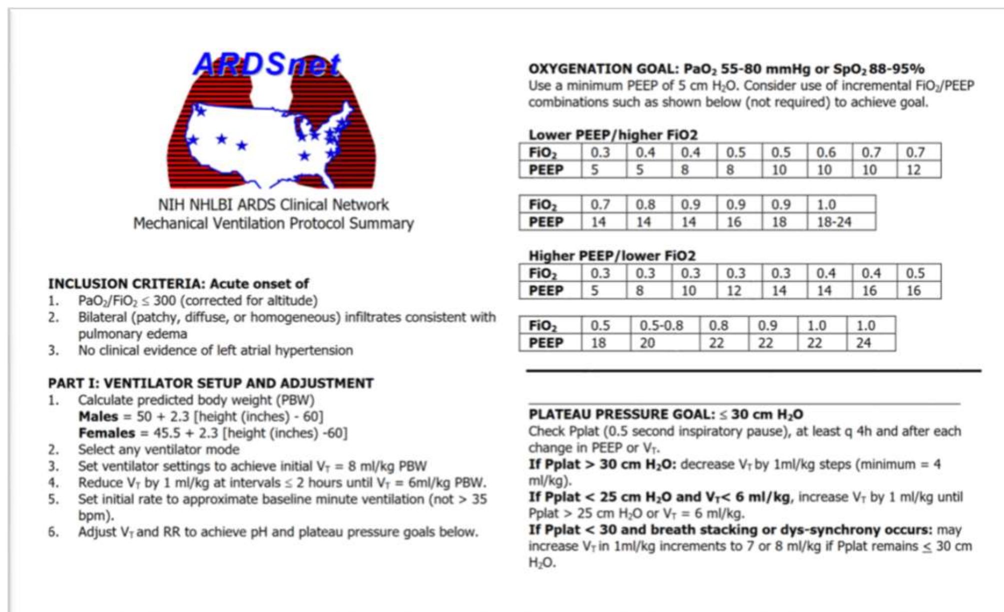
CONCLUSIONS

We found that ΔP was the ventilation variable that best stratified risk. Decreases in ΔP owing to changes in ventilator settings were strongly associated with increased survival. (Funded by Fundação de Amparo e Pesquisa do Estado de São Paulo and others.)

From the Cardio-Pulmonary Department, Pulmonary Division, Heart Institute (Incor), University of São Paulo (M.B.P.A., E.L.V.C., C.R.R.C.), and the Research and Education Institute, Hospital Sírio-Libanês (E.L.V.C.) — both in São Paulo; the Departments of Clinical Epidemiology and Biostatistics and Medicine, McMaster University, Hamilton, ON (M.O.M., T.E.S., M.B.), and the Keenan Research Centre for Biomedical Science, St. Michael's Hospital (A.S.S., L.B.), and the Interdepartmental Division of Critical Care Medicine and Department of Medicine, University of Toronto (A.S.S., L.B.), Toronto — all in Canada; the Massachusetts General Hospital Biostatistics Center, Harvard Medical School (D.A.S.), and Department of Anesthesia, Critical Care, and Pain Medicine, Beth Israel Deaconess Medical Center and Harvard Medical School (D.T.) — both in Boston; the Basel Institute for Clinical Epidemiology and Biostatistics, University Hospital Basel, Basel, Switzerland (M.B.); the Department of Intensive Care and Hyperbaric Medicine, Angers University Hospital, Angers (A.M.), the Emergency Department, General Hospital of Annecy, Annecy (J.-C.M.R.), and INSERM UMR 955, Creteil (J.-C.M.R.) — all in France; and the Division of Pulmonary and Critical Care Medicine, Johns Hopkins University School of Medicine, Baltimore (R.G.B.). Address reprint requests to Dr. Amato at Faculdade de Medicina, Universidade de São Paulo, Av. Dr. Arnaldo 455, sala 2144 (2nd Fl.), 01246-903, São Paulo, Brazil, or at amato.marcelo.bp@gmail.com.

N Engl J Med 2015;372:747-55.
DOI: 10.1056/NEJMoa1410639

1) NEJM Driving pressure and Survival 2015
2) ARDS.net Ventilator Protocol card



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
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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

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.
If Pplat > 30 cm H_2O: decrease V_T by 1ml/kg steps (minimum = 4 ml/kg).
If Pplat < 25 cm H_2O and V_T< 6 ml/kg, increase V_T by 1 ml/kg until Pplat > 25 cm H_2O or V_T = 6 ml/kg.
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.

Summary

* Don't neglect MAP! Have A High MAP strategy you are comfortable with in your facility.
* Be sure to use enough Peep. Print and carry ARDSnet
* Try to determine best Peep. Practice on a test lung.
* Embrace Driving pressure <15

Thank You!