The Use of Ventilator Graphics to Optimize Mechanical Ventilation During ARDS

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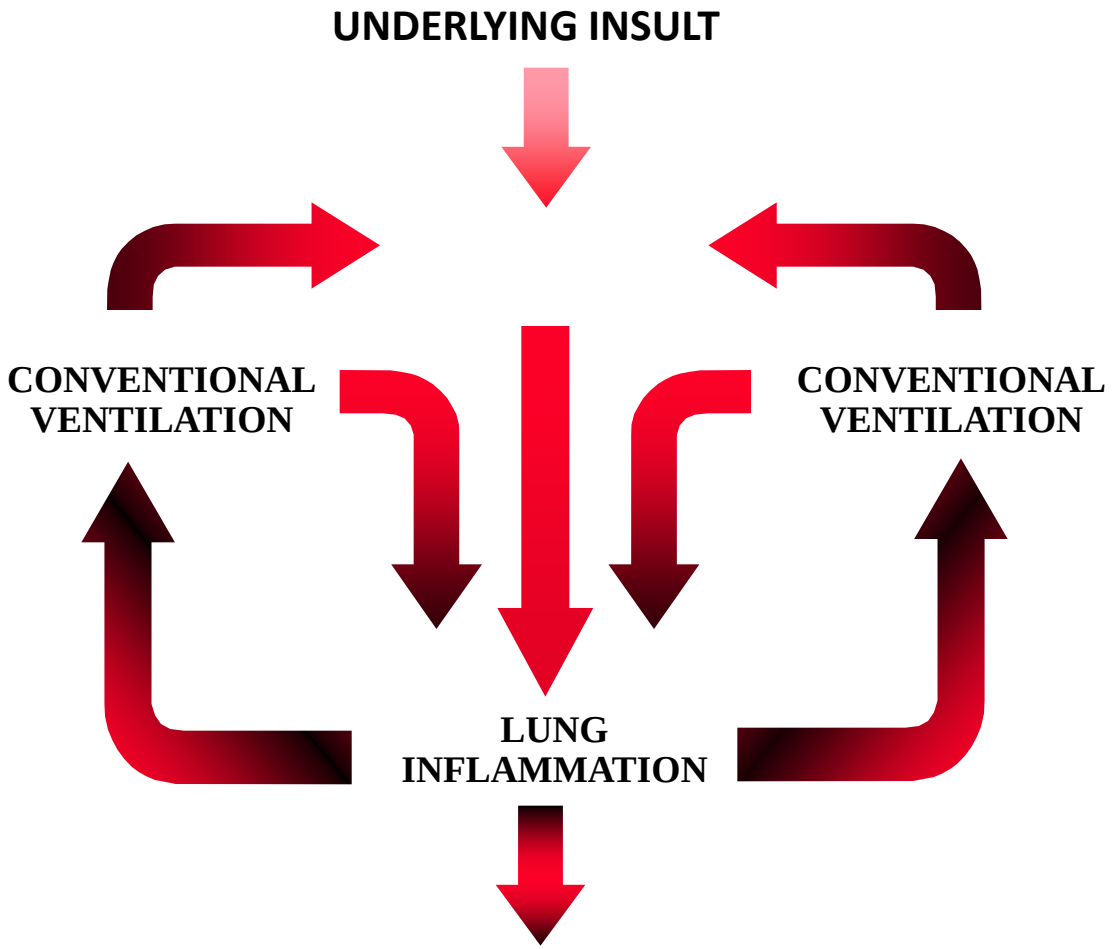
Presenter Disclosure Information

John Davies MA RRT FAARC:

Within the past 12 months, the presenter has had a financial interest/arrangement or affiliation with the organizations listed below:

Teleflex	Consultant
Philips Healthcare	Advisory Board

Pathogenesis of ARDS



Ventilator Graphics and ARDS

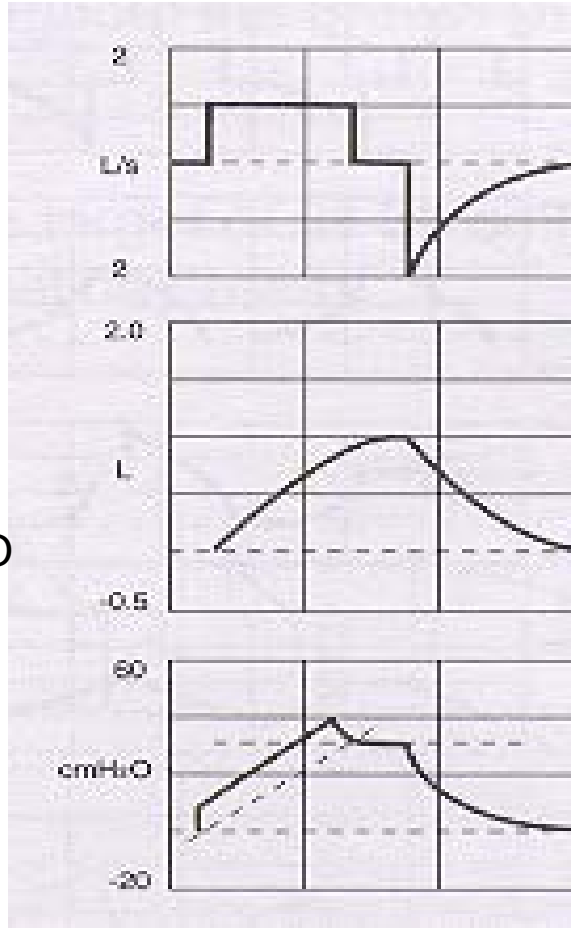
- Pressure-Volume Graphics
  - Traditional
  - Slow flow
  - Stress index
- Airway vs Trans-Pulmonary Pressure
- Patient Ventilator Synchrony

Traditional Airway Graphics

Peak-Pplat = flow P
=10 cm H2O

Pplat = resp system distention
= 30 cm H2O

Crs = V/Pplat
= 1000/30 = 33 ml/cm H2O



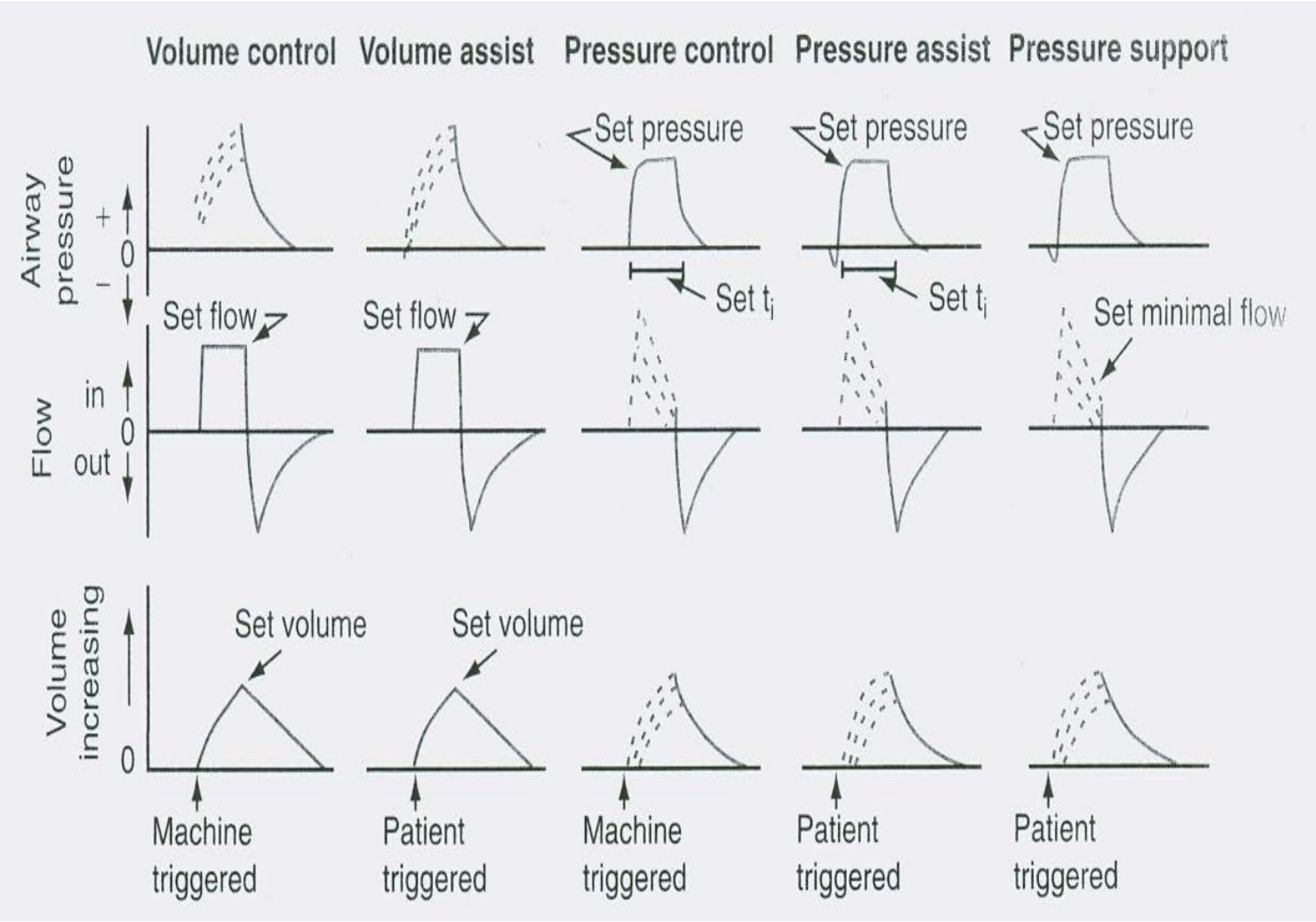
V’

V

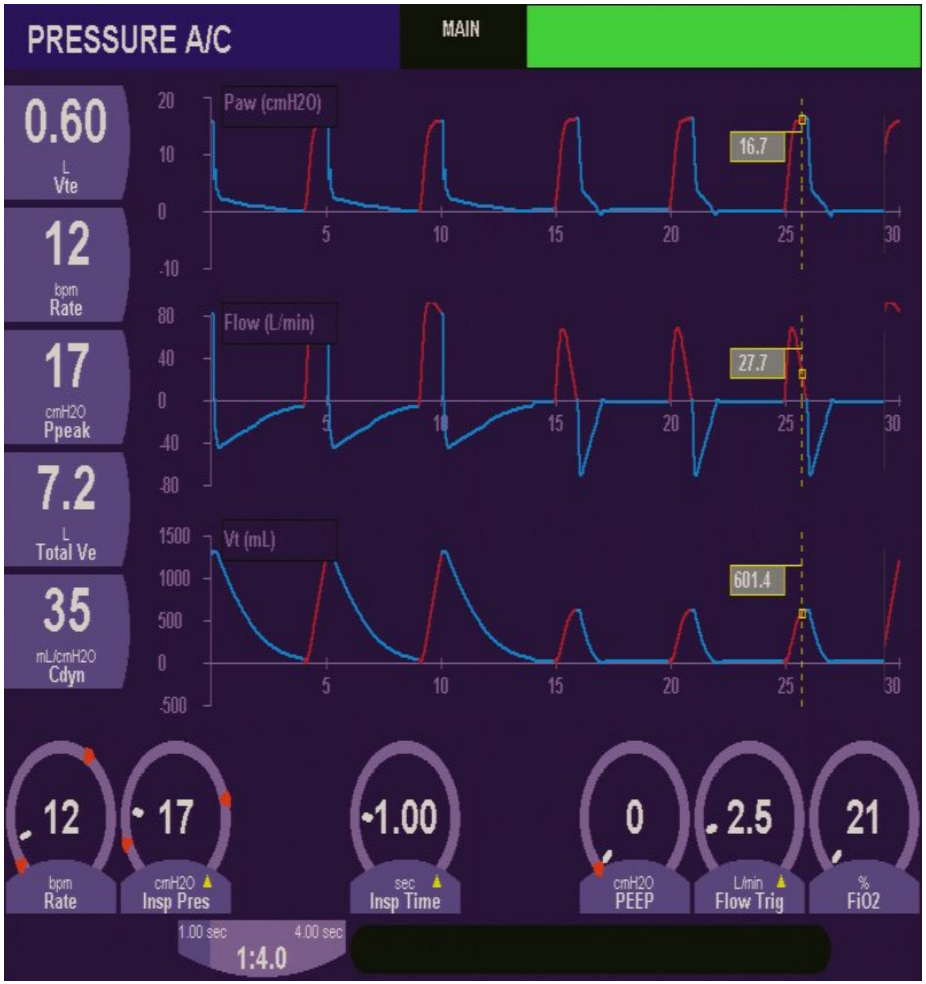
Paw

“Protective” targets = VT< 6 ml/kg AND:
Pplat < 30 cm H2O, “Best” compliance titration with PEEP

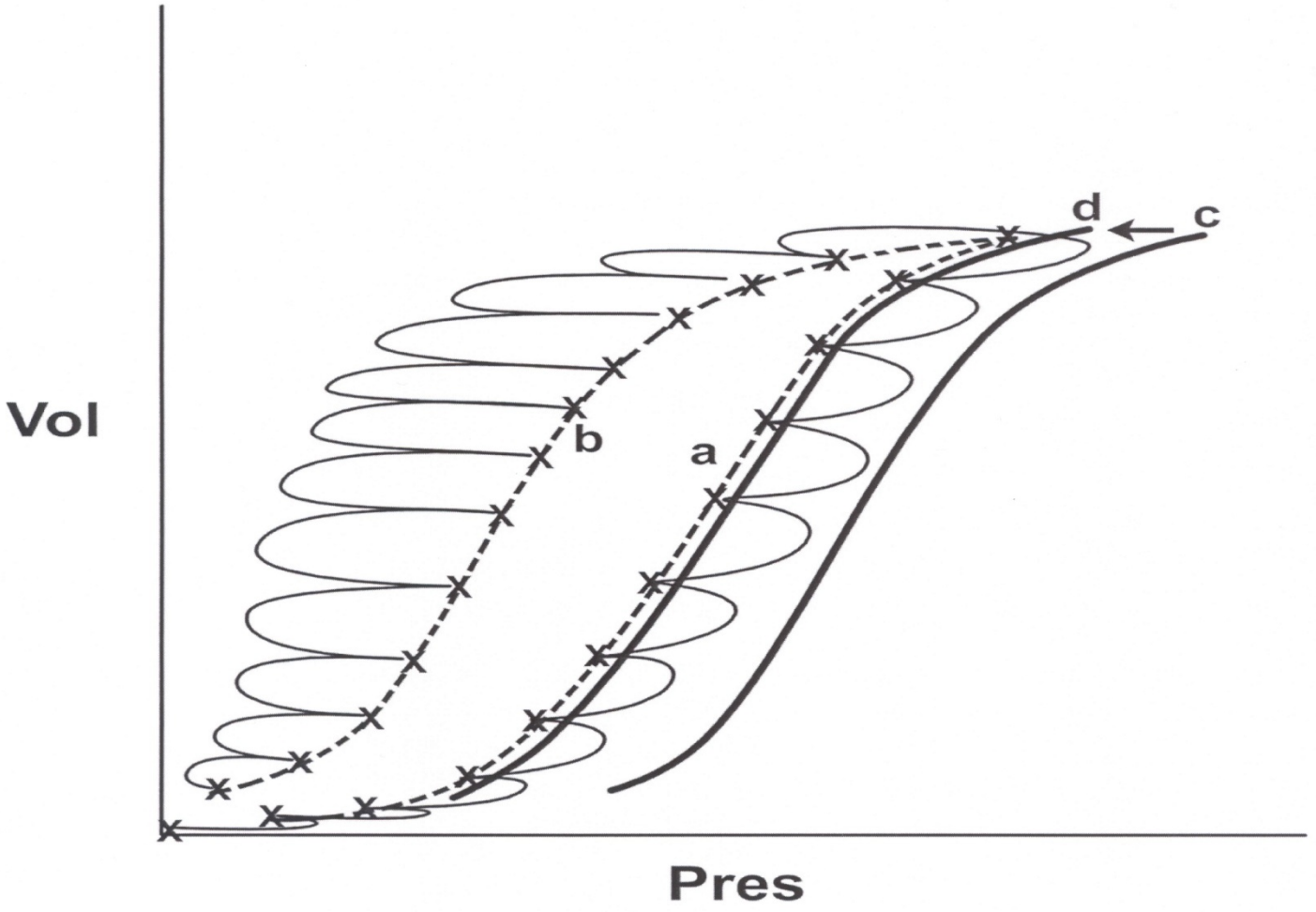
Breath Characteristics



Decreased Compliance



Slow Flow Maneuver

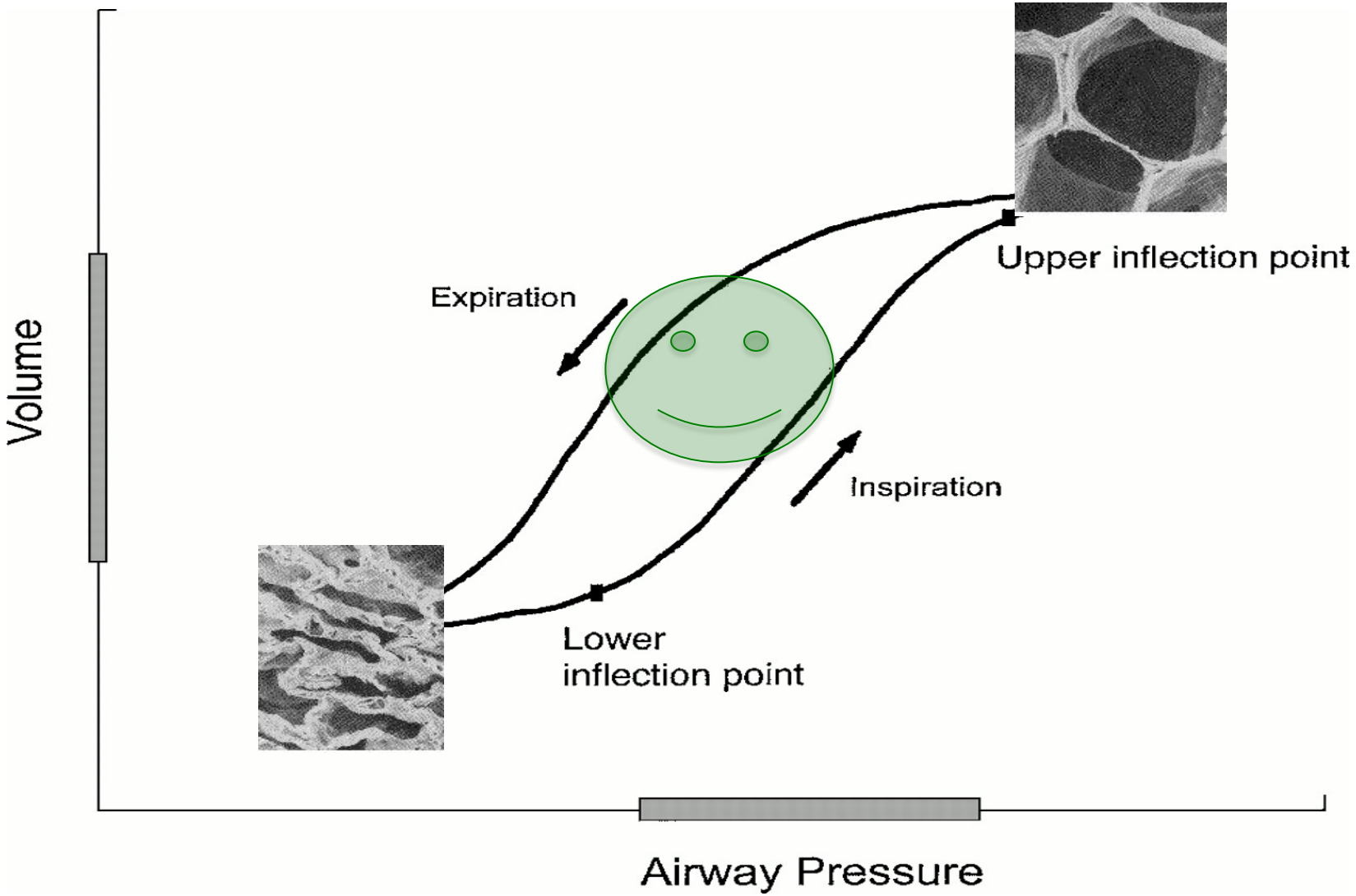


a,b = static

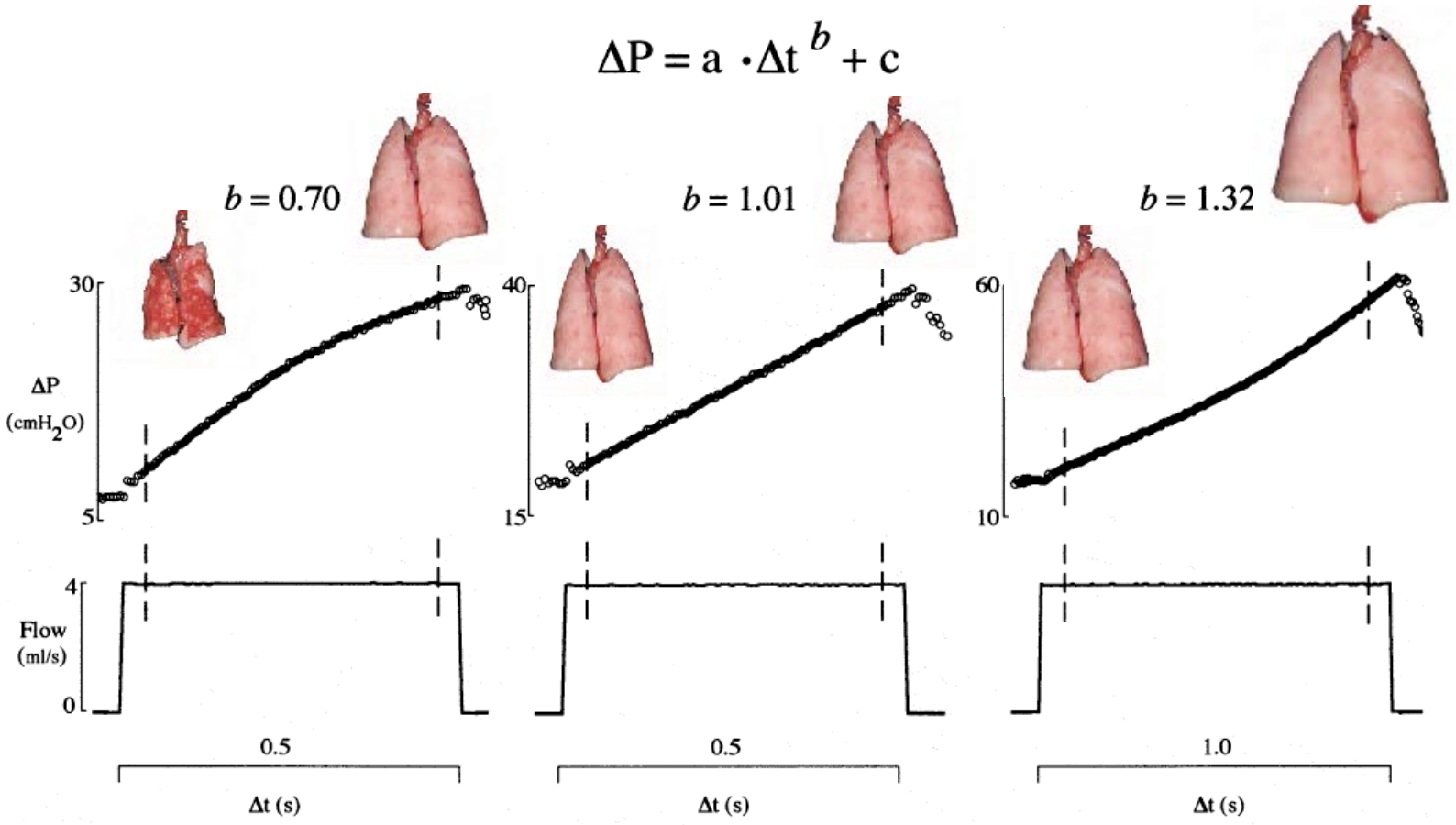
c = 60L/min

d = 10L/min

Overdistention/Under-recruitment injury



Stress Index



Airway Pressure Release Ventilation (APRV)

- Long periods of inspiratory phase followed by brief pressure releases or deflation periods

  P_{high} = CPAP

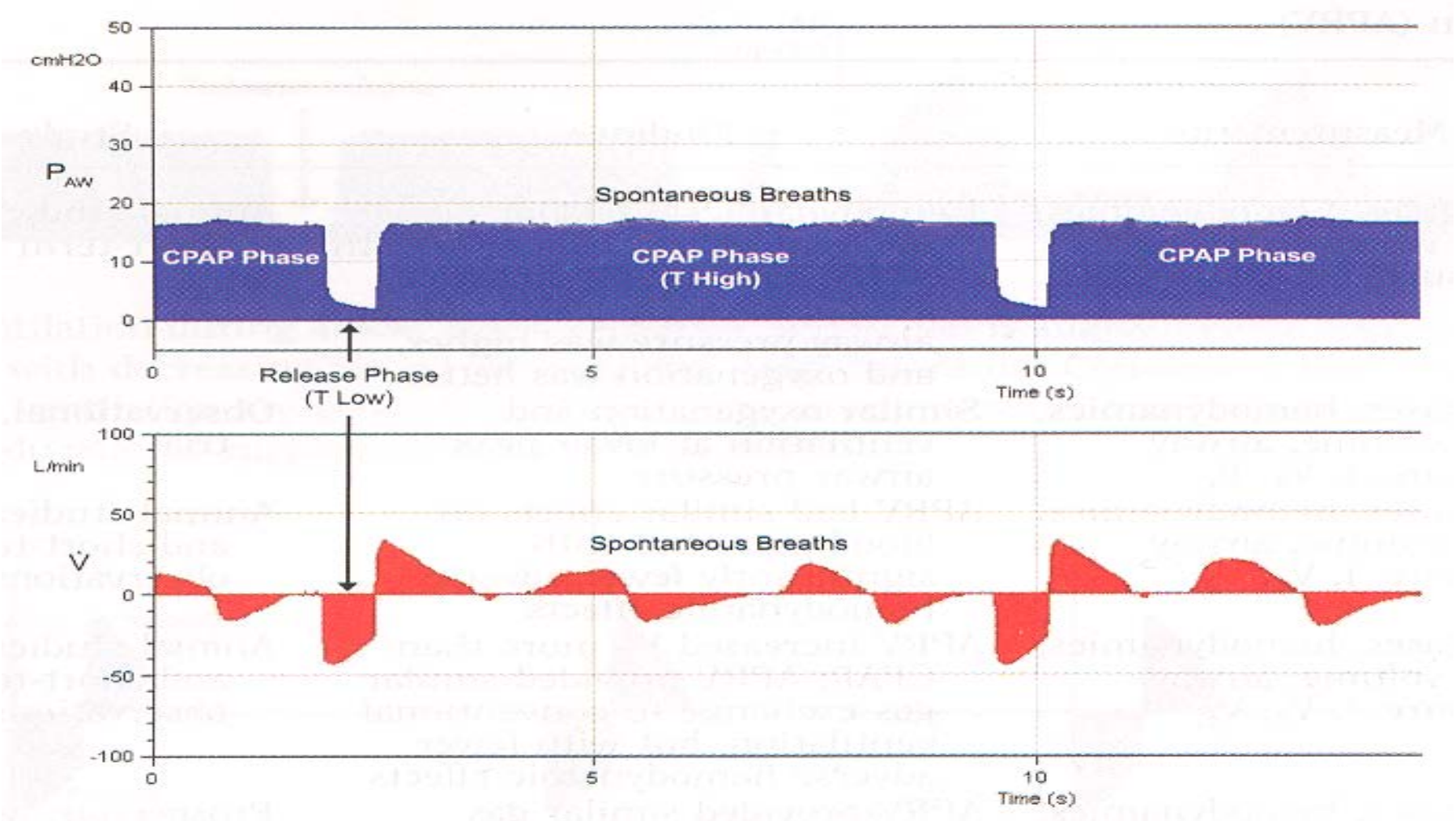
  P_{low} = Release Pressure

  T_{high} = Time at P_{high}

  T_{low} = Time at P_{low}

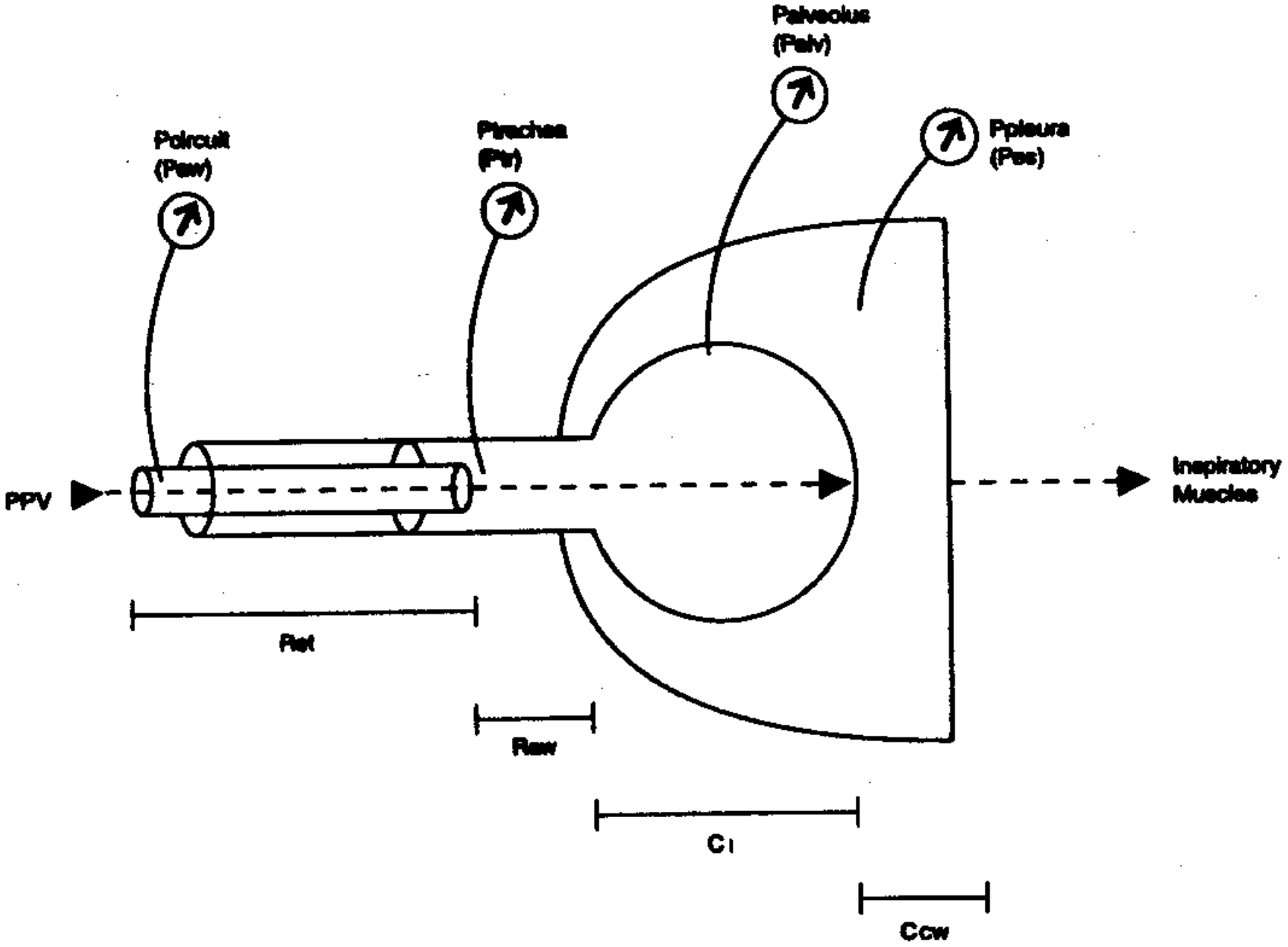
- Patients can breath spontaneously at P_{high}

APRV: pressure target/spont breaths

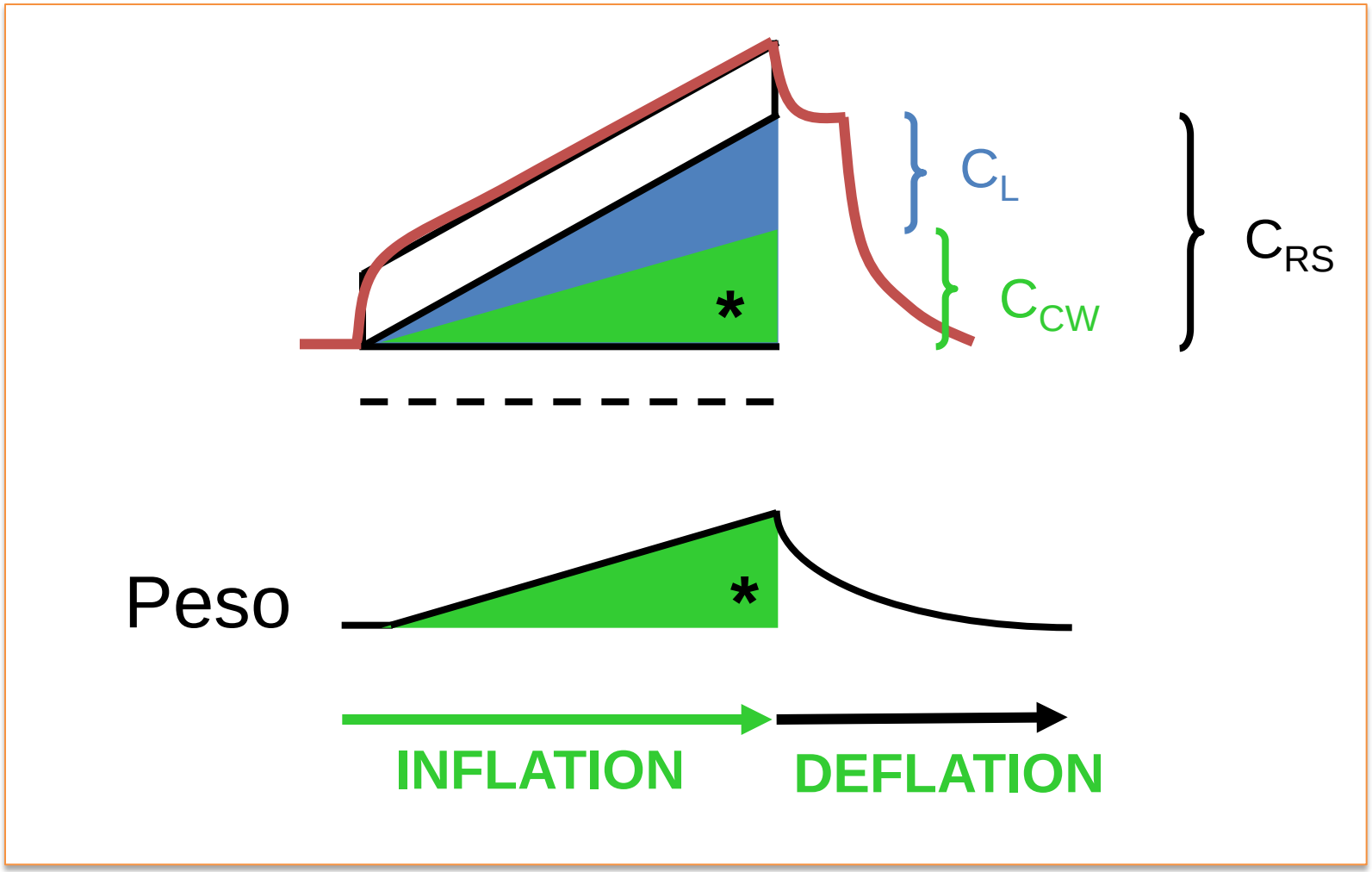


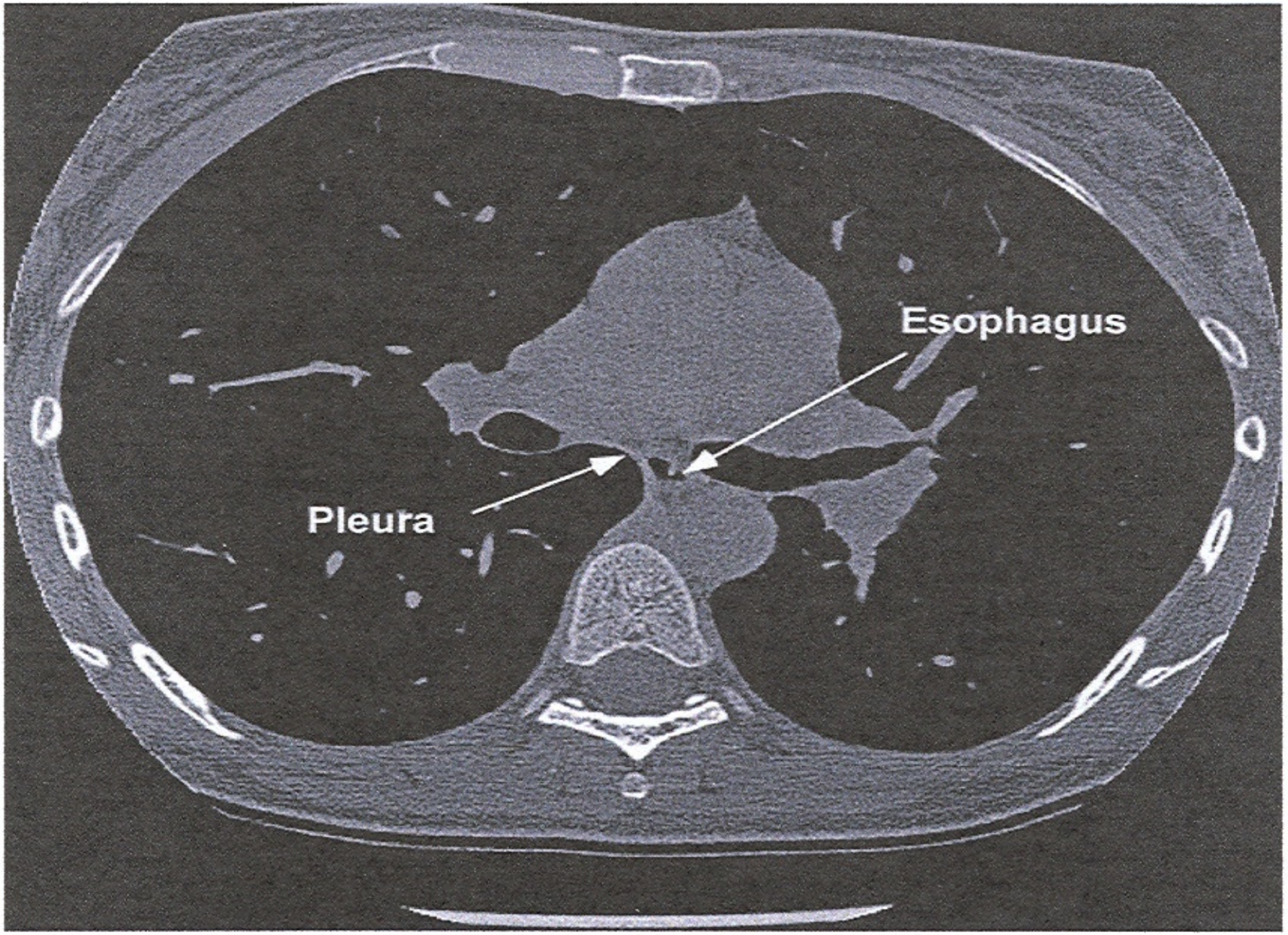
Ventilator Graphics and ARDS

- Pressure-Volume Graphics
  - Traditional
  - Slow flow
  - Stress index
  - APRV
- Airway vs Trans-Pulmonary Pressure
- Patient Ventilator synchrony


Palveolus
(Palv)
Paircuit
(Paw)
Pirachea
(Pit)
Ppleura
(Ppl)
PPV
Inspiratory
Muscles
Ret
Raw
Cl
Ccw

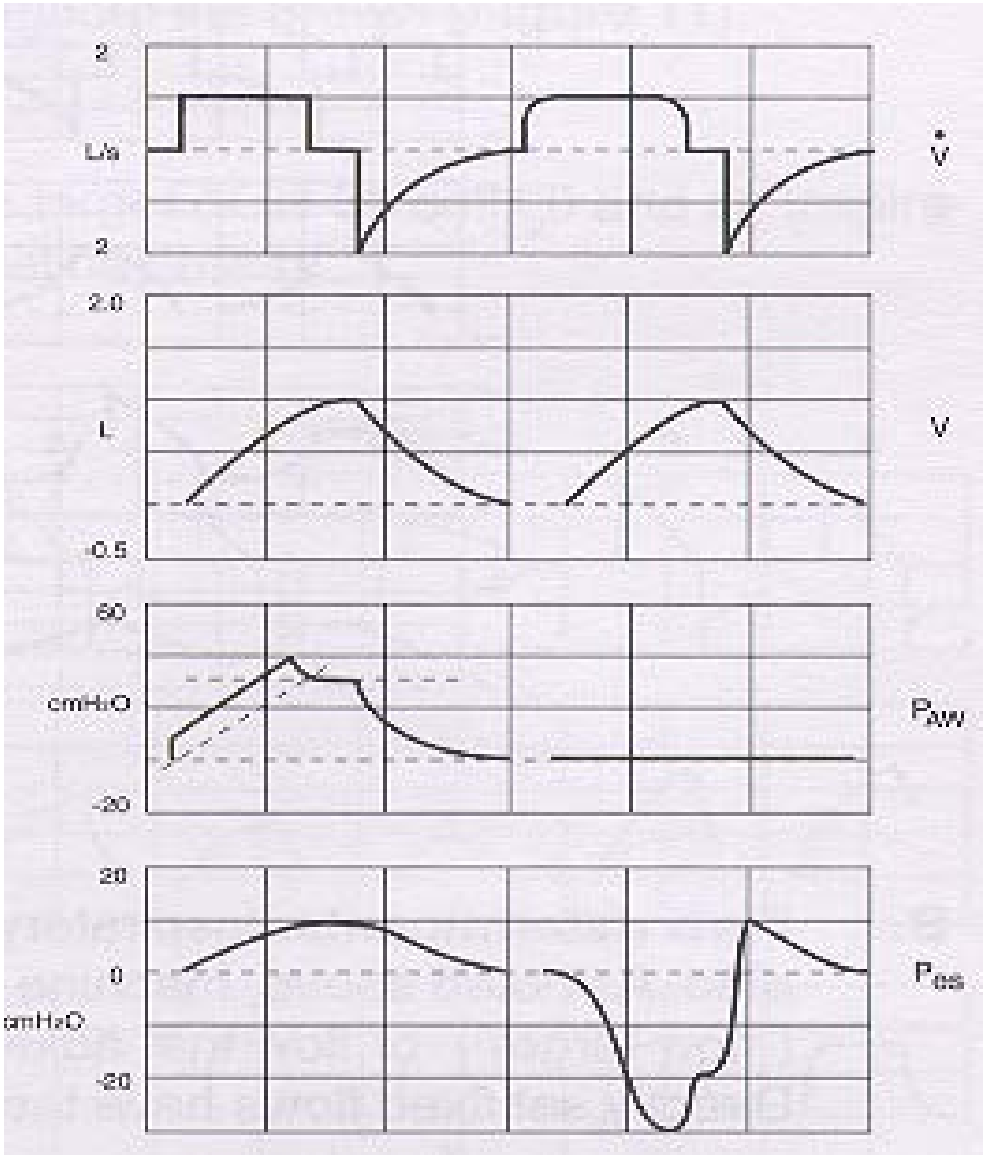
Volume Assist Control




Esophagus
Pleura

Separating Pressures Related to R, Cl, and Ccw

Pes during machine breath reflects passive “push” against Ccw. Pes during spontaneous breath reflects active “pull” against Cl and R.



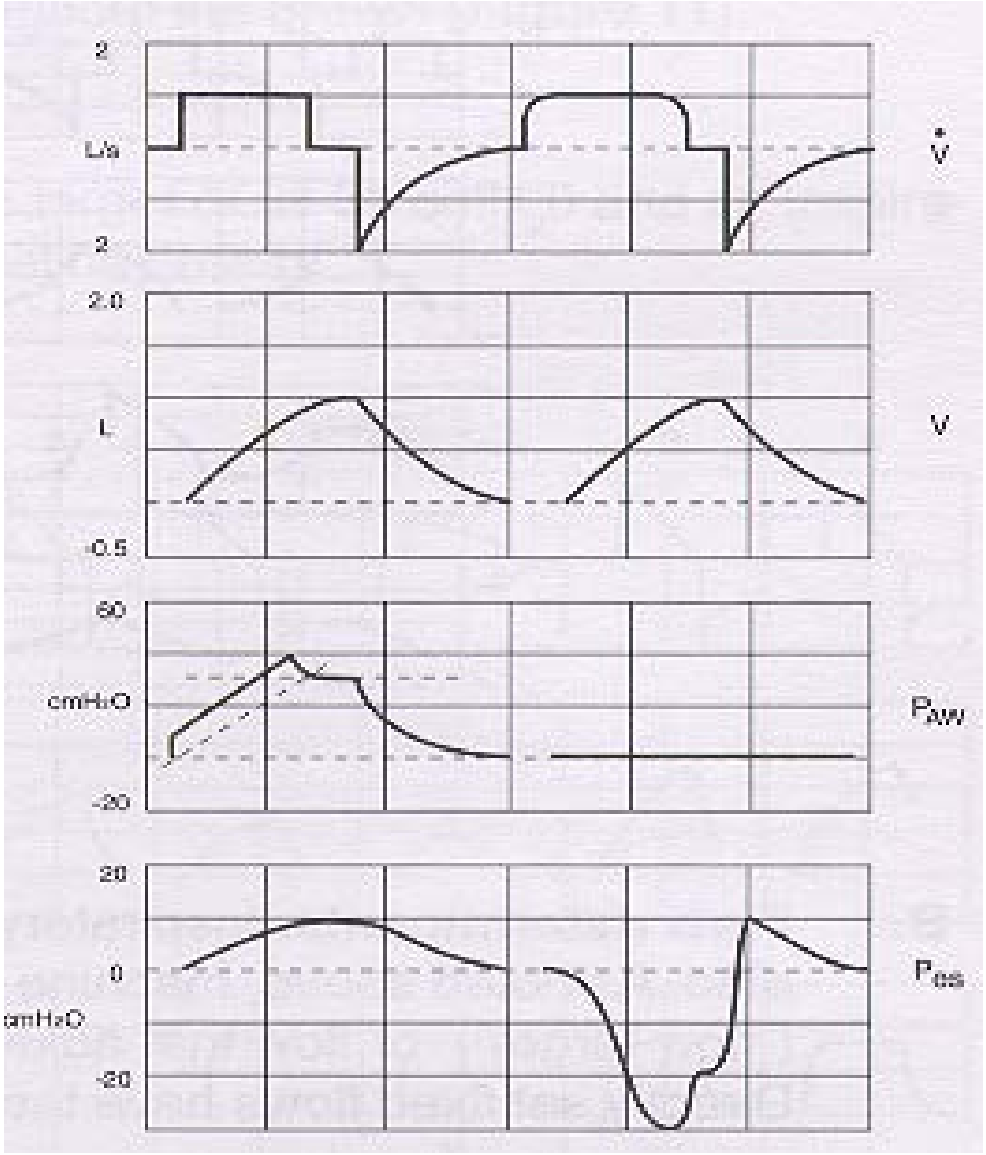
Separating Pressures Related to R, Cl, and Ccw

Peak-Pplat = flow P
=10 cm H2O

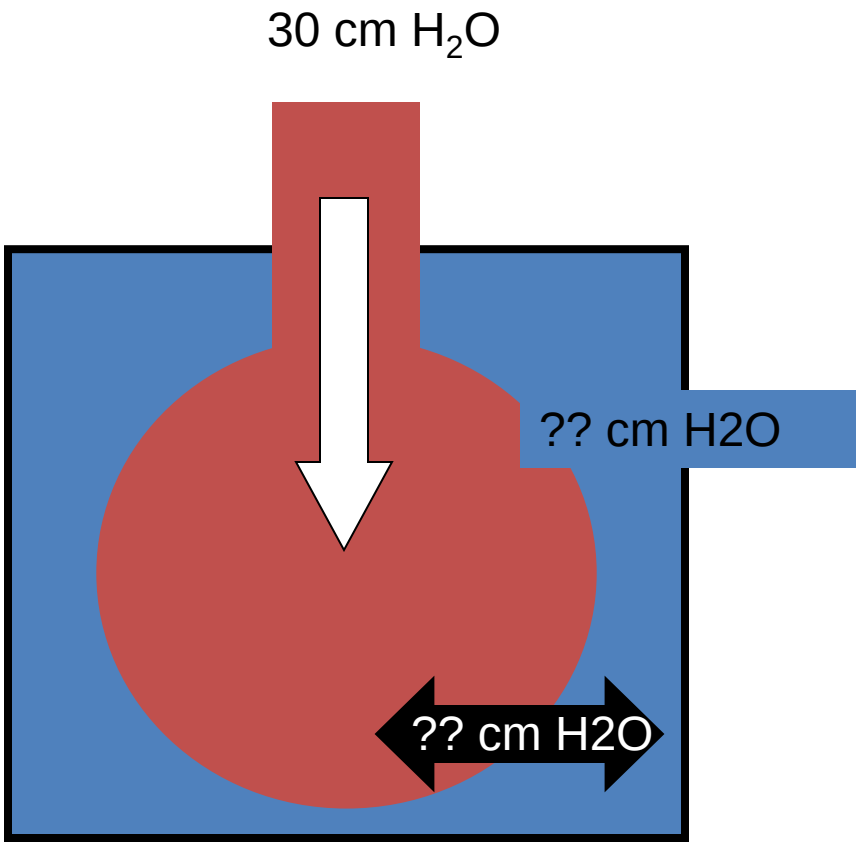
Pplat = resp system distention
= 30 cm H2O

Pes = chest wall distention P
= 10 cm H2O

Pplat-Pes = lung distention (TPP)
= 20 cm H2O

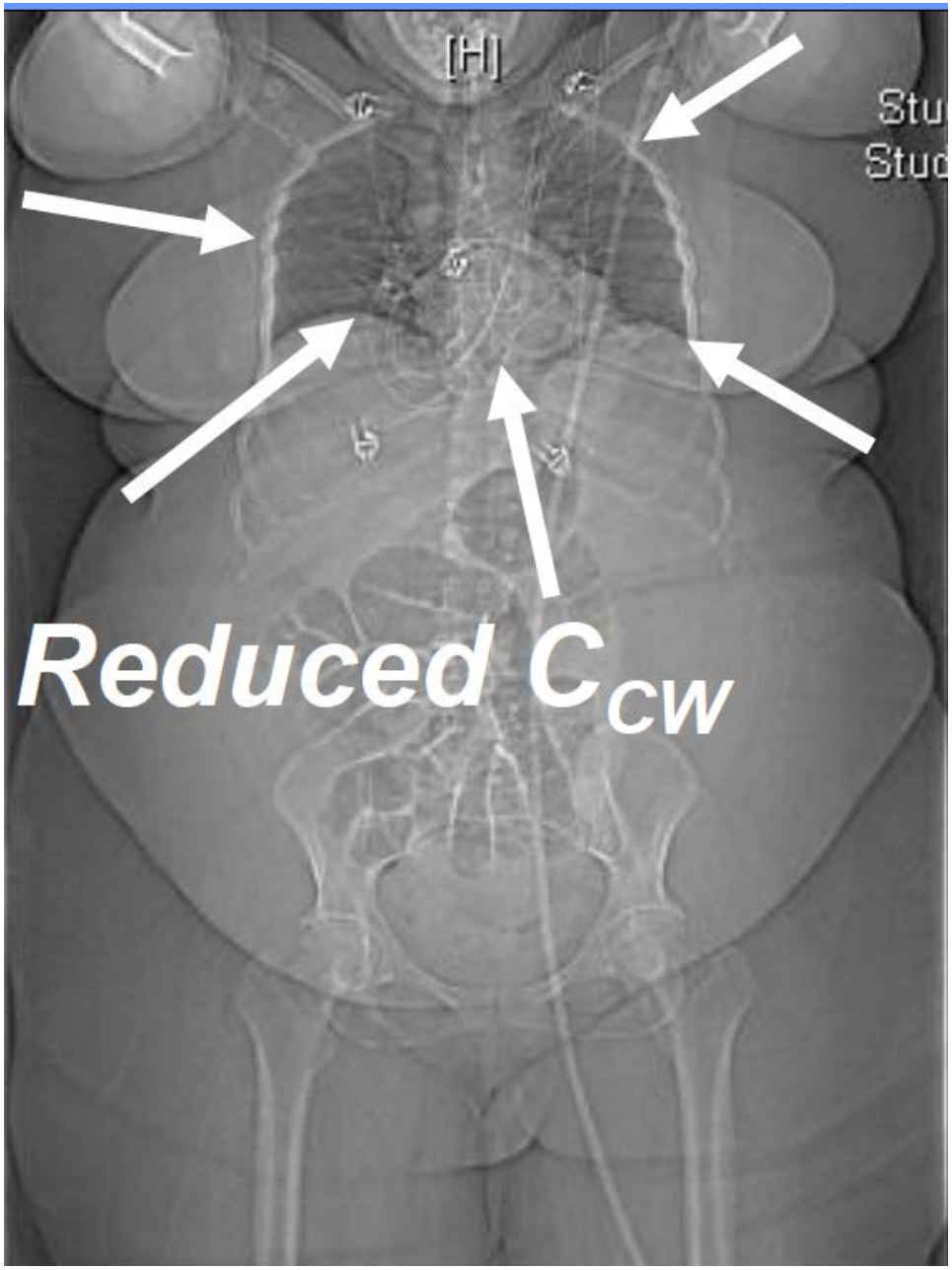


Transpulmonary P = VILI Risk

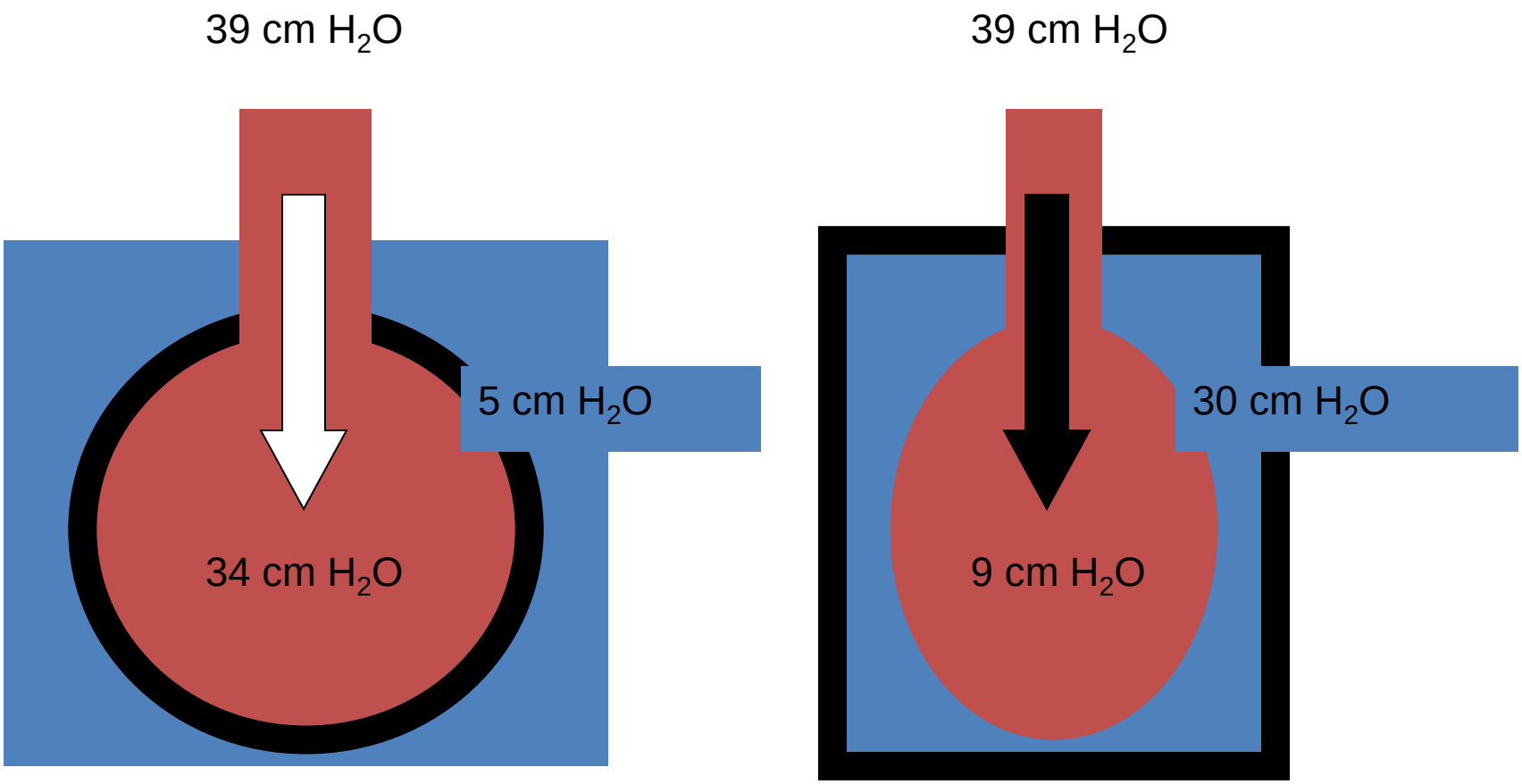


Transpulmonary P:

- Pplat-Pes
- Distending

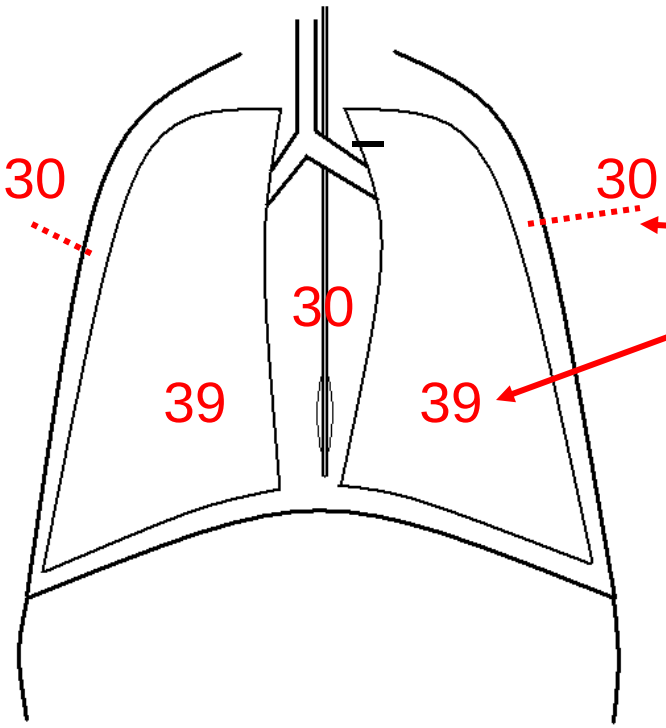

[H]
Reduced C_{cw}

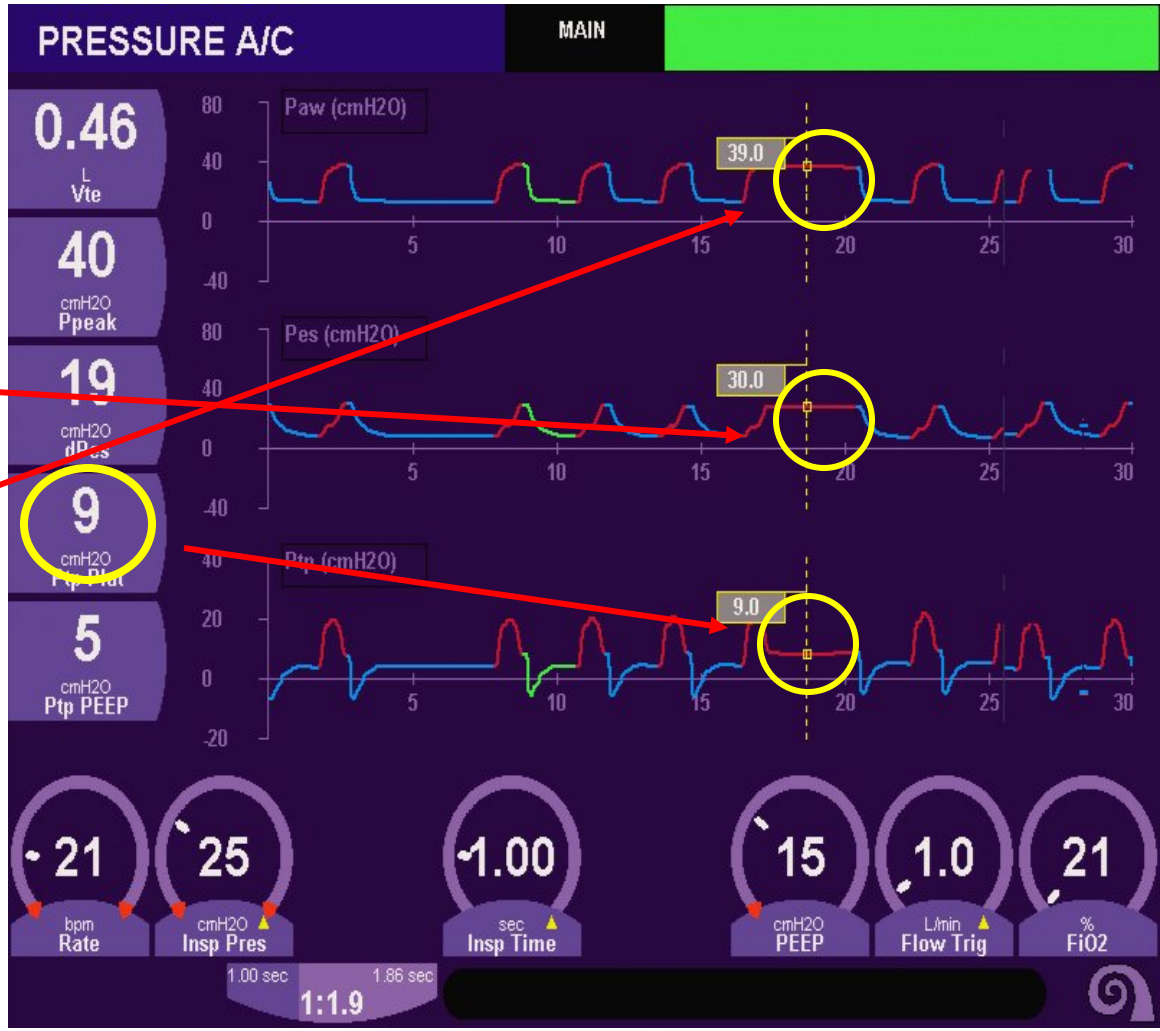
Influence of chest wall stiffness

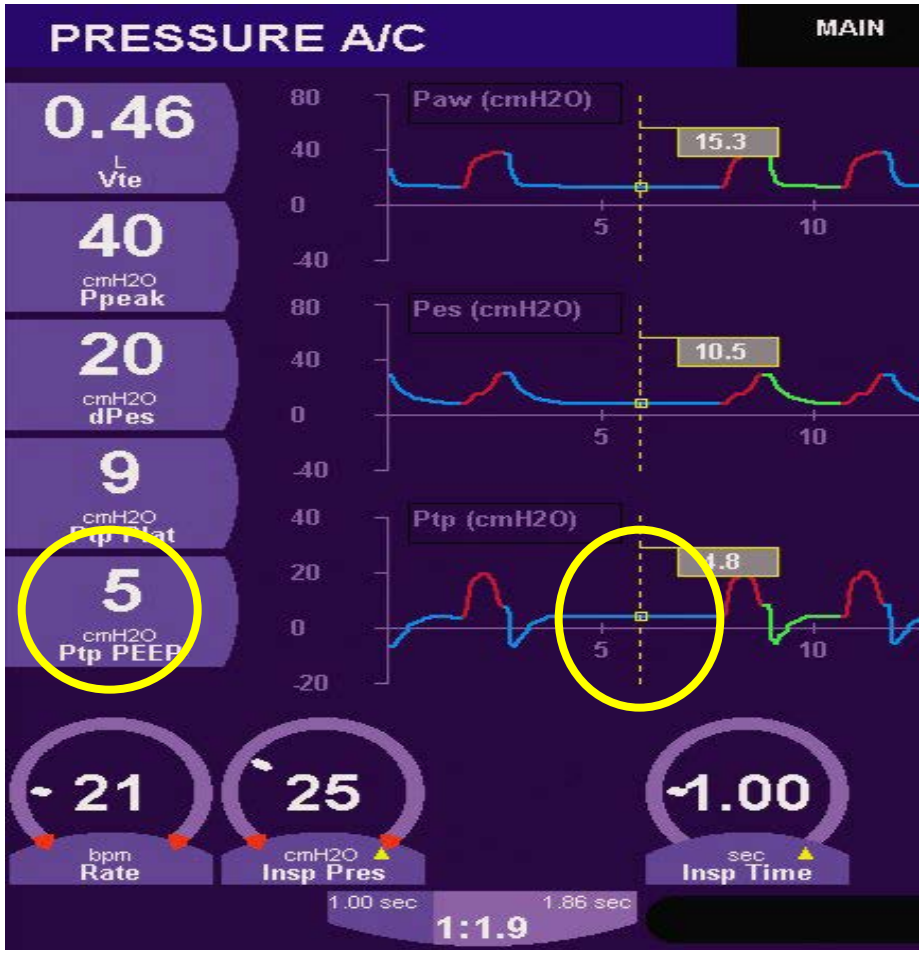


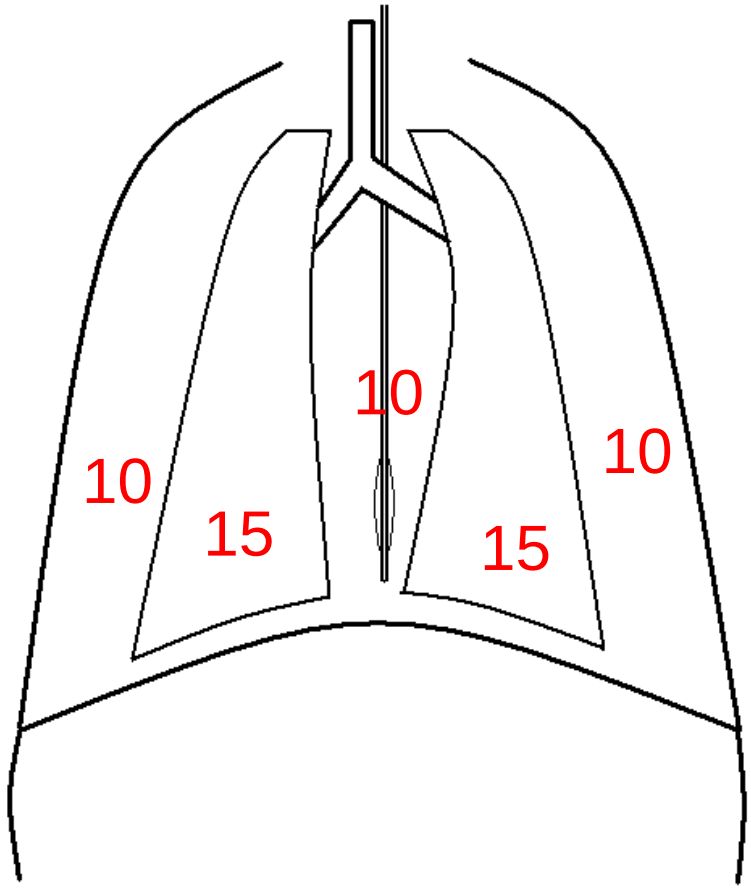
Unsafe to add more Paw

Safe to add more Paw

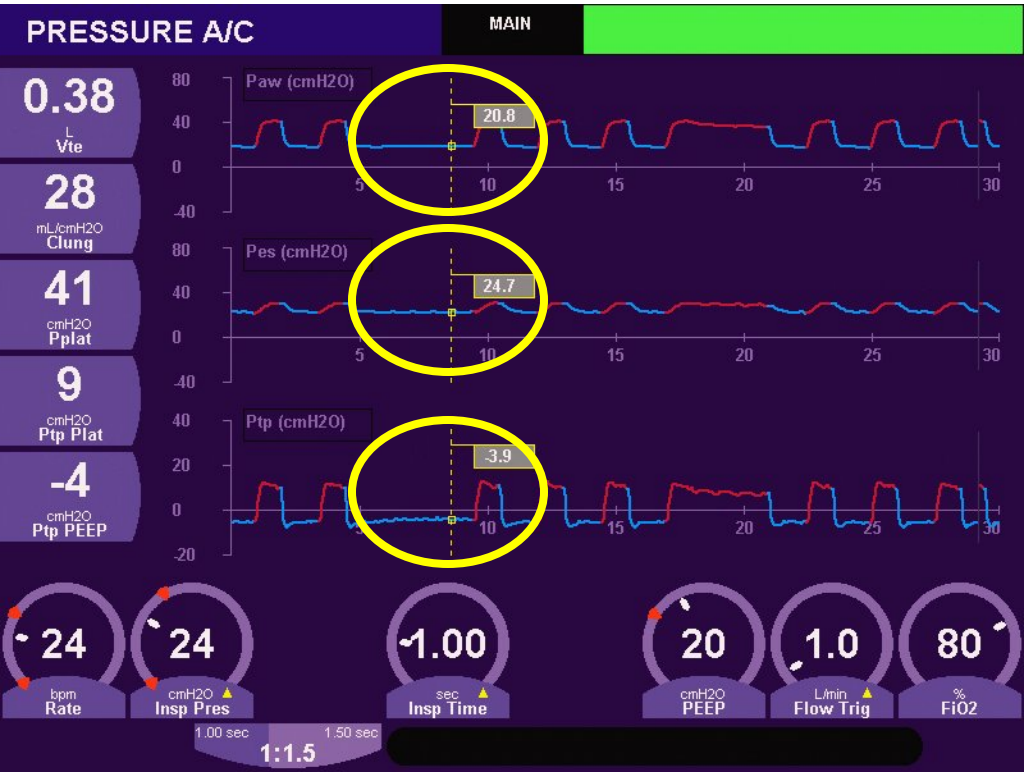

30
30
30
39
39

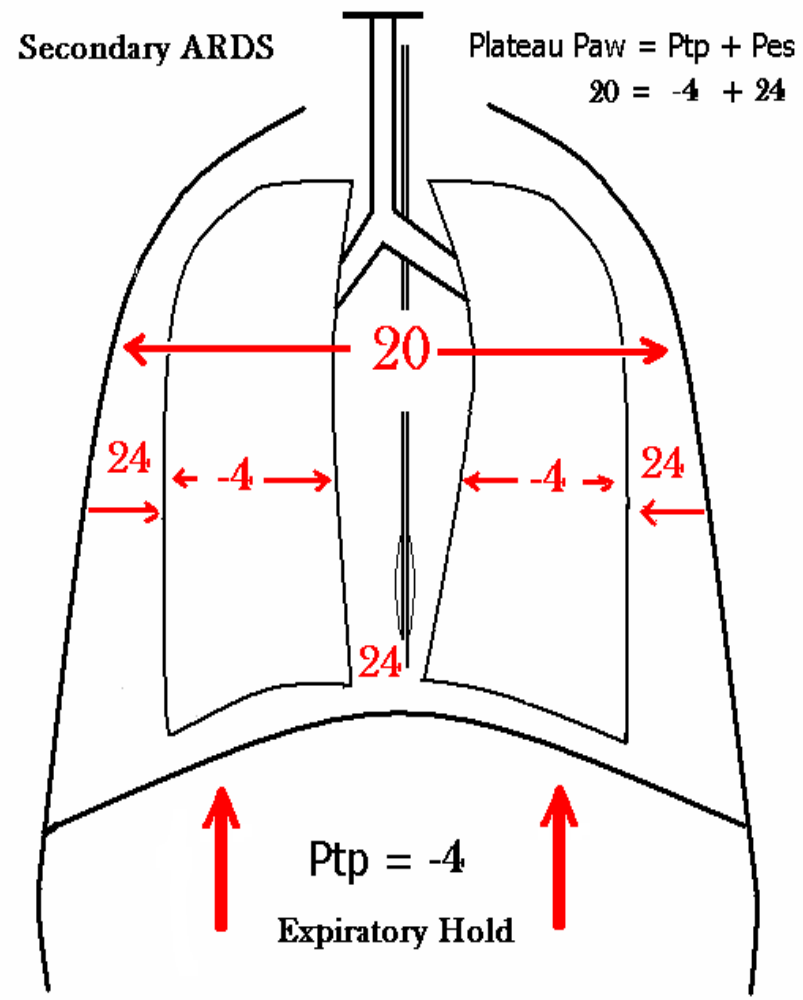

PRESSURE A/C
MAIN
0.46
L
Vte
40
cmH2O
Ppeak
19
cmH2O
9
cmH2O
5
cmH2O
Ptp PEEP
Paw (cmH2O)
39.0
Pes (cmH2O)
30.0
9.0
21
bpm
Rate
25
cmH2O
Insp Pres
1.00
sec
Insp Time
15
cmH2O
PEEP
1.0
L/min
Flow Trig
21
%
FiO2
1.00 sec
1.86 sec
1:1.9



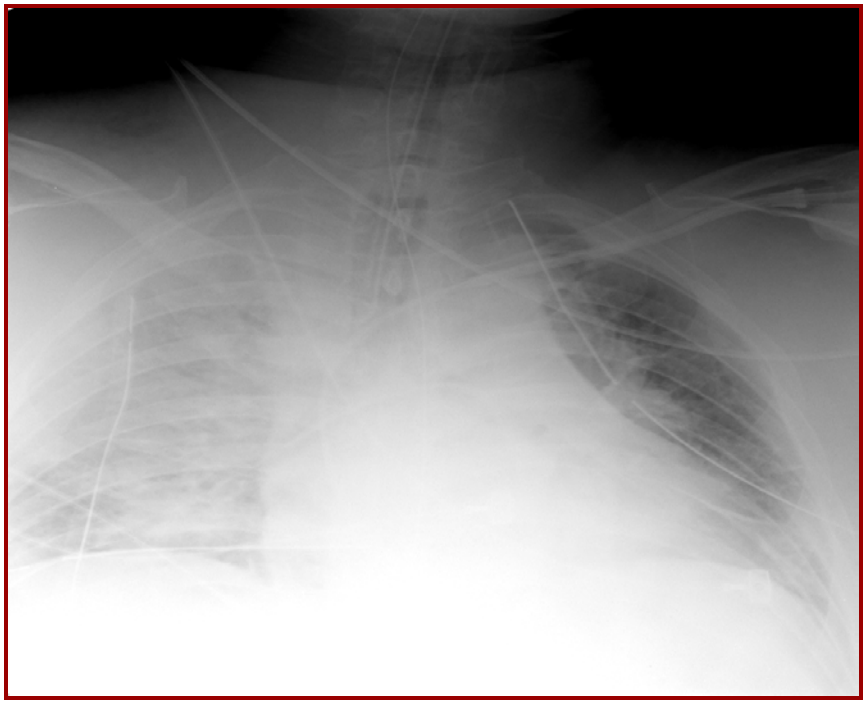


- Key: Keep P_{tp} Exp Pressures $\geq$ 0 cmH2O
  - Increased abdominal pressures impose a load on the lungs and increase the pleural (esophageal) pressures
  - Maintaining airway pressures at, or above, the esophageal pressures, measured during the expiratory phase, keeps the lung recruited


PRESSURE A/C
MAIN
0.38
L
Vte
28
mL/cmH2O
Clung
41
cmH2O
Pplat
9
cmH2O
Ptp Plat
-4
cmH2O
Ptp PEEP
Paw (cmH2O)
20.8
Pes (cmH2O)
24.7
Ptp (cmH2O)
-3.9
24
bpm
Rate
24
cmH2O
Insp Pres
1.00
sec
Insp Time
20
cmH2O
PEEP
1.0
L/min
Flow Trig
80
%
FiO2
1.00 sec
1.50 sec
1:1.5

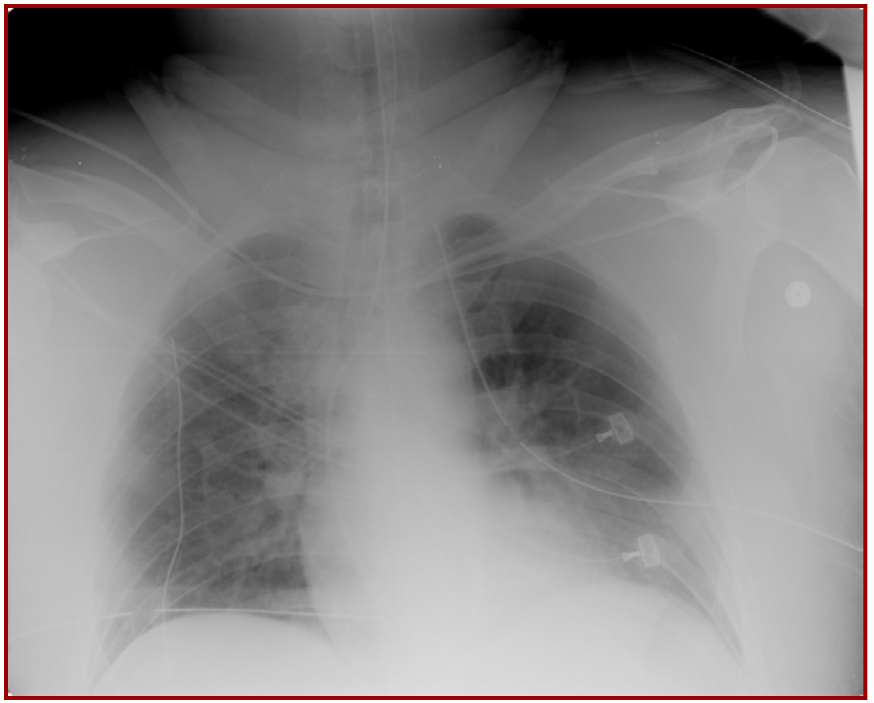

Secondary ARDS
Plateau Paw = Ptp + Pes
20 = -4 + 24
20
24
-4
-4
24
24
Ptp = -4
Expiratory Hold

Pes to assure safety/efficacy of PEEP



Before

Paw = 40/13
Pes = 33/20
Ptp = 7/-7



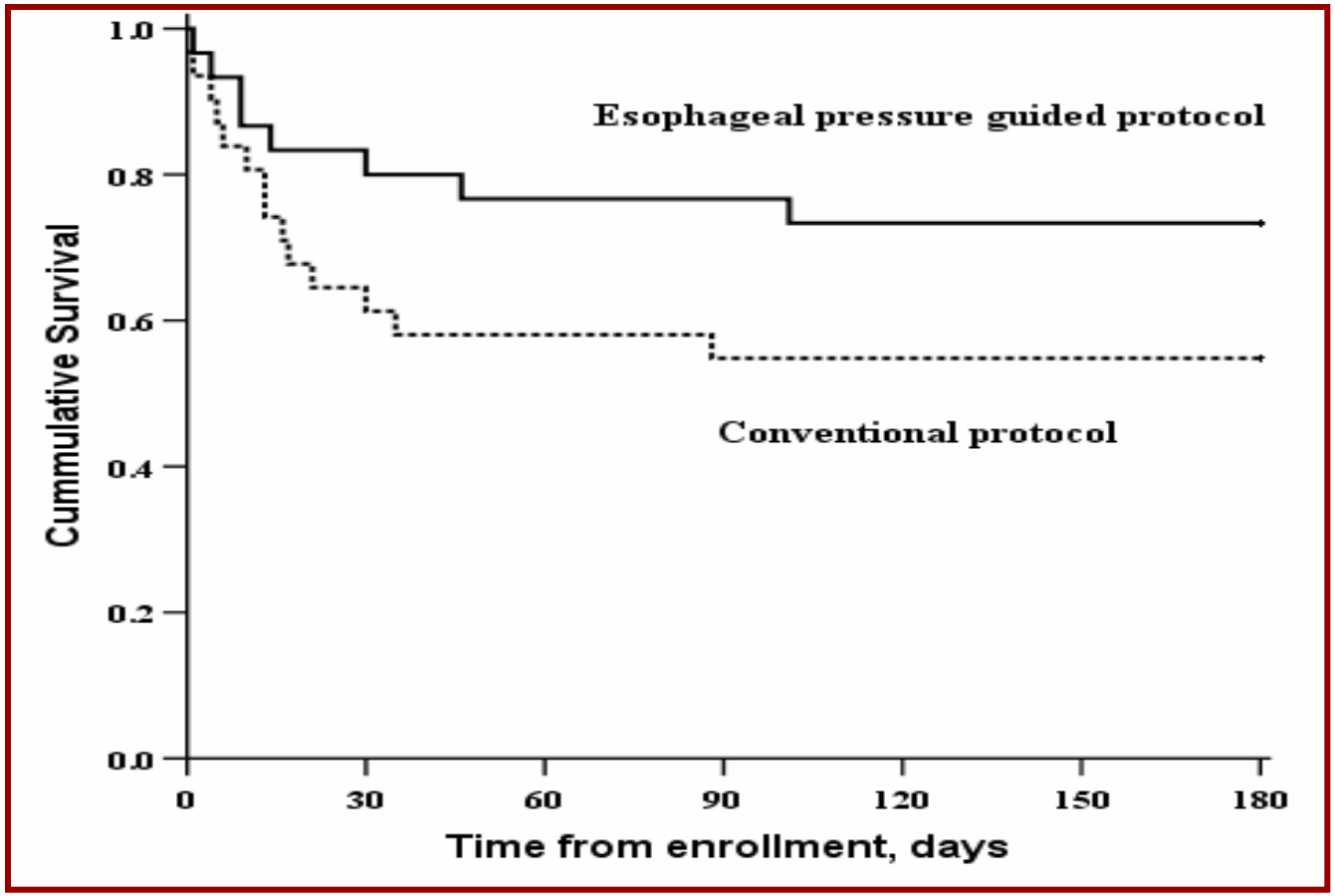
After

Paw = 46/26
Pes = 33/22
Ptp = 13/4

NEJM 2008, 359(20);2095-104

Pleural Pressure Measurement

MV Guided by Pes in ALI NEJM 2008, 359(20);2095-104



6 Month Survival

Ventilator Graphics and ARDS

- Concept of VILI
- Pressure-Volume Graphics
  - Traditional
  - Slow flow
  - Stress index
- Airway vs Trans-Pulmonary Pressure
- Patient Ventilator Synchrony

Assisted Ventilation

- The ventilator must interact with the patient and meet his needs
  - Load depends on effort (pt) and applied support (vent)
- A mismatch in patient demand and ventilator response can result in patient ventilator dys-synchrony (PVD)
  - “Tug of war”

Why should we be concerned?

PVD:

- Patient discomfort and dyspnea
- Structural injury to the lungs
- Worse mechanics (intrinsic PEEP)
- Altered gas exchange
- Unnecessary WOB
- Counteract lung protective ventilation (breath stacking)
- Clinician confusion

Types of PVD

- Delayed triggering
- Missed triggering
- Auto triggering

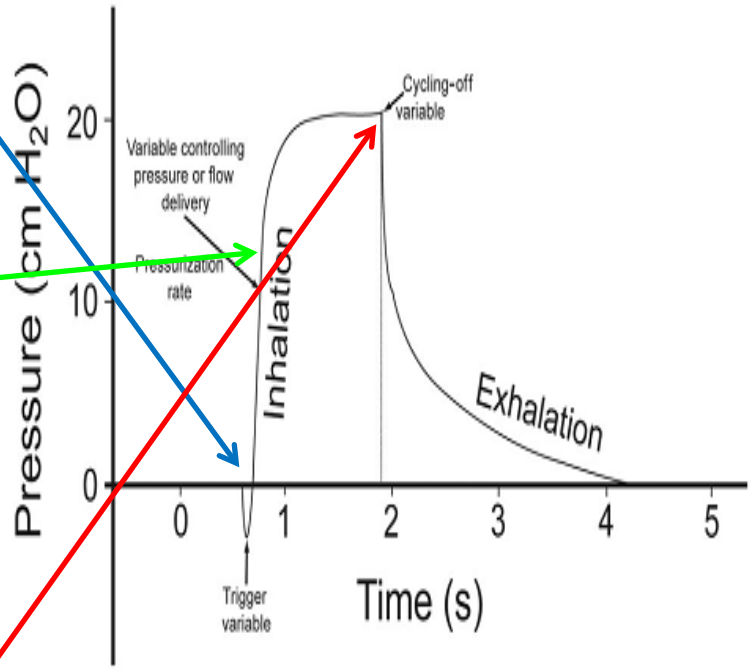
Onset

- Flow asynchrony
- Mode asynchrony
- Double triggering

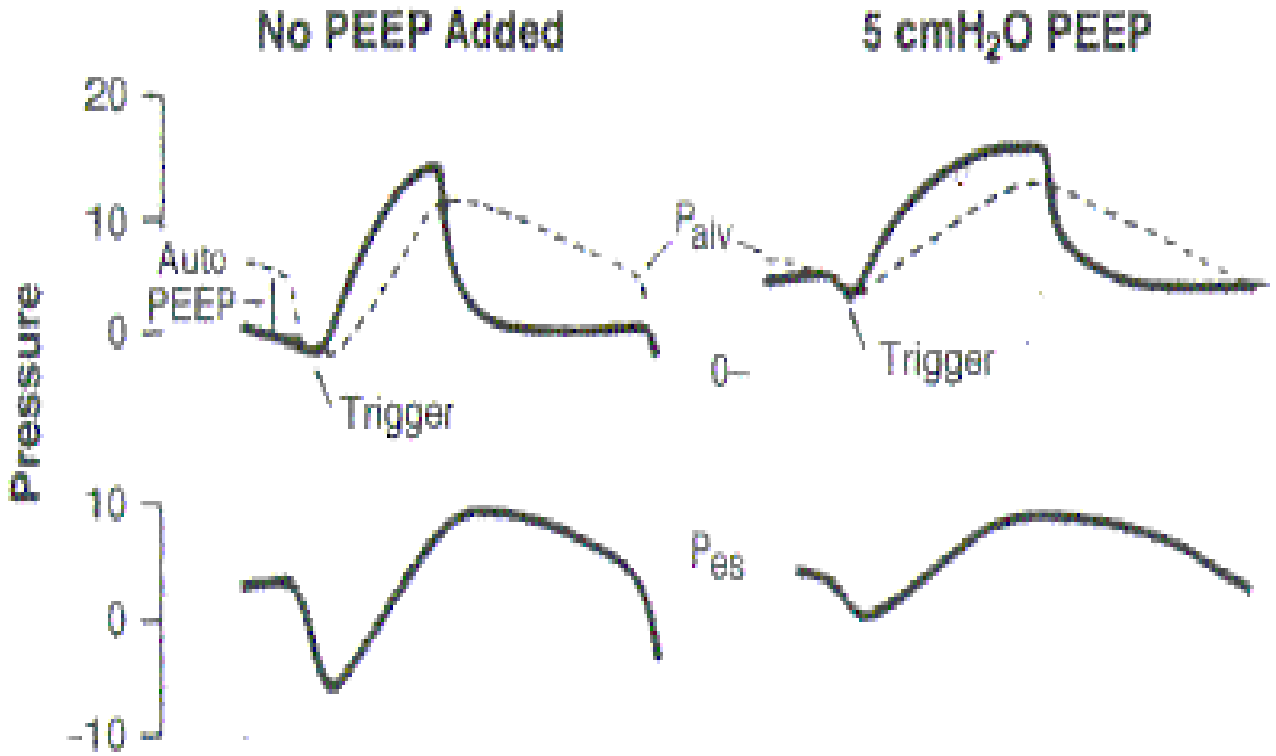
During

- Premature cycling
- Delayed cycling

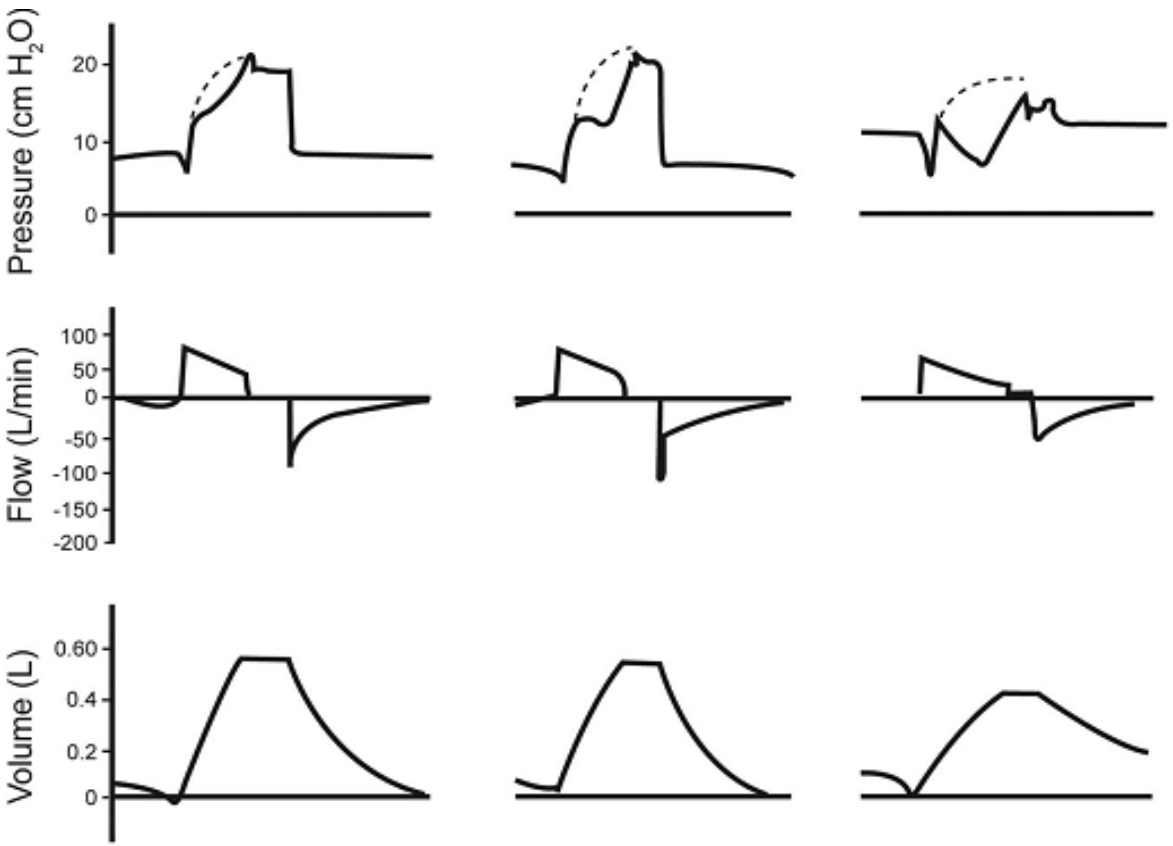
Termination



Trigger Dys-synchrony



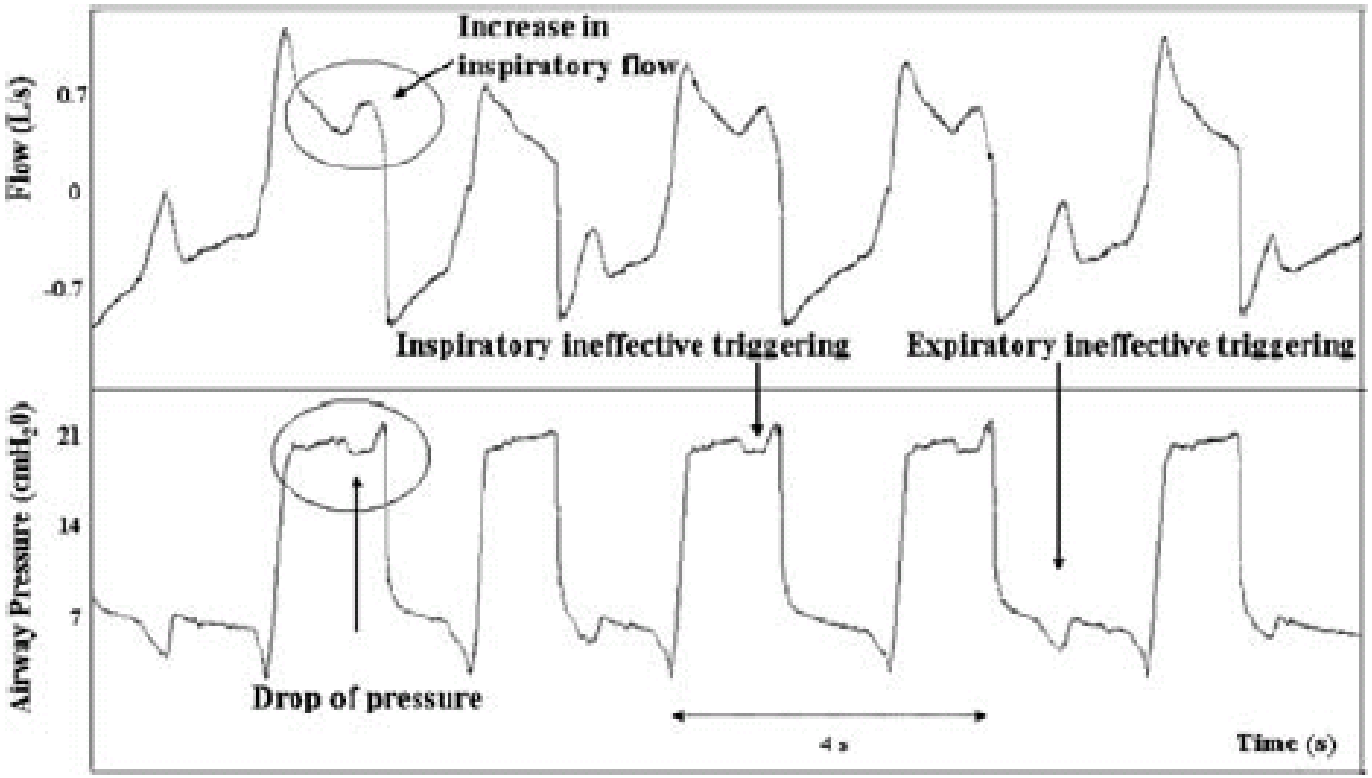
Flow Dys-synchrony



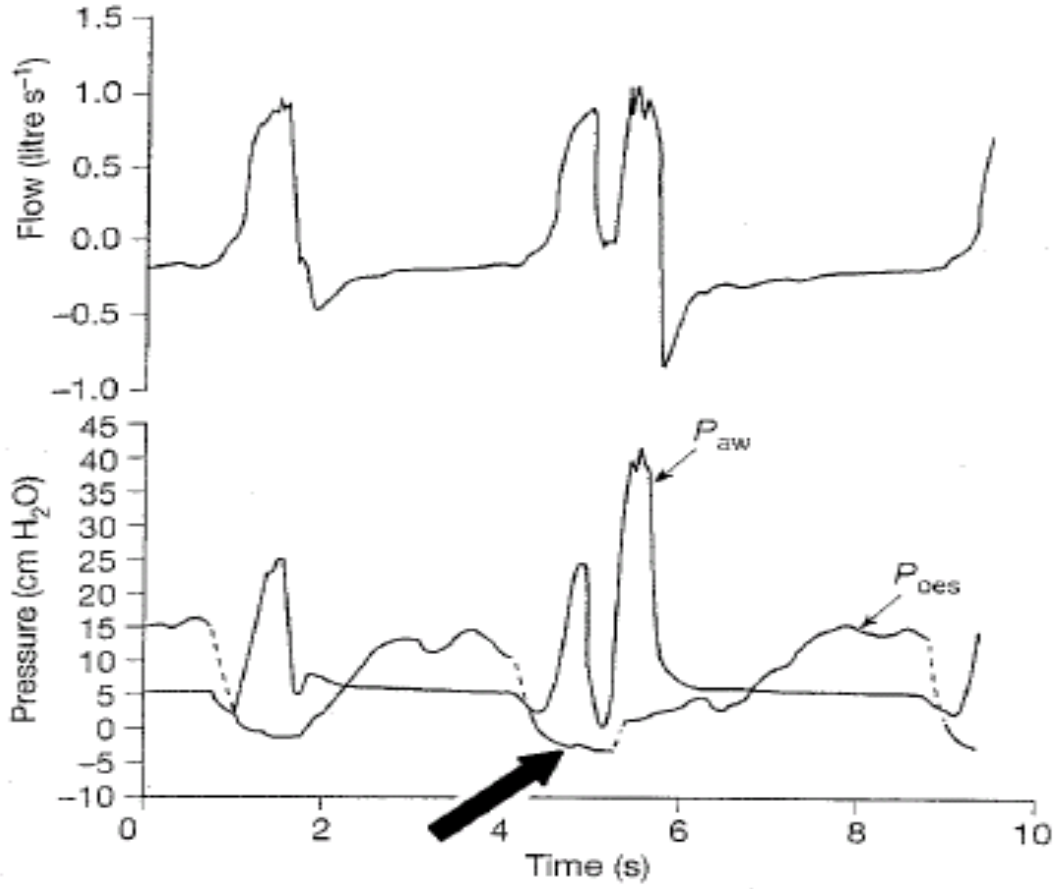
Ventilator response < pt demand

Pmus: Patient Effort

Flow Dys-synchrony in PSV

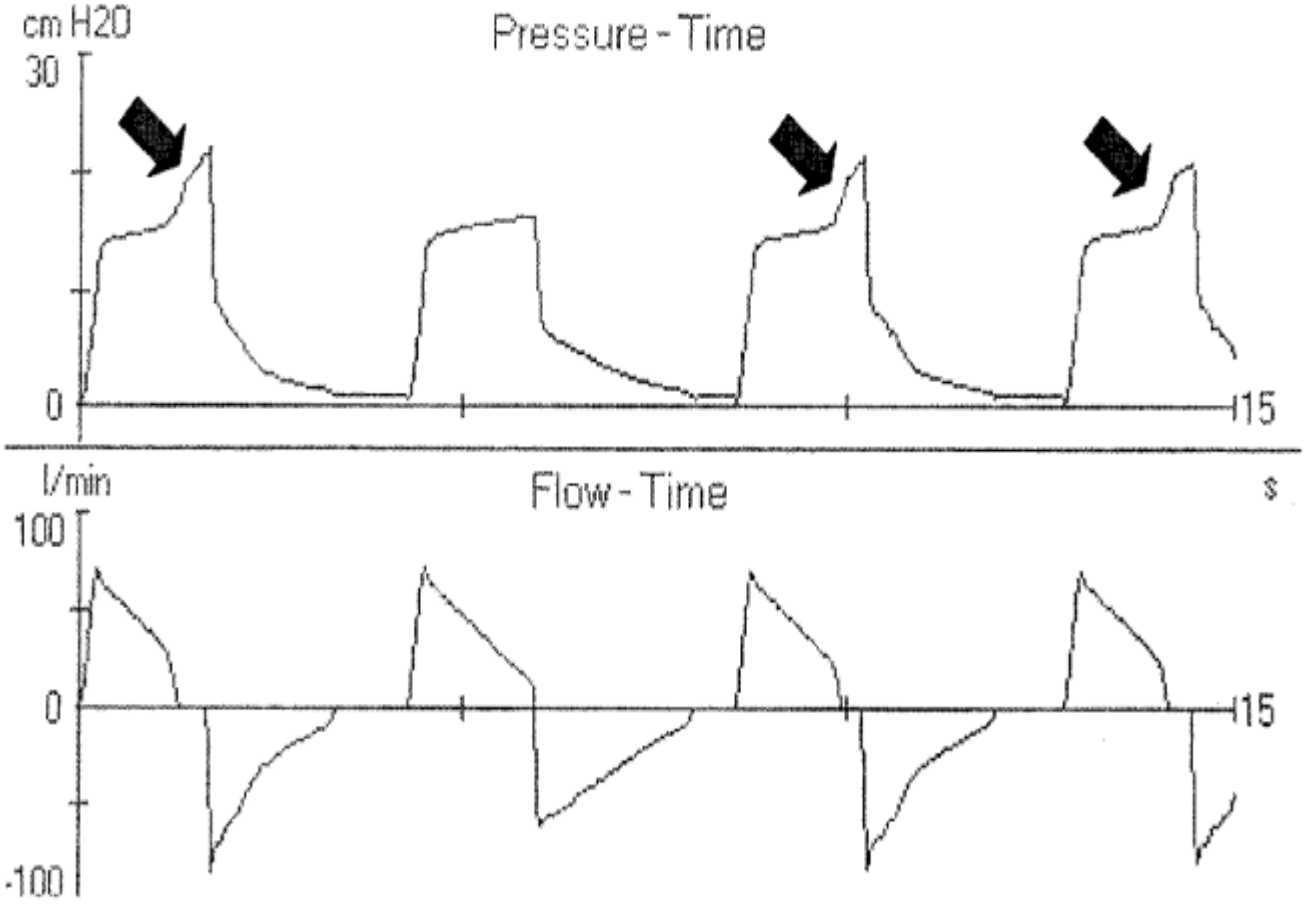


Cycling Dys-synchrony



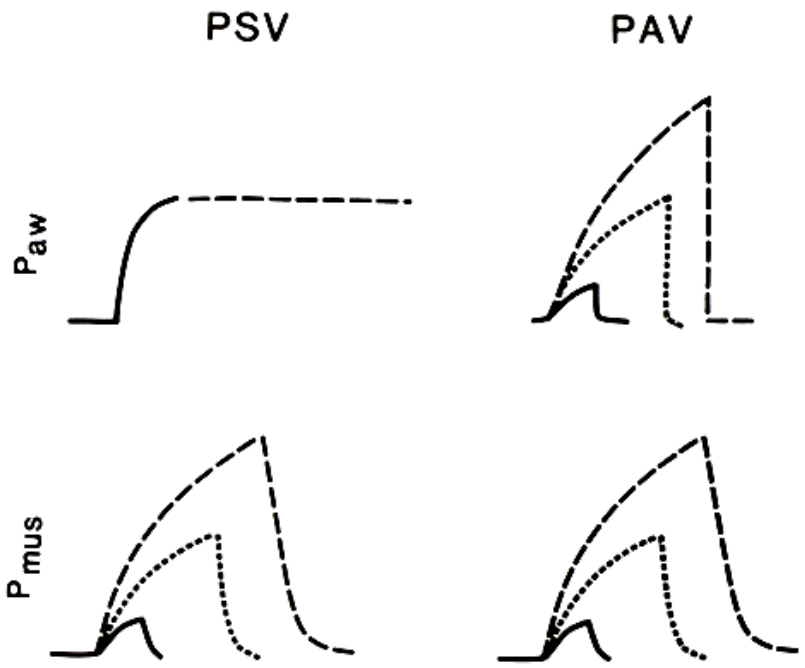
Ventilator response > Pt demand

Delayed Cycling



Proportional Assist Ventilation

- Spontaneous mode
- Clinician sets WOB
- IP, Ti, Vt, RR all variable
- Like power steering

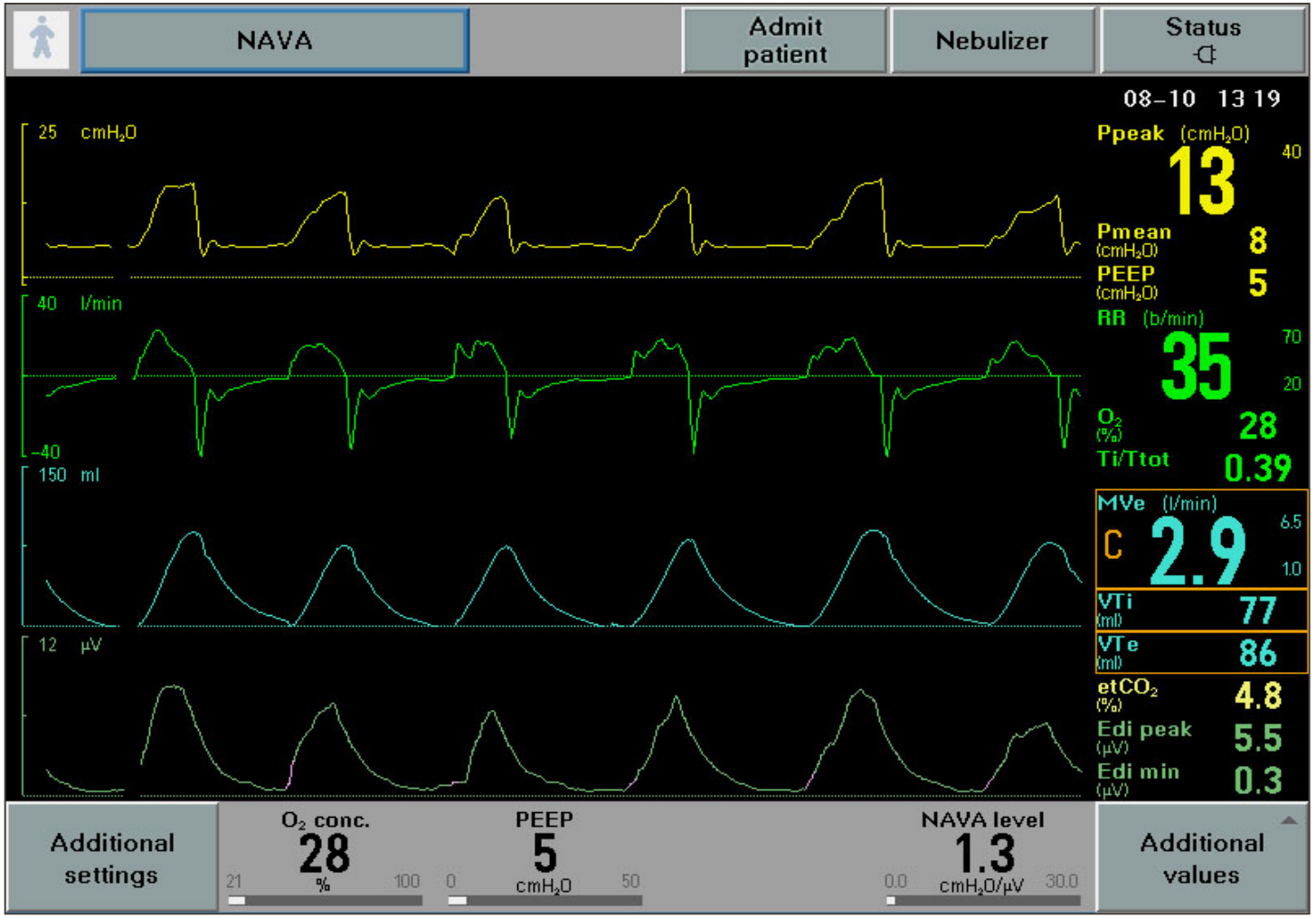



S
P PEAK
9.8
P MEAN
5.7
PEEP
3.0
I:E
1:1.8
f TOT
24
V TE
204
V̇ E TOT
10.2
Circuit Type: Adult
Humidification Type: HME
Tube Type: ET
Tube I.D.: 8.0 mm
15:32
31 Jan 2009
PLOT SETUP
UNFREEZE
C PAV
50
mL/cmH2O
R PAV
2.4
cmH2O/L/s
PEEP I 0.1
cm H2O
P CIRC
cmH2O
25
20
15
10
5
0
-5
-10
-15
0
2
4
6
8
10
12s
P LUNG
WOB
J/L
E
R
WOB PT
WOB TOT
0.0
0.3
0.7
1.0
2.0 J/L
MANUAL EVENT

Neurally Adjusted Ventilatory Assist (NAVA)

- Spontaneous mode
- Specially designed NG with electrodes that pick up the electrical activity of the diaphragm
- Clinician sets cm per microvolt
- IP, Ti, Vt RR all variable

NAVA


NAVA
Admit patient
Nebulizer
Status
08–10 13 19
25 cmH2O
40 l/min
-40
150 ml
12 µV
Ppeak (cmH2O)
13
40
Pmean (cmH2O) 8
PEEP (cmH2O) 5
RR (b/min)
35
70
20
O2 (%) 28
Ti/Ttot 0.39
MVe (l/min)
C 2.9
6.5
1.0
VTi (ml) 77
VTe (ml) 86
etCO2 (%) 4.8
Edi peak (µV) 5.5
Edi min (µV) 0.3
Additional settings
O2 conc. 28 % 21 100
PEEP 5 cmH2O 0 50
NAVA level 1.3 cmH2O/µV 0.0 30.0
Additional values

Summary

- Pressure-Volume Graphics
  - Traditional
  - Slow flow
  - Stress index
- Airway vs Trans-Pulmonary Pressure
- Patient Ventilator Synchrony