Dynamic Lung Function and Monitoring

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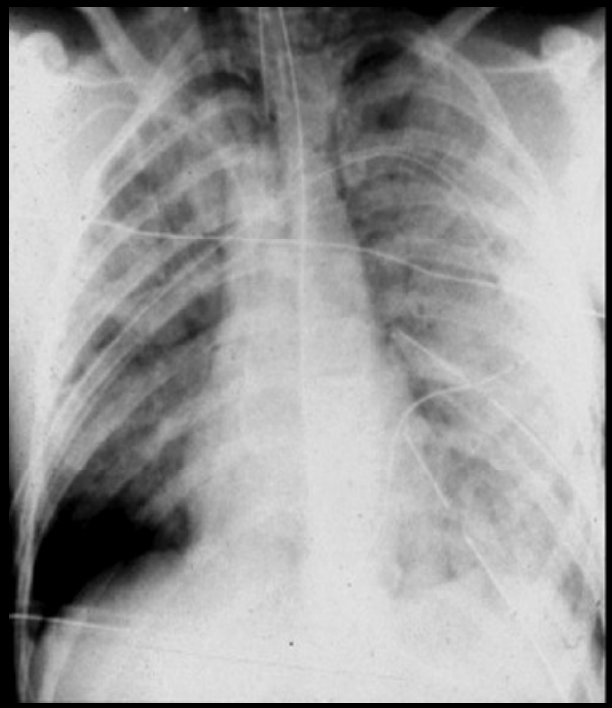
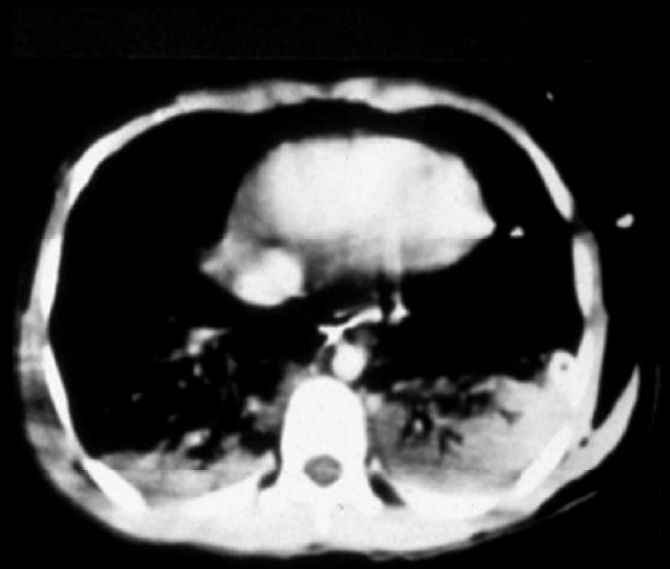
My tools – and how I can use them



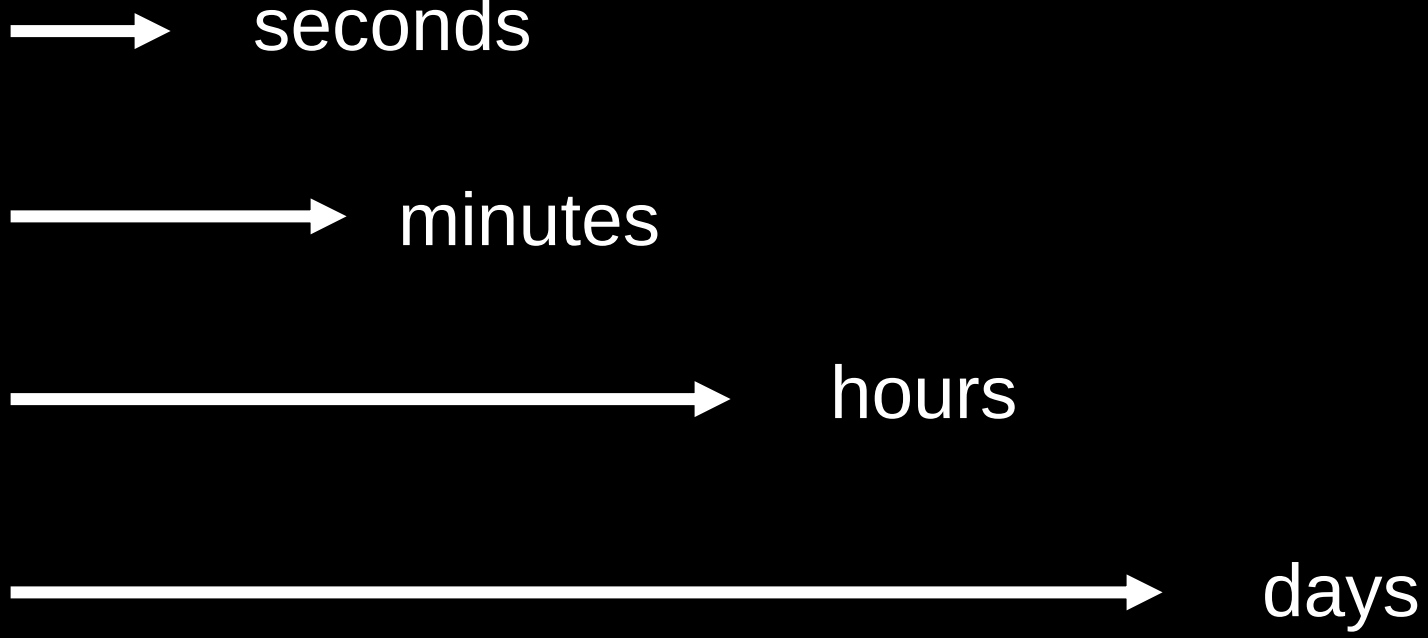


Physiologic response to my intervention: pO2, So2, Pco2, EtCO2

The ventilator as a monitoring device: Vt, Pressures
Curves and Loops
Calculated numbers (e.g. Cdyn)

Dynamic Lung Function and Monitoring

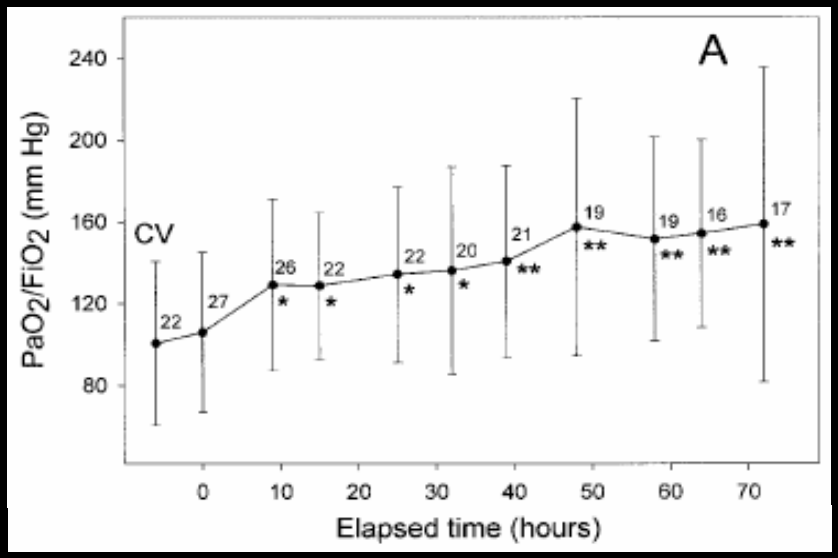
"Notion of Time"



hours

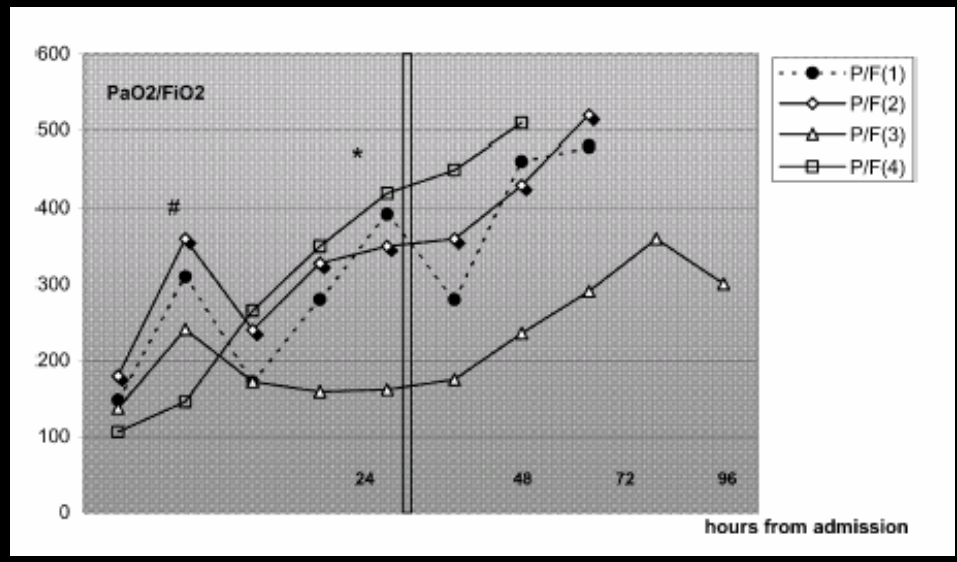
days

HFOV in ARDS



Metha S Crit Care Med 2001; 29:1360 –1369

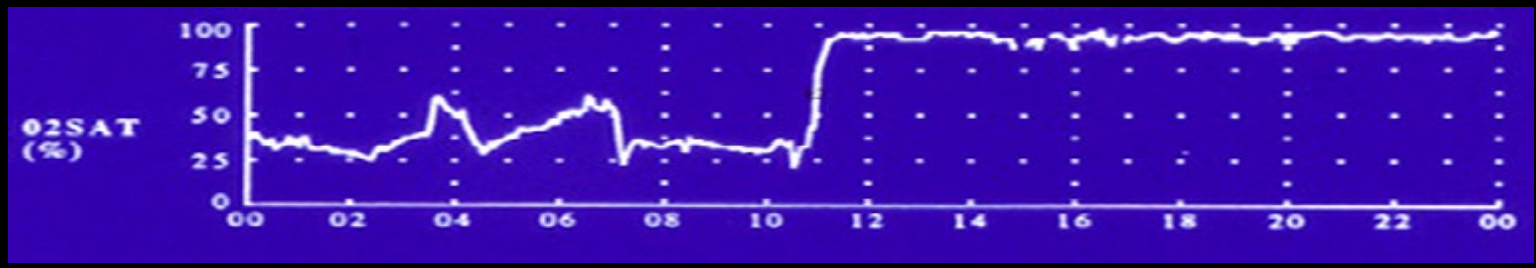
Non-invasive ventilation in ARDS



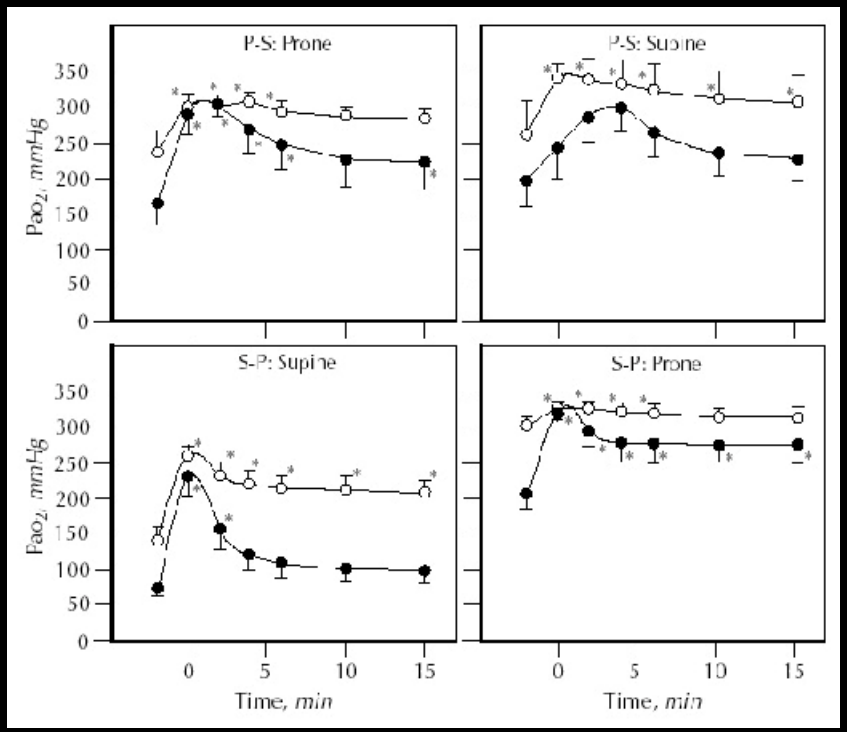
Piastra M Intensive Care Med 2004; 30:472–476

Disease dynamics (?)

minutes

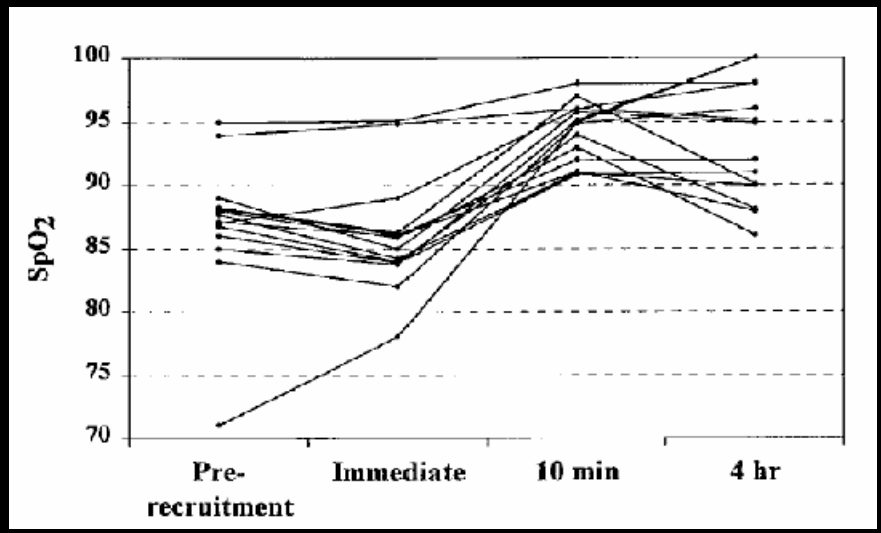


Position changes: supine ←→ prone

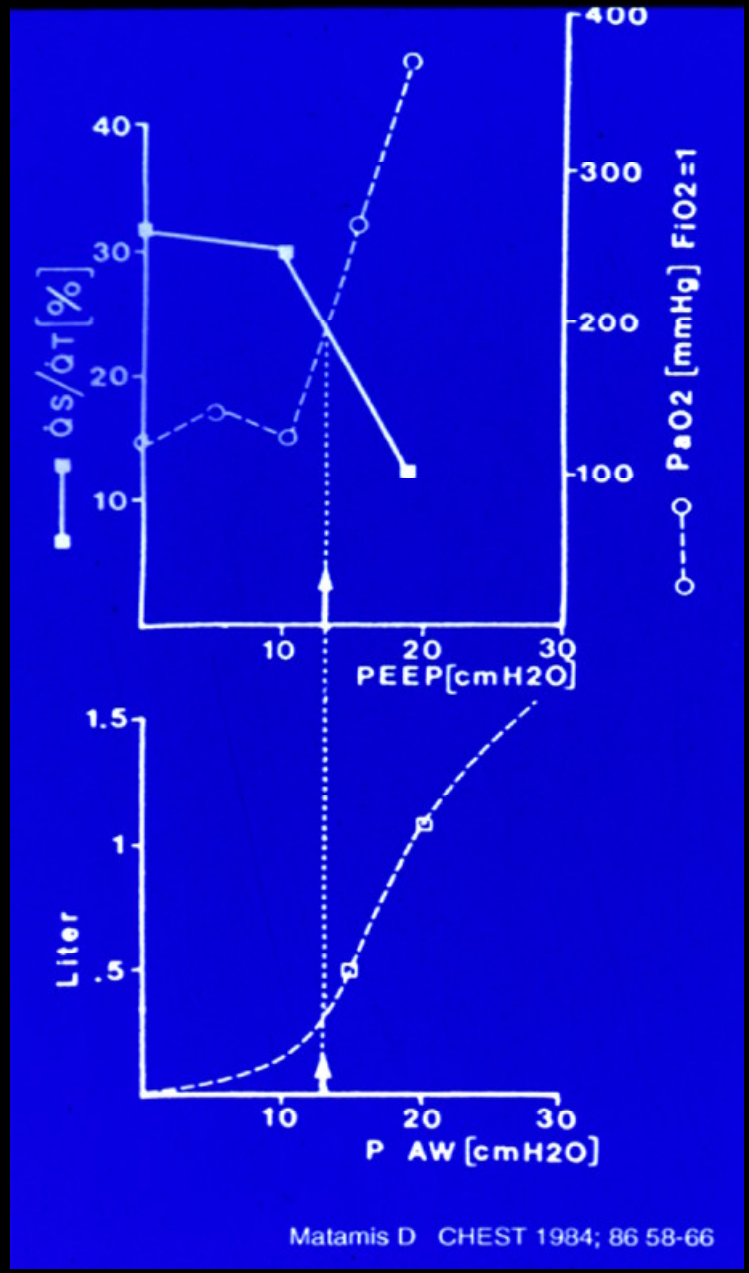


Cakar N et al. AJRCCM 2000; 161:1949–1956

Recruitment Maneuver:
CPAP to 45 H2O for 20 secondes

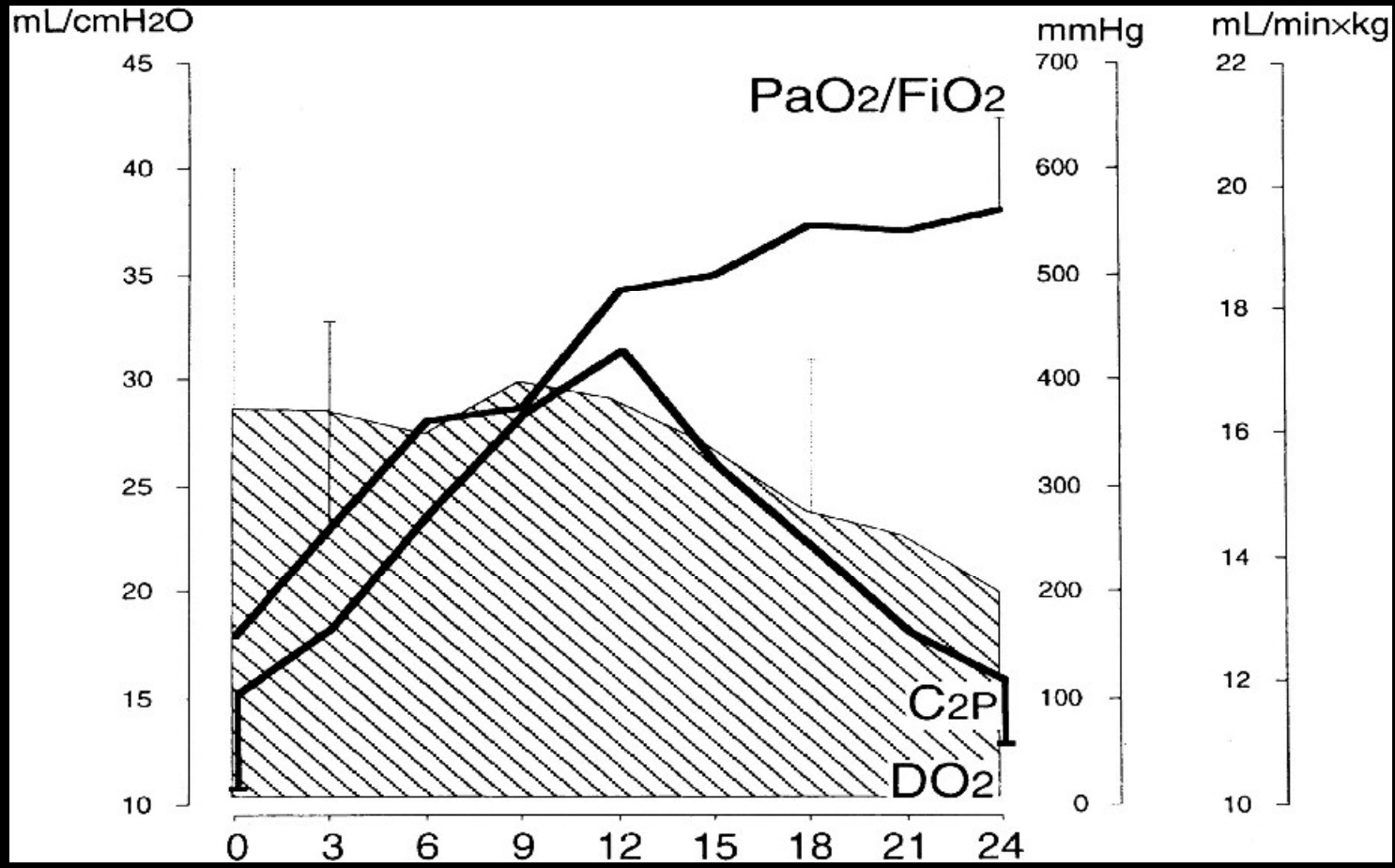


Lapinsky SE Intensive Care Med 1999; 25:1297


400
300
200
100
40
30
20
10
$\dot{Q}S/\dot{Q}T$ [%]
PaO2 [mmHg] FiO2=1
10
20
30
PEEP[cmH2O]
1.5
1
.5
Liter
10
20
30
P AW [cmH2O]
Matamis D CHEST 1984; 86 58-66

The oxygen response (limitations)

P/F-ratio, oxygen delivery and Crs during PEEP steps



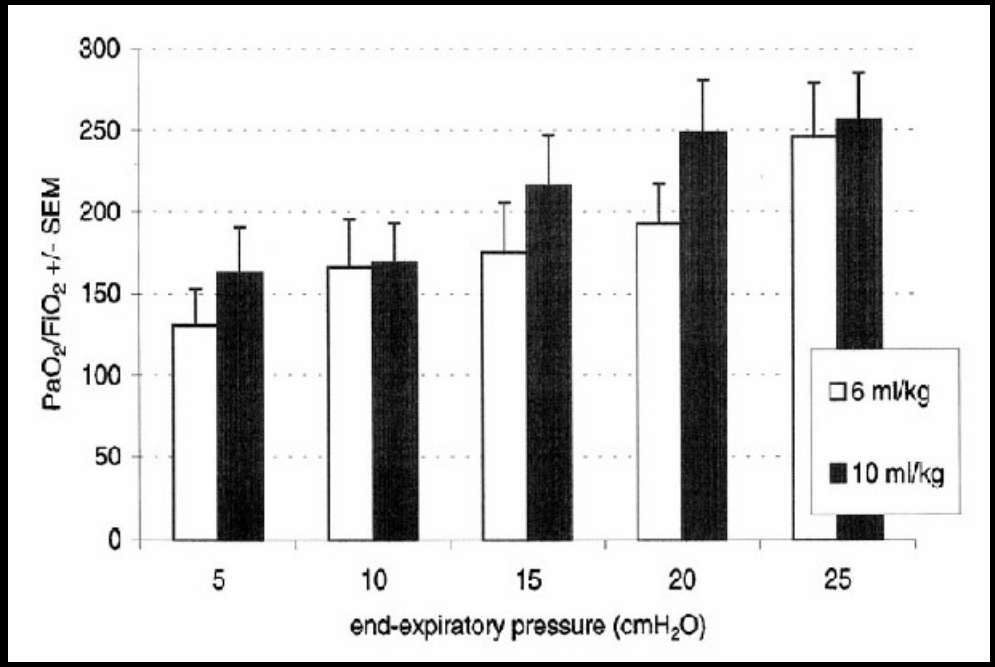
Lichtwarck-Aschoff M AJRCCM 2000; 182:2125-32

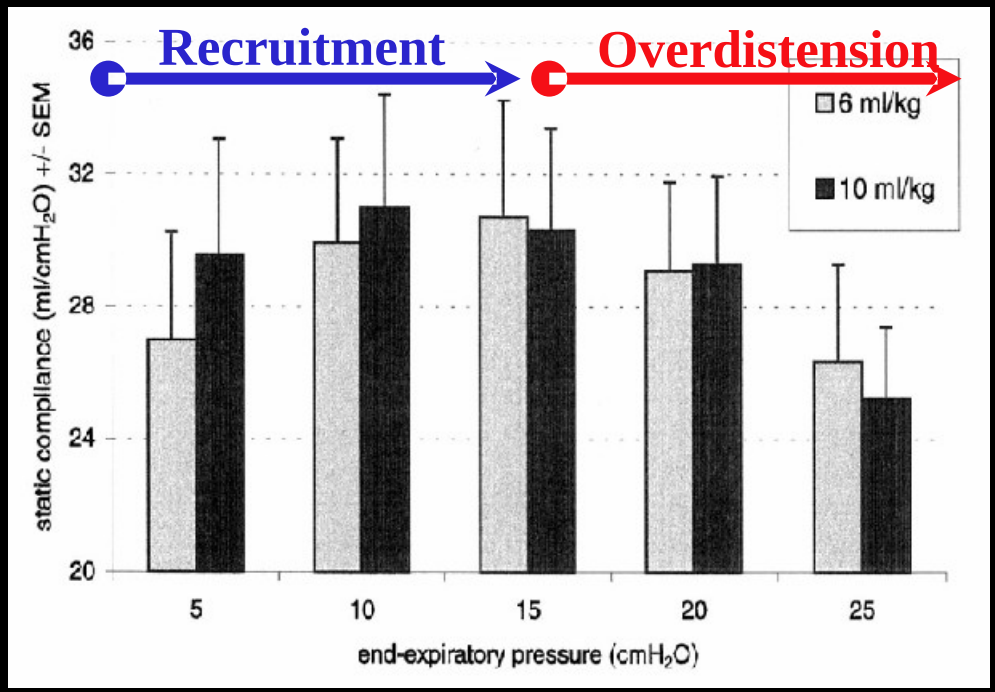
The oxygenation response: Can it be used?

PEEP and Vt effects in ALI

"static" compliance:

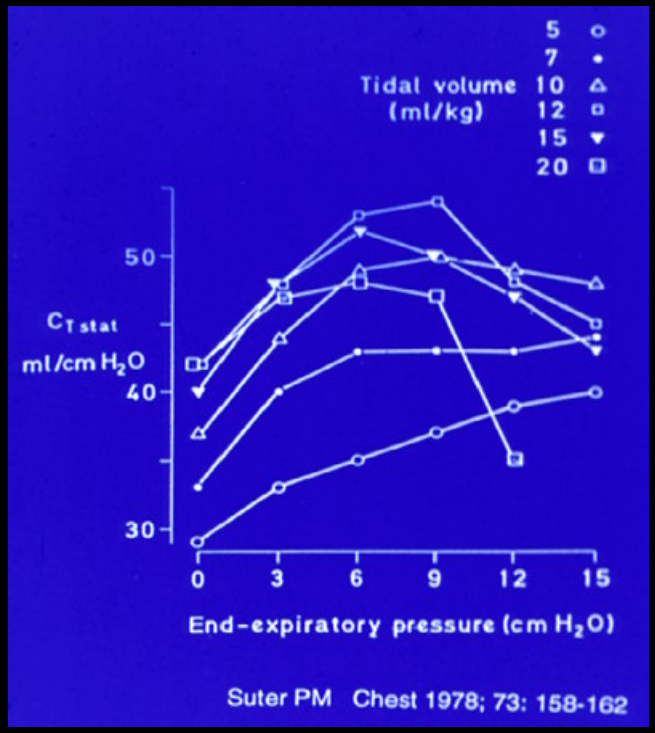
$$Cst = \frac{\text{tidal volume}}{\text{static PIP (Pplat) - PEEP}}$$

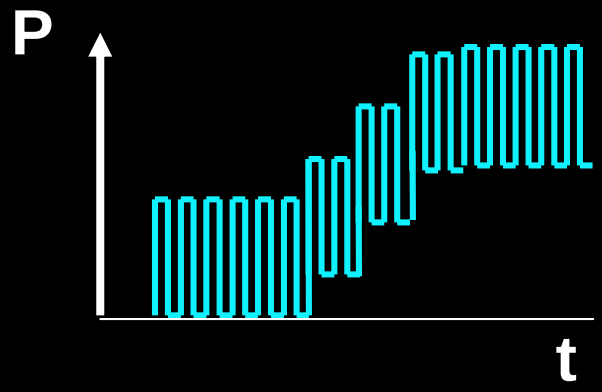




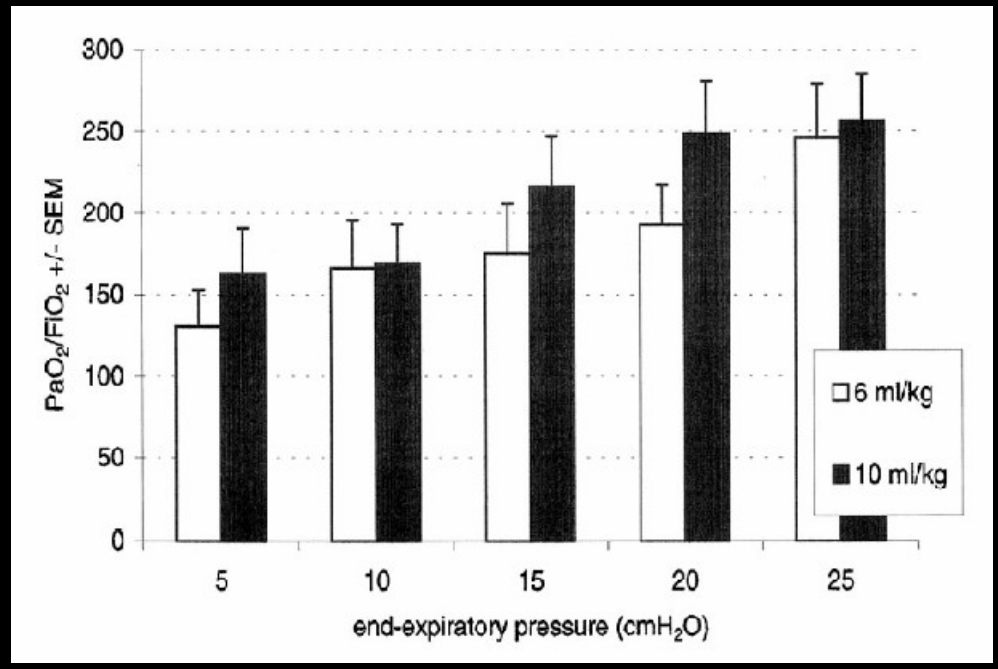
Burns D J Trauma 2001;51:1177-81

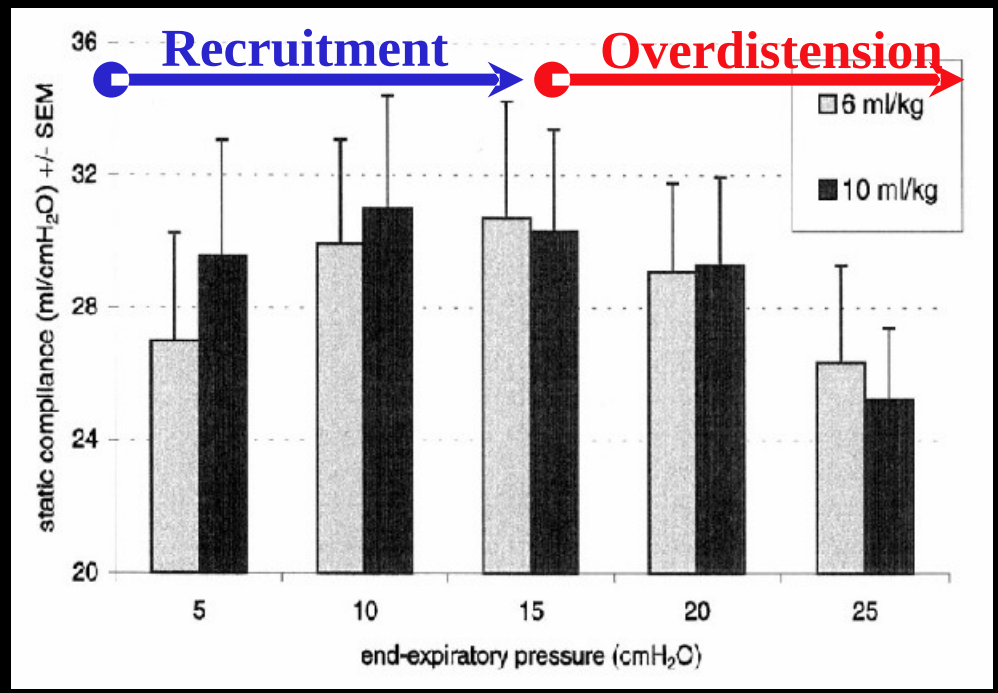
PEEP titration



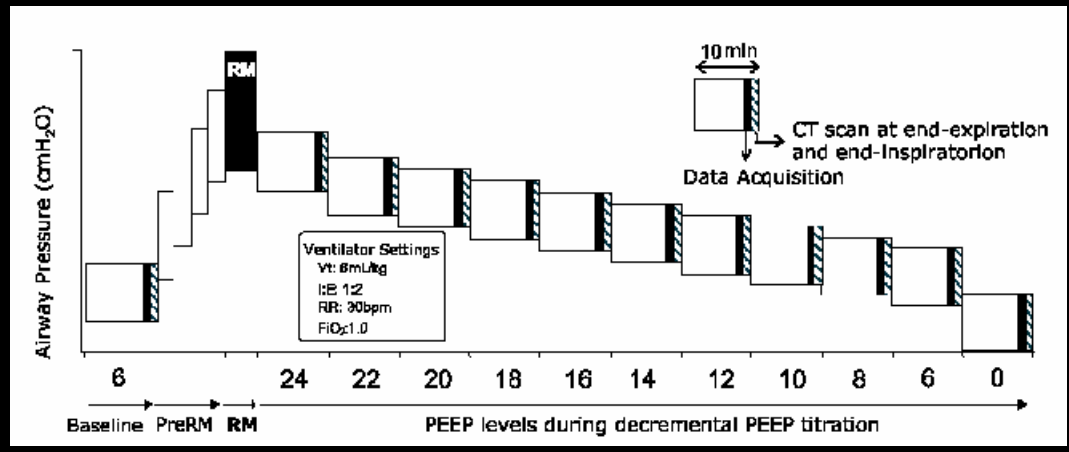


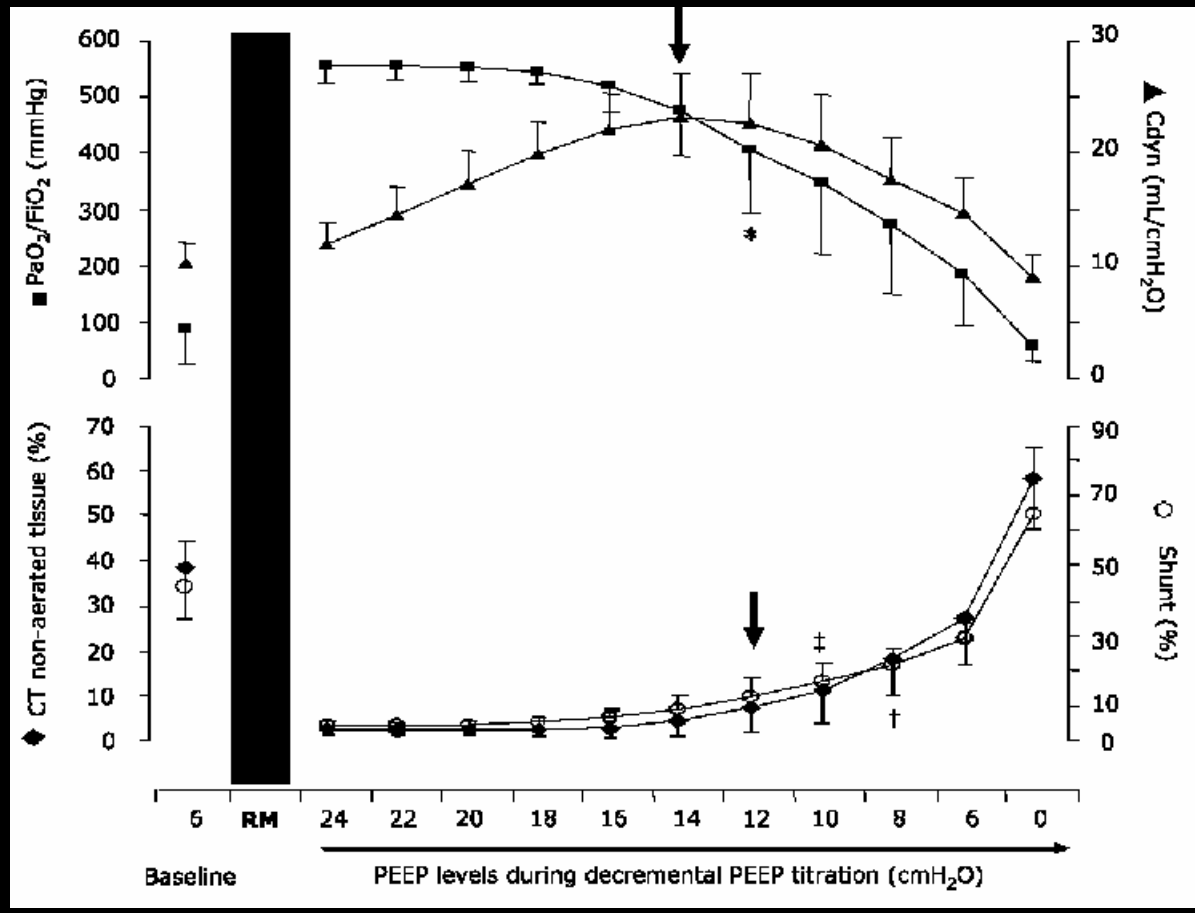
Burns D J Trauma 2001;51:1177-81





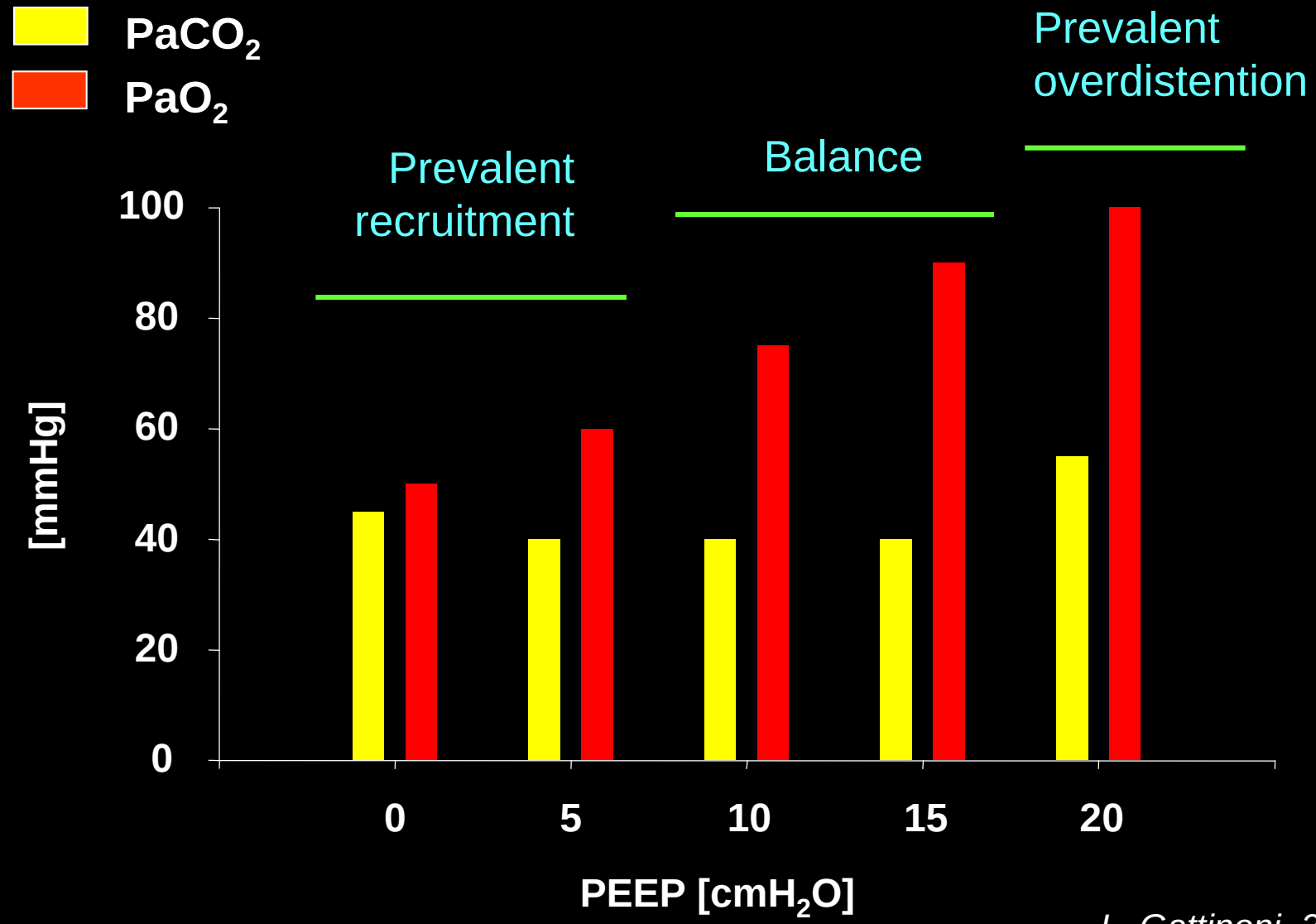
Use of dynamic compliance for open lung positive end-expiratory pressure titration in an experimental study





F Suarez-Sipman
Crit Care Med 2007; 35:214–221

Constant V_T : $PaCO_2$ and PaO_2

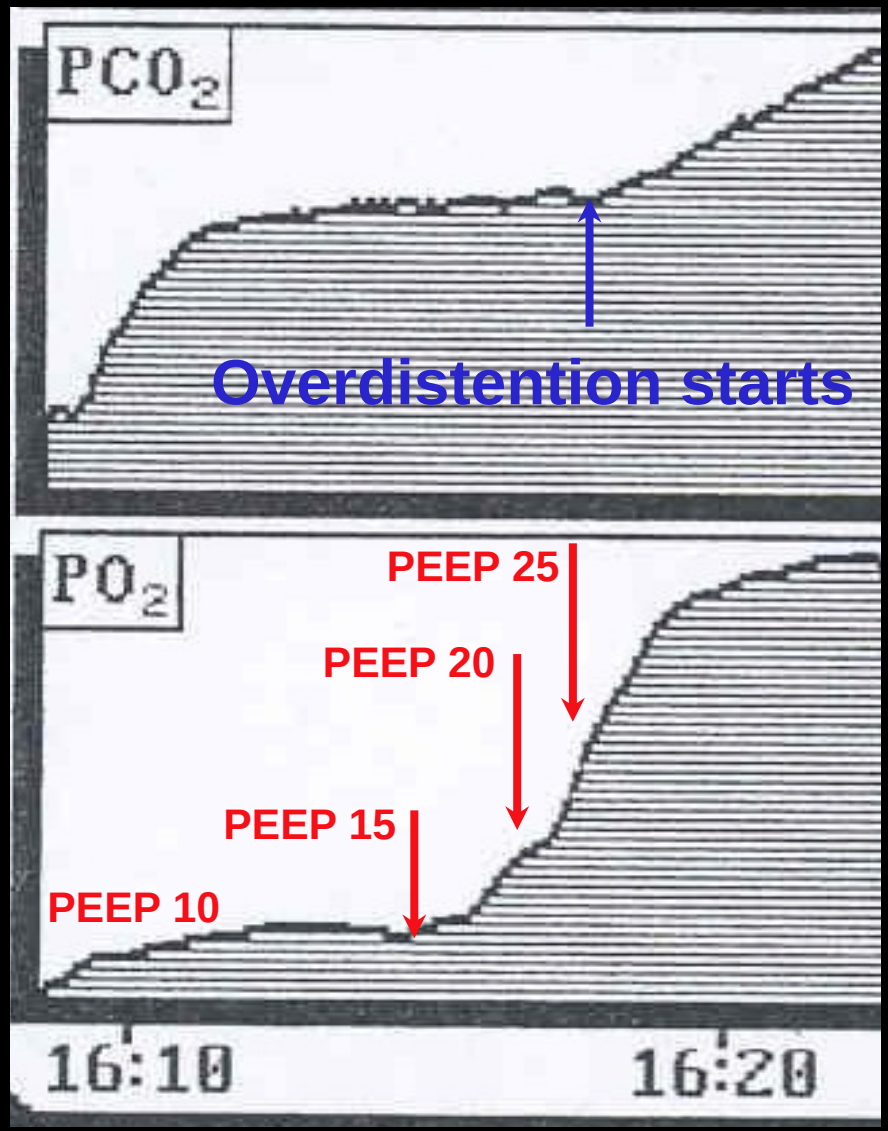


L. Gattinoni, 2003

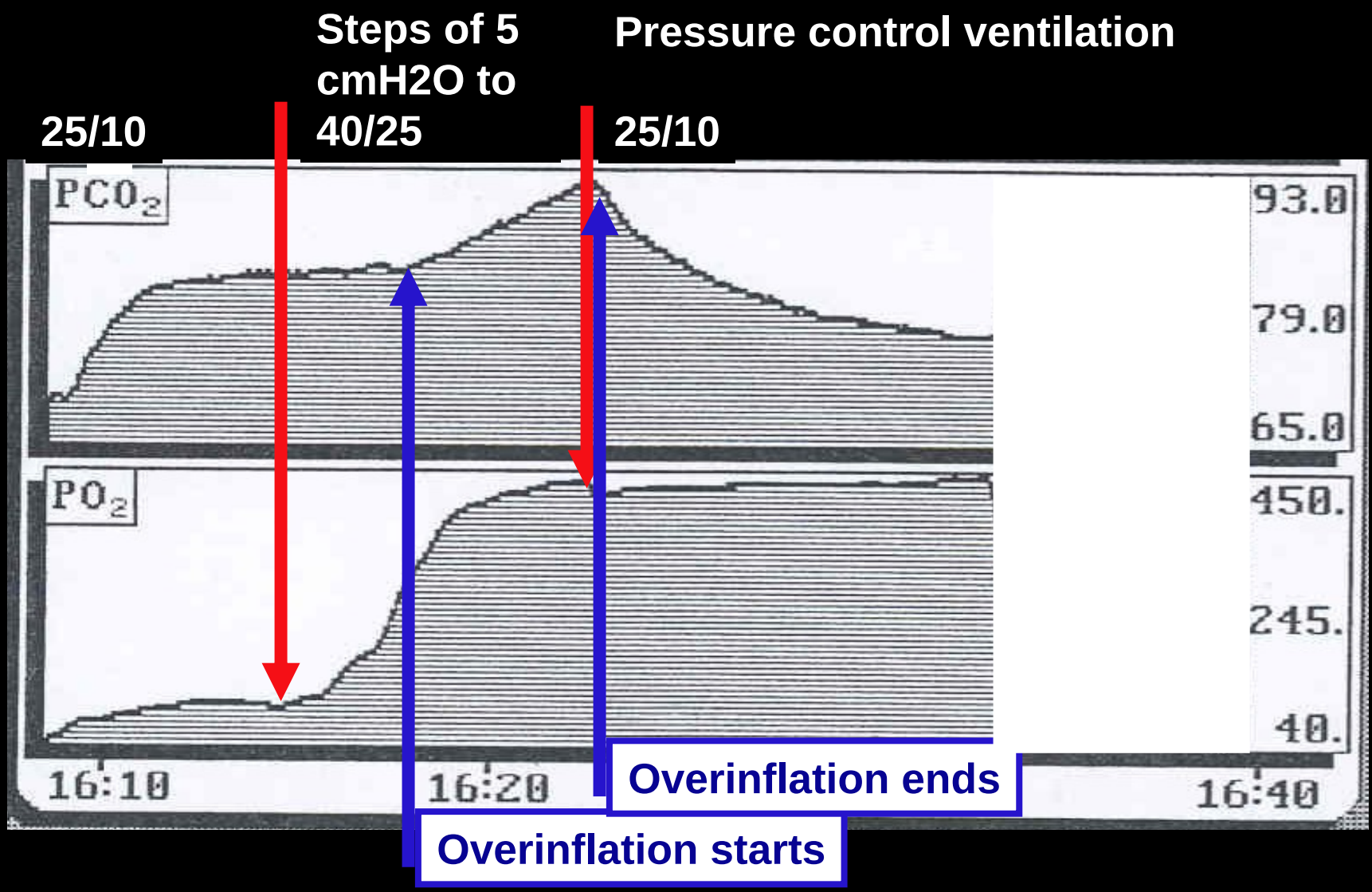
PEEP titration and the physiologic response

CO_2-response

Oxygenation



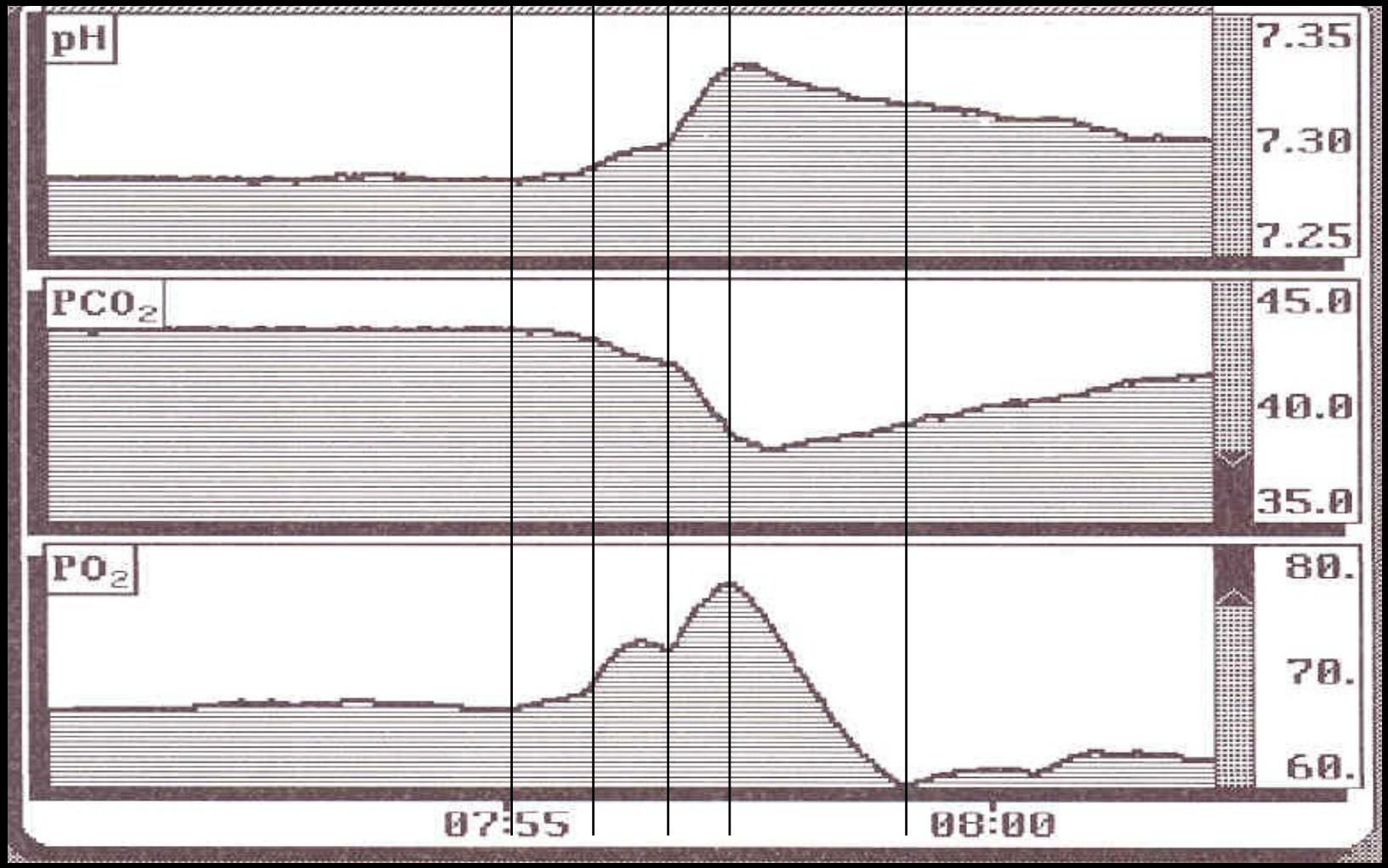
PEEP titration and the physiologic response



Physiologic response to pressure changes during HFO

CDP: 13 12 11 10 9 11

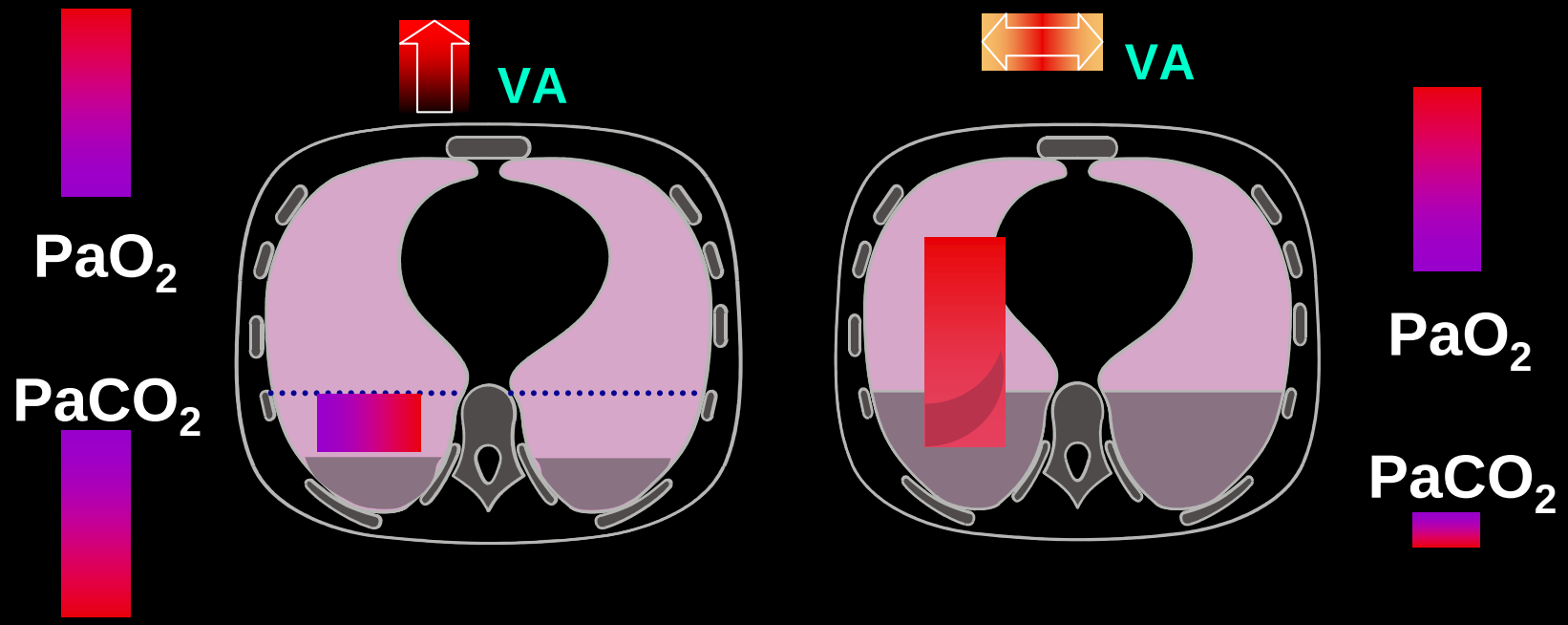
Overdistention Collapse



O_2-improvement = Shunt improvement =

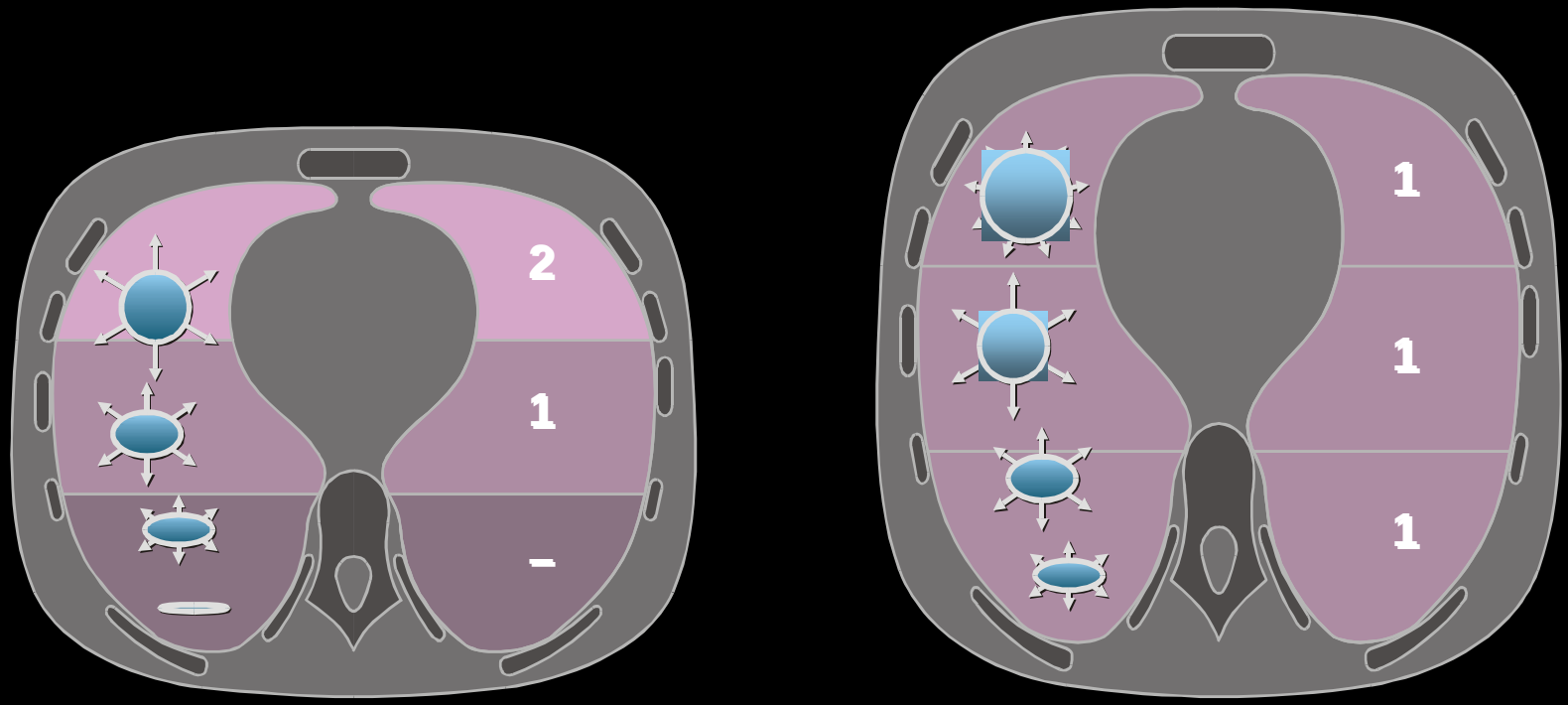
a) recruitment

b) flow diversion



L. Gattinoni, 2003

Prevalent overinflation = dead space effect

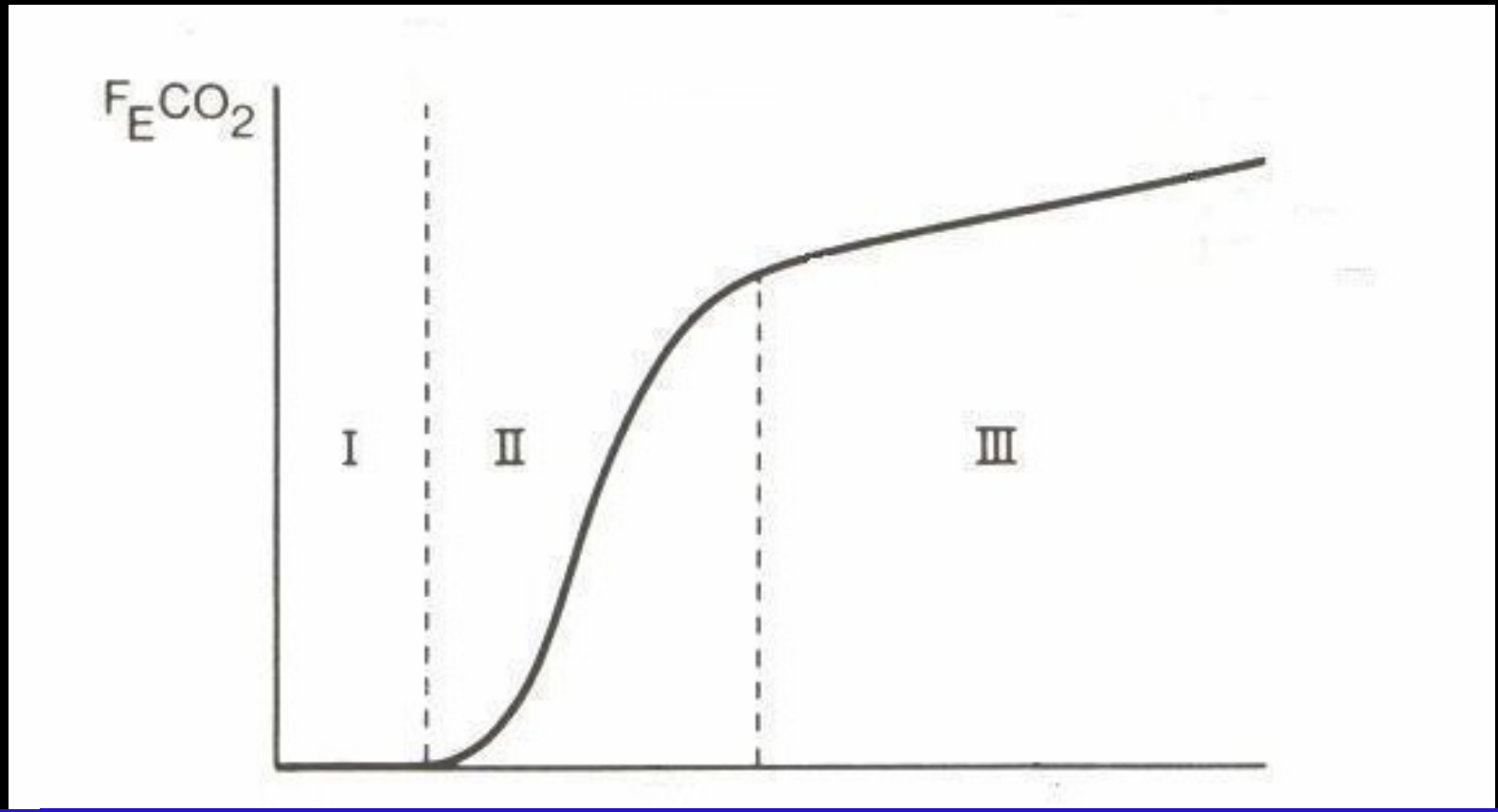


PEEP 0 *PEEP 20*

PaO_2 and $PaCO_2$ increase

L. Gattinoni, 2003

Single breath CO_2-tracing



Phase III **Alveolar gas** – called plateau but ascends gradually due to

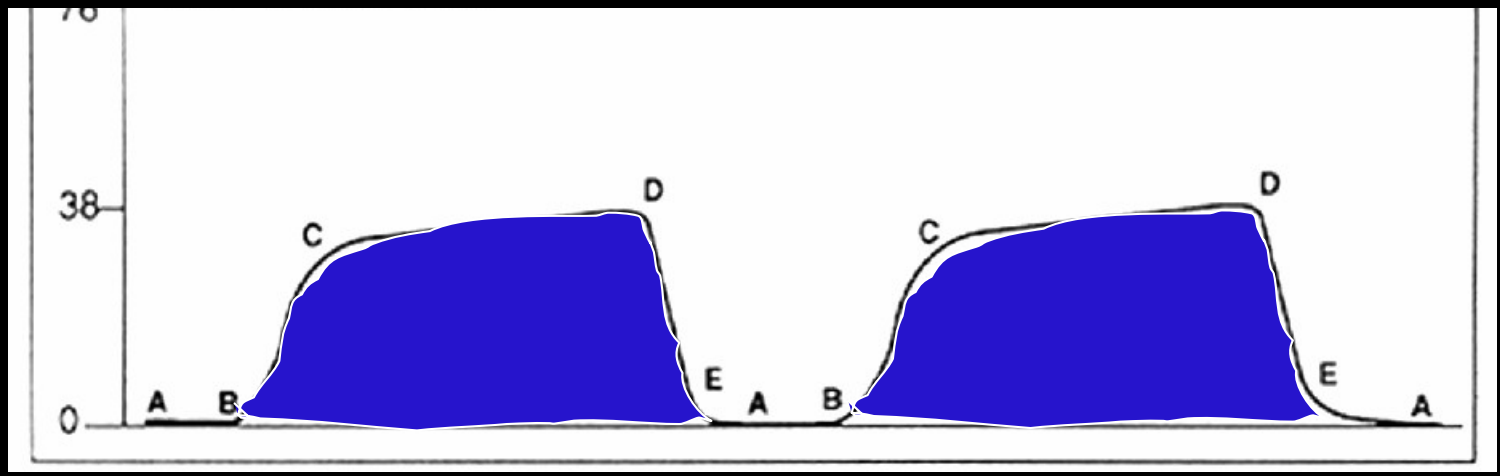
a) sequential emptying of lung regions with different V/Q-ratios

b) within units V/Q mismatching secondary to incomplete gas mixing

c) the continual release of CO_2 into the alveoli during expiration

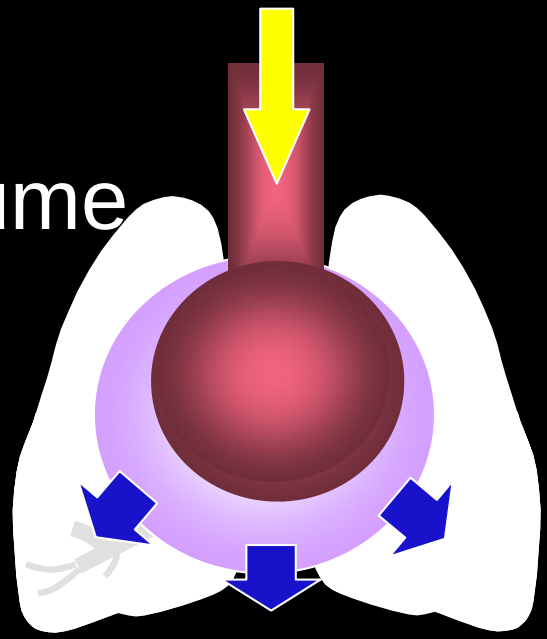
CO_2 in ventilatory monitoring

$etCO_2$	endtidal value
$FeCO_2$	fraction of CO_2 in expired gas
VCO_2	minute elimination (”production”)
$VTCO_2$	tidal elimination



Breath by Breath

Pressure – Flow – Time - Volume



$$\Delta Vol,max = \Delta P \times Crs$$

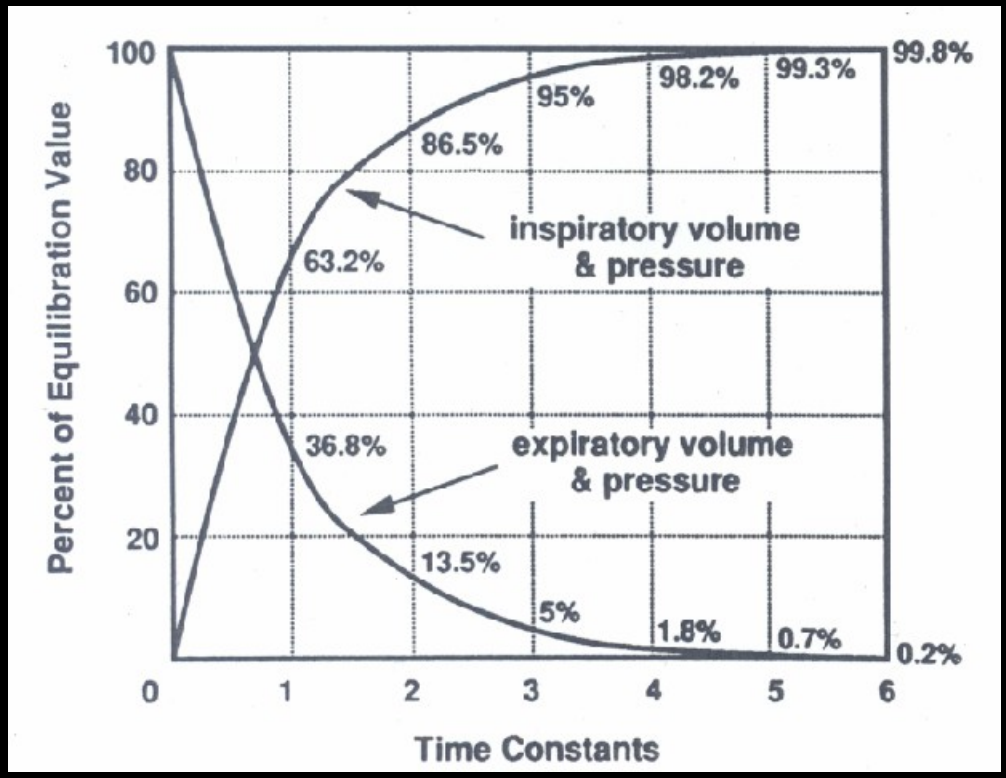
Volume change requires time to take place.

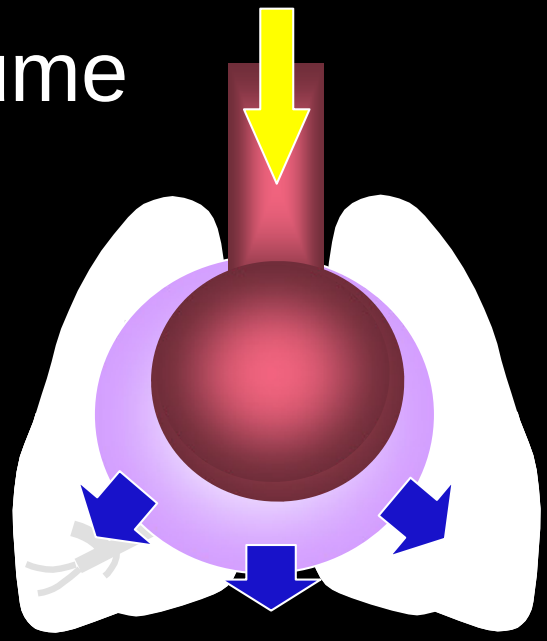
When a step change in pressure is applied, the instantaneous change in volume follows an exponential curve, which means that, formerly faster, it slows down progressively while it approaches the new equilibrium.

Time constant: T = Crs x Rrs

Pressure – Flow – Time - Volume

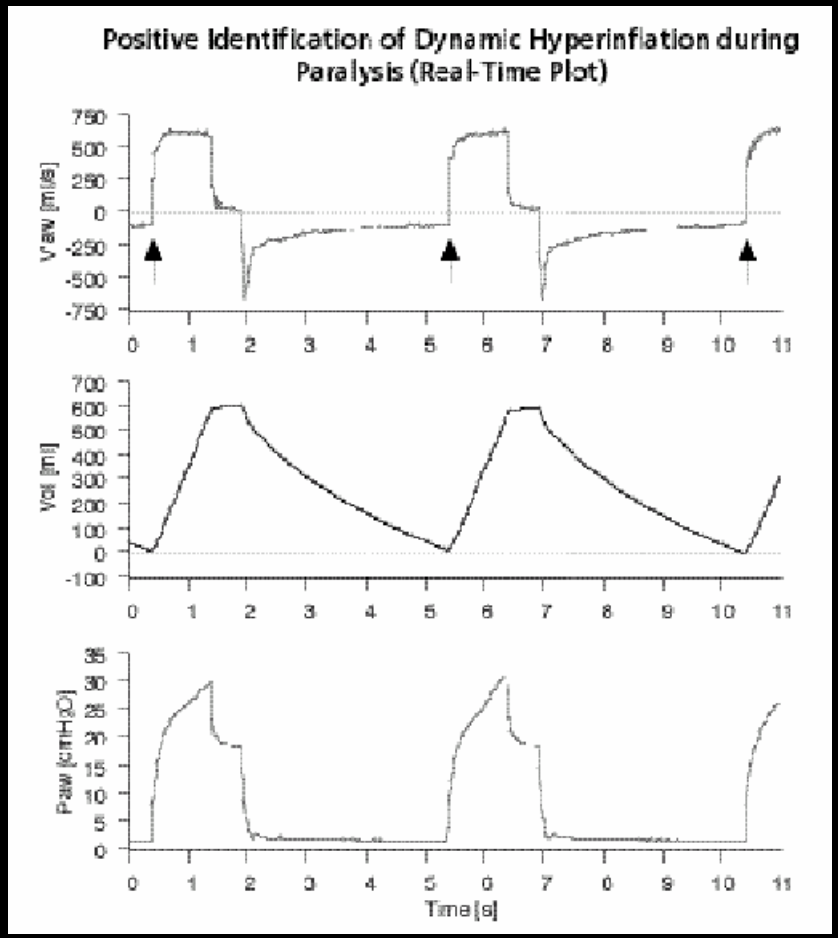
Time constant: T = Crs x Rrs

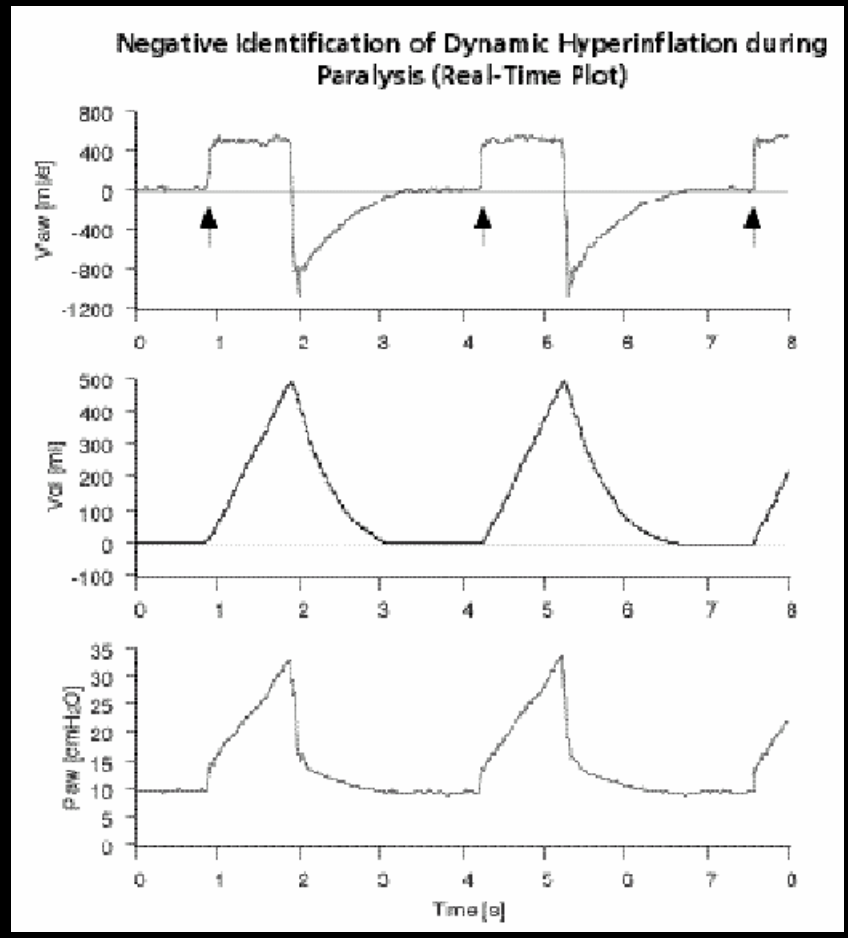




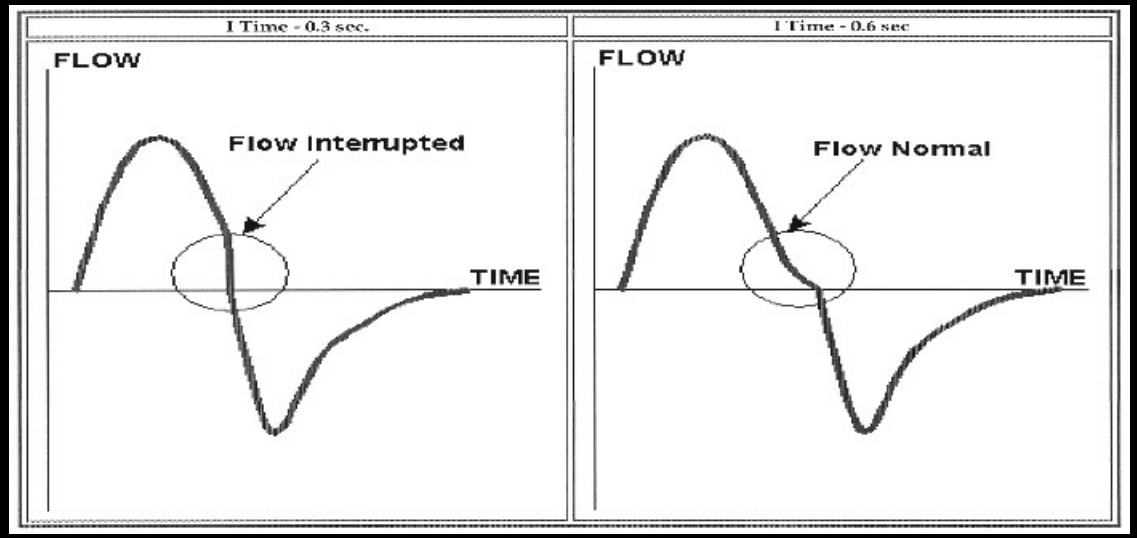
Patient-Ventilator Interaction - Monitoring

Flow termination and auto-PEEP

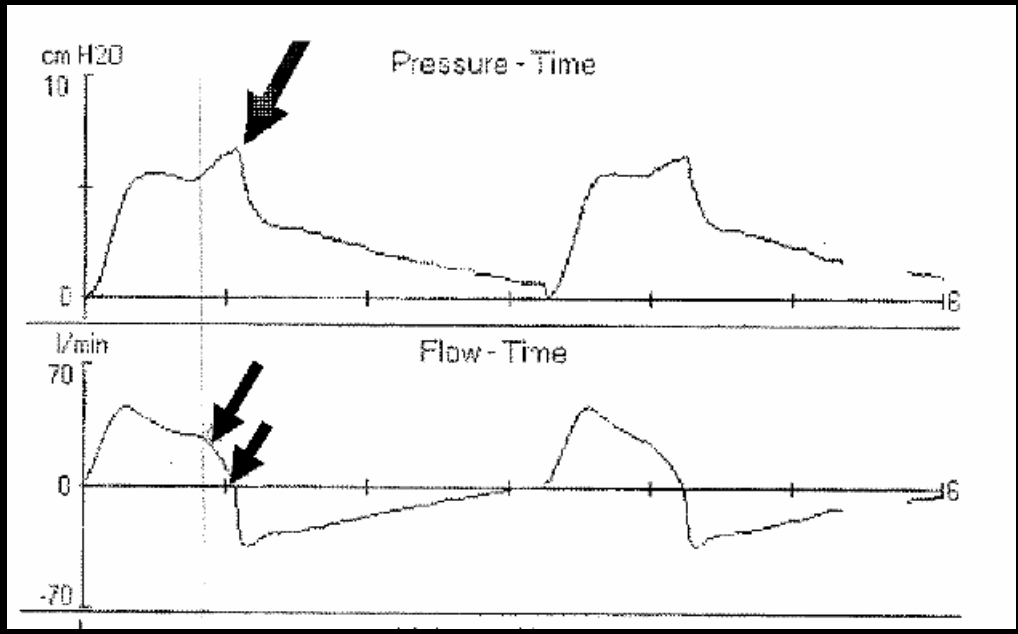




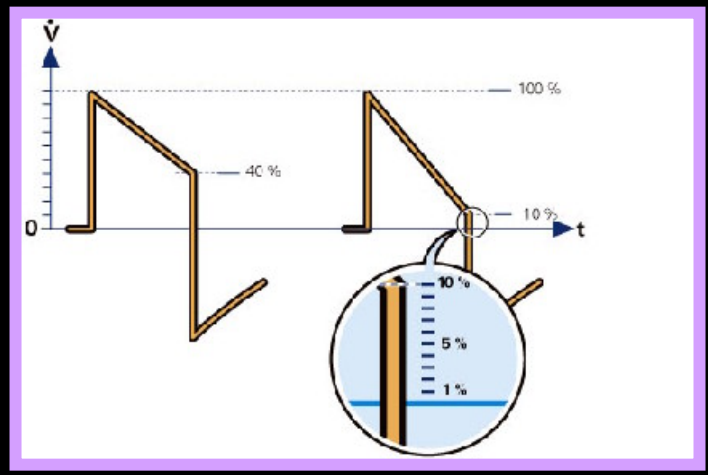
Control Modes



Support Modes

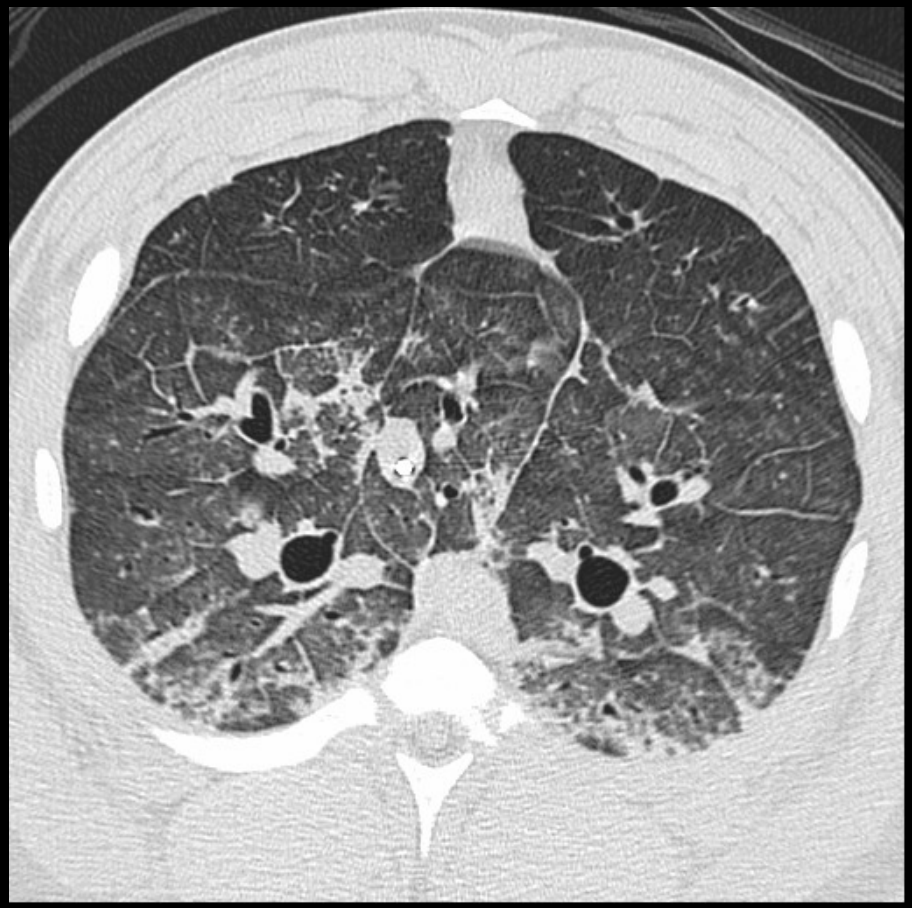


Flow termination criteria

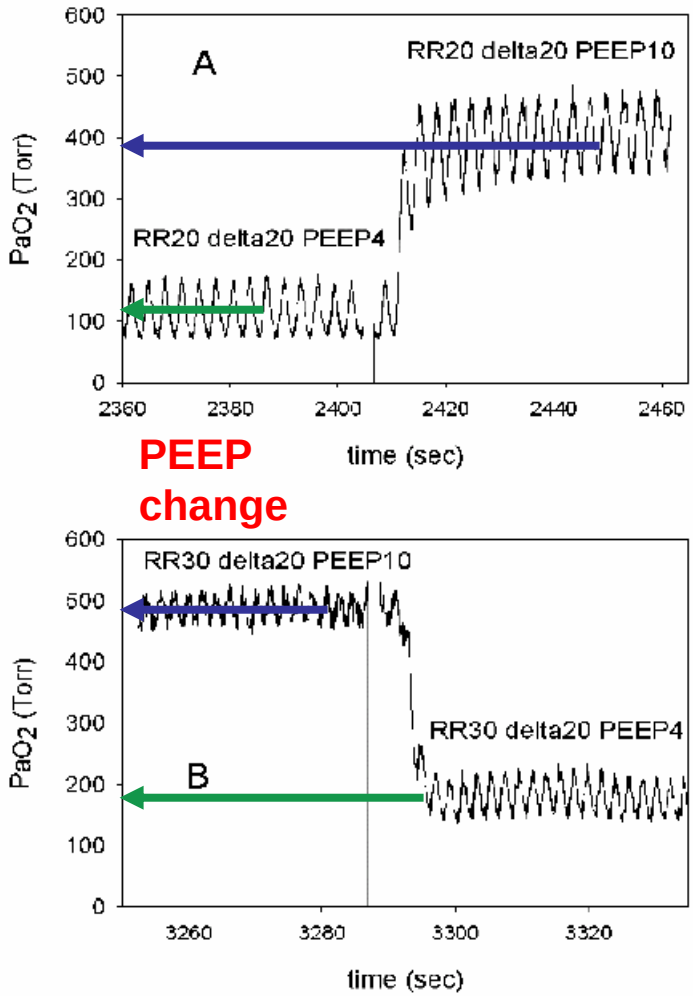


Nilsestuen J Respir Care 2005;50:202–232

Breath by Breath “Dynamics” Visualized

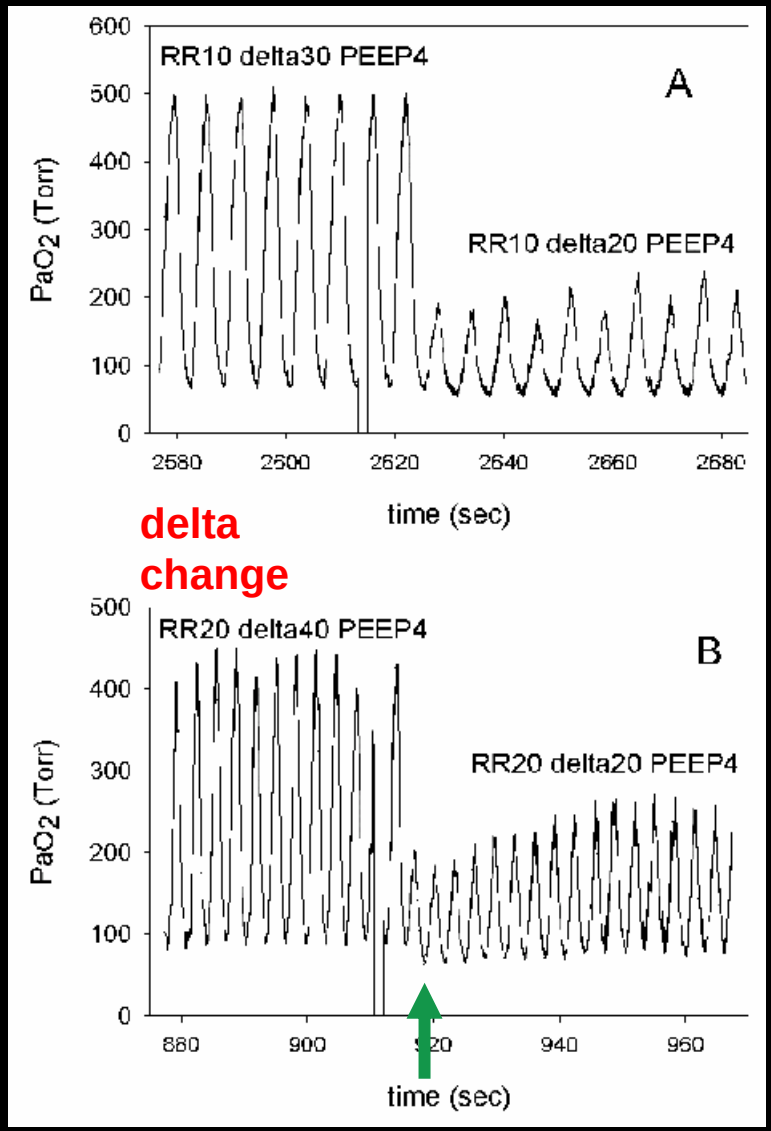


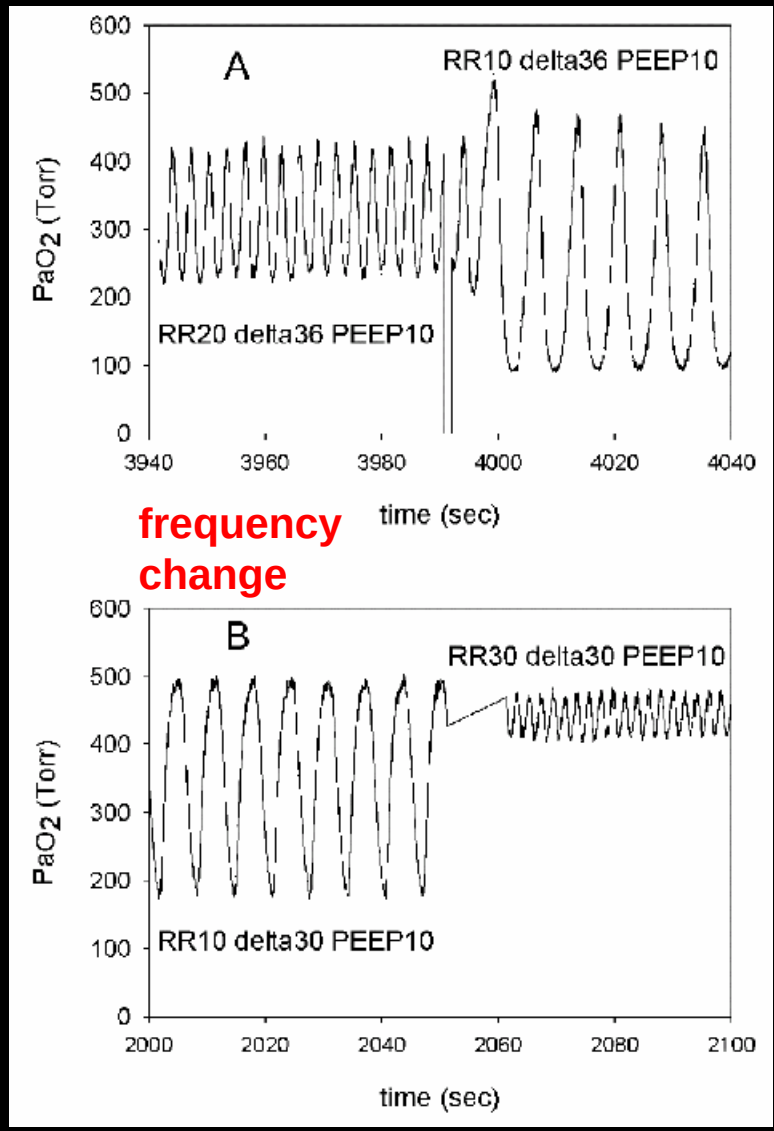
Digital sample rate of 12.2 Hz



Baumgardner JE AJRCCM 2002; 166:1556-62

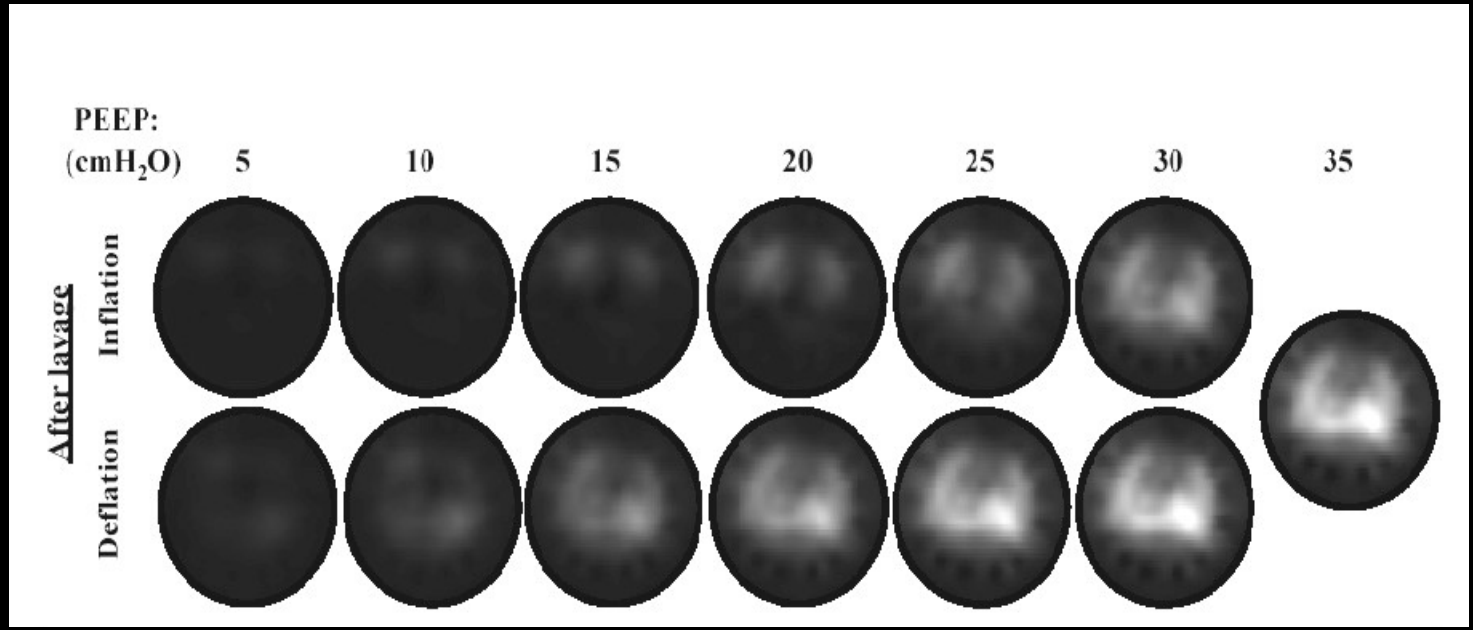
Breath by Breath "Dynamics" Visualized



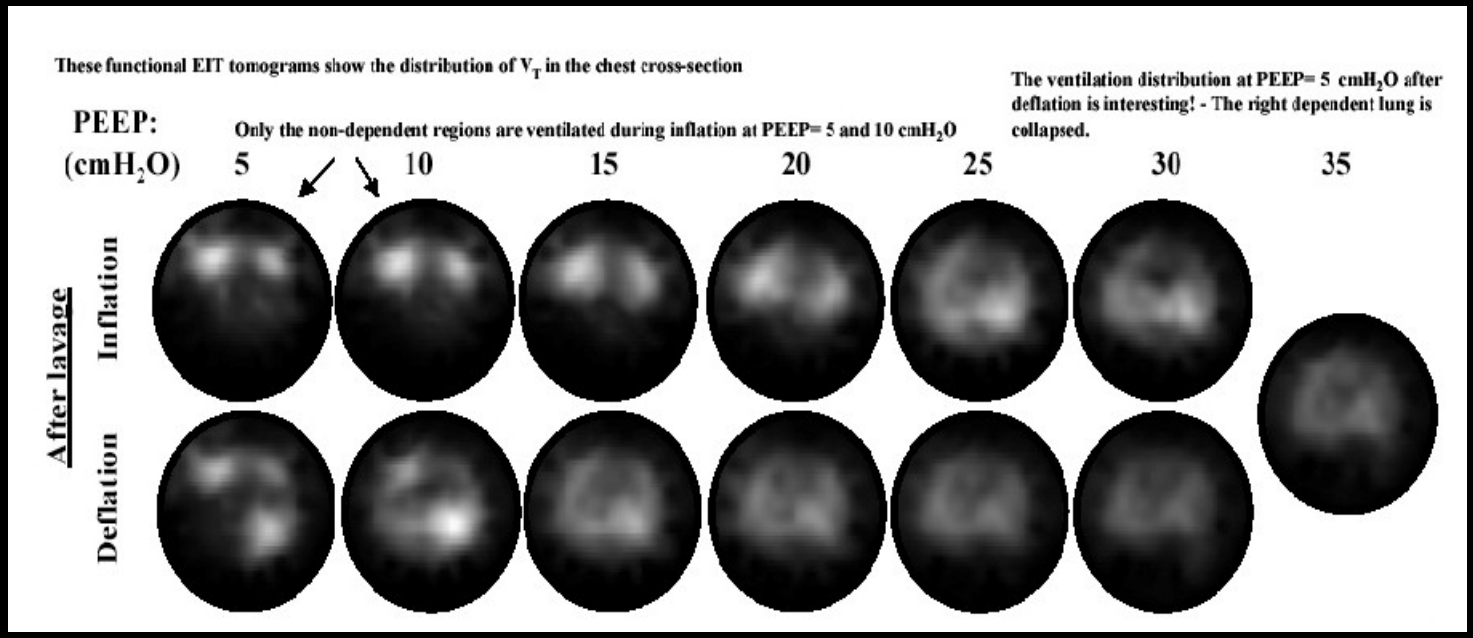


Baumgardner JE AJRCCM 2002; 166:1556-62

Volume distribution

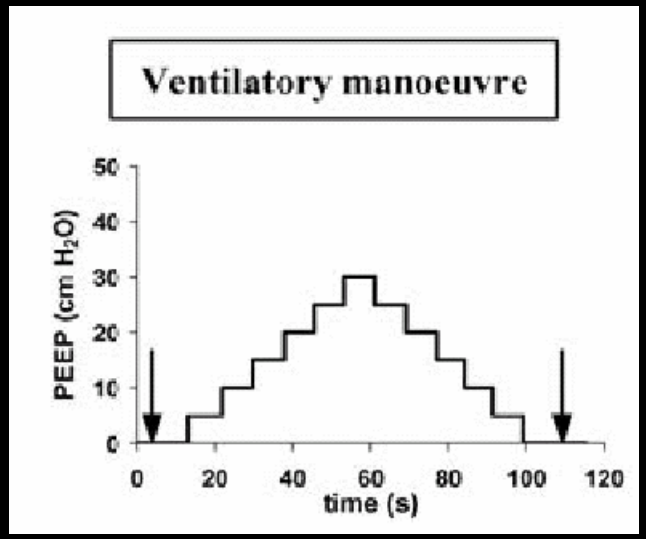


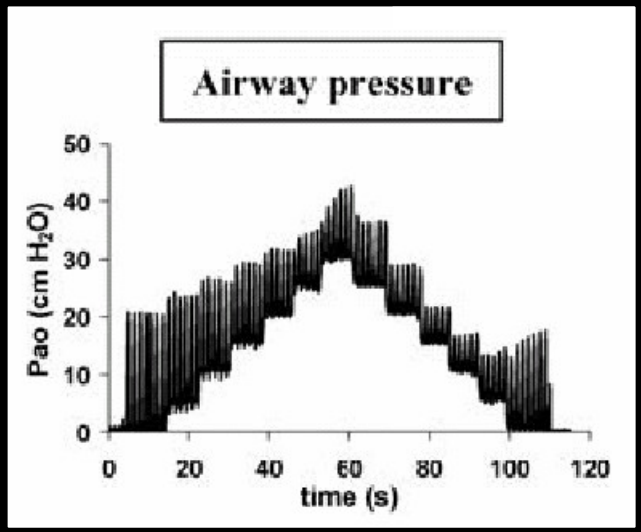
Tidal volume distribution

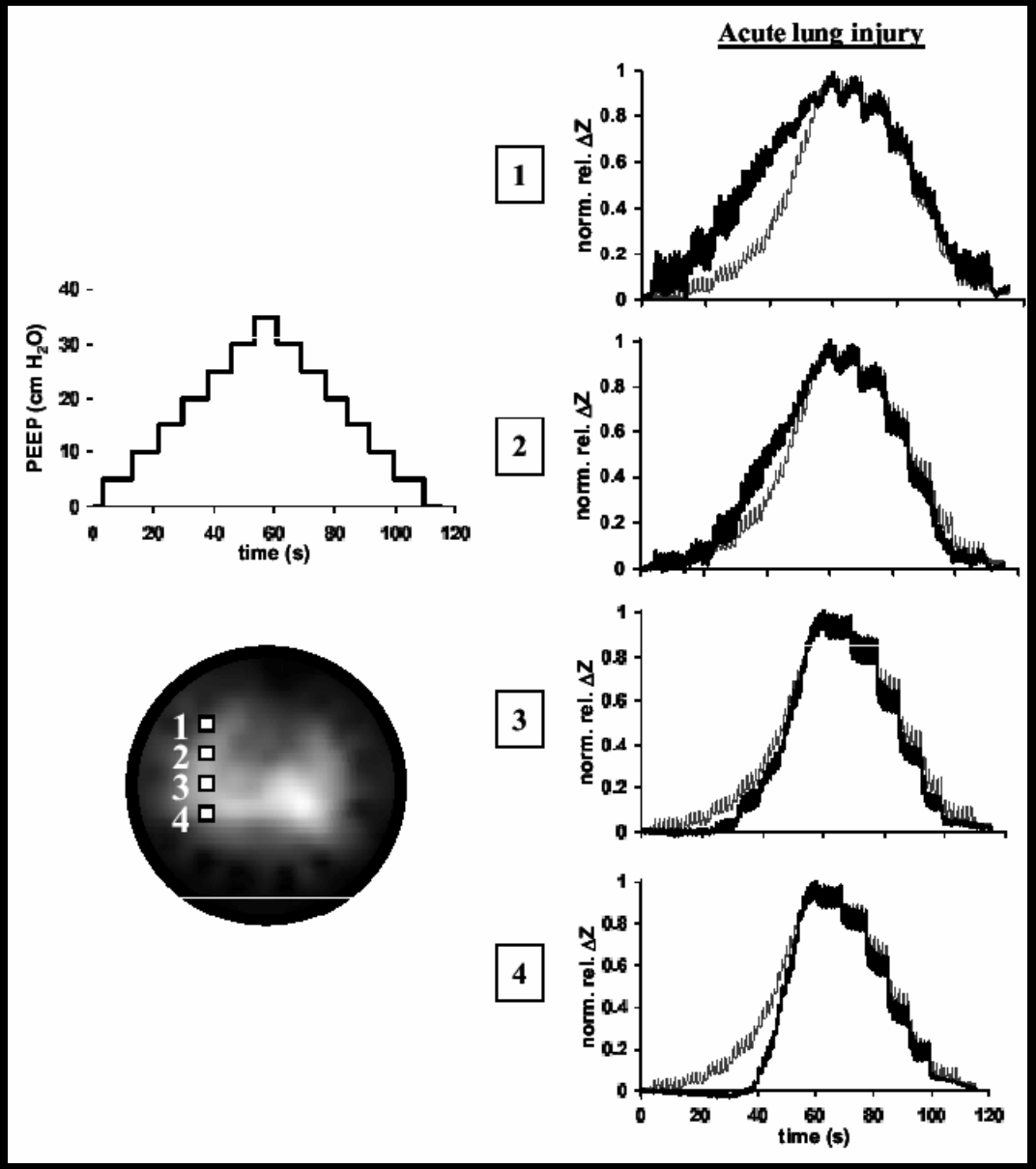


Frerichs I, Dargaville P, Rimensberger PC Intensive Care Med 2003

EIT to quantify Vt-distribution

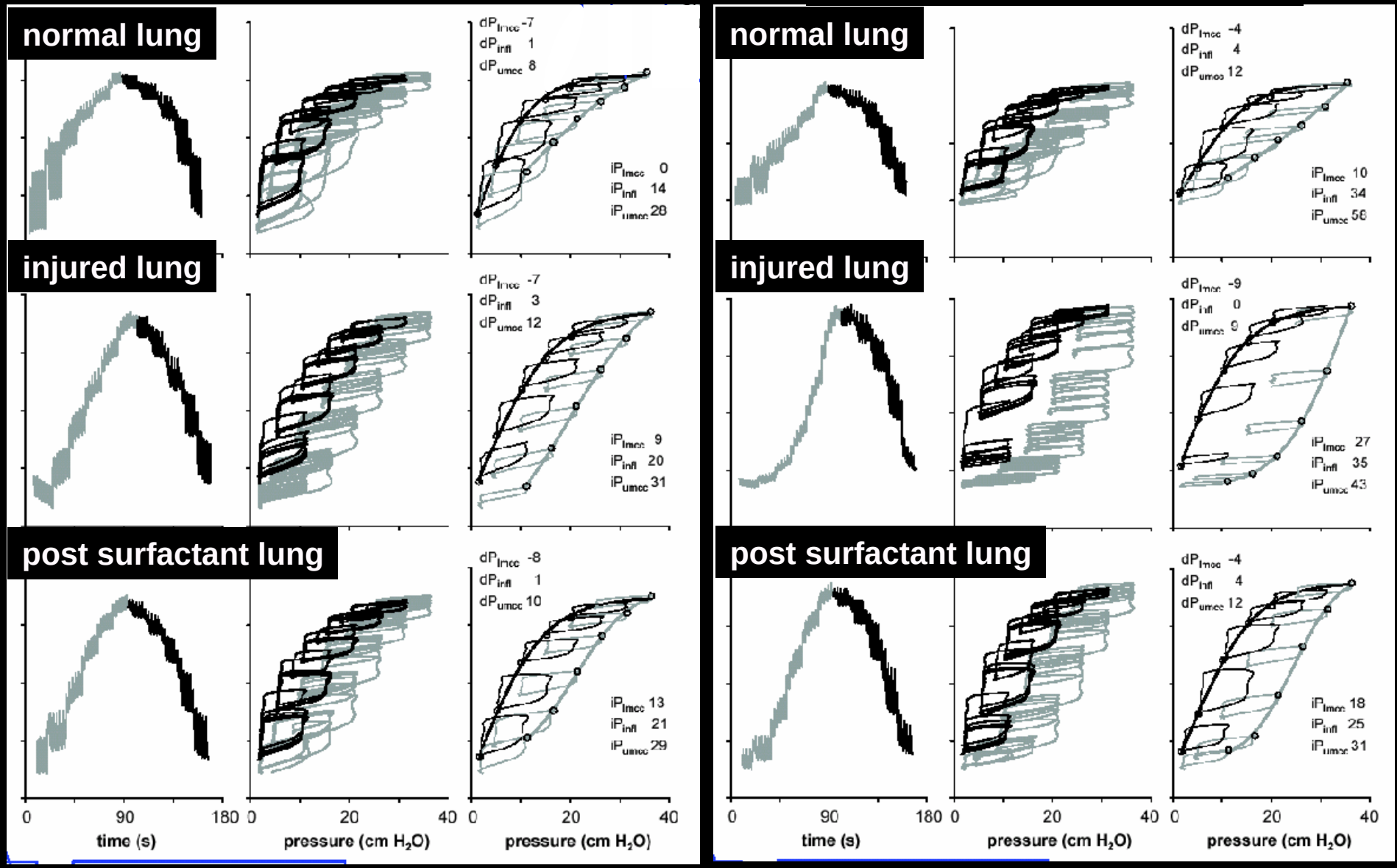




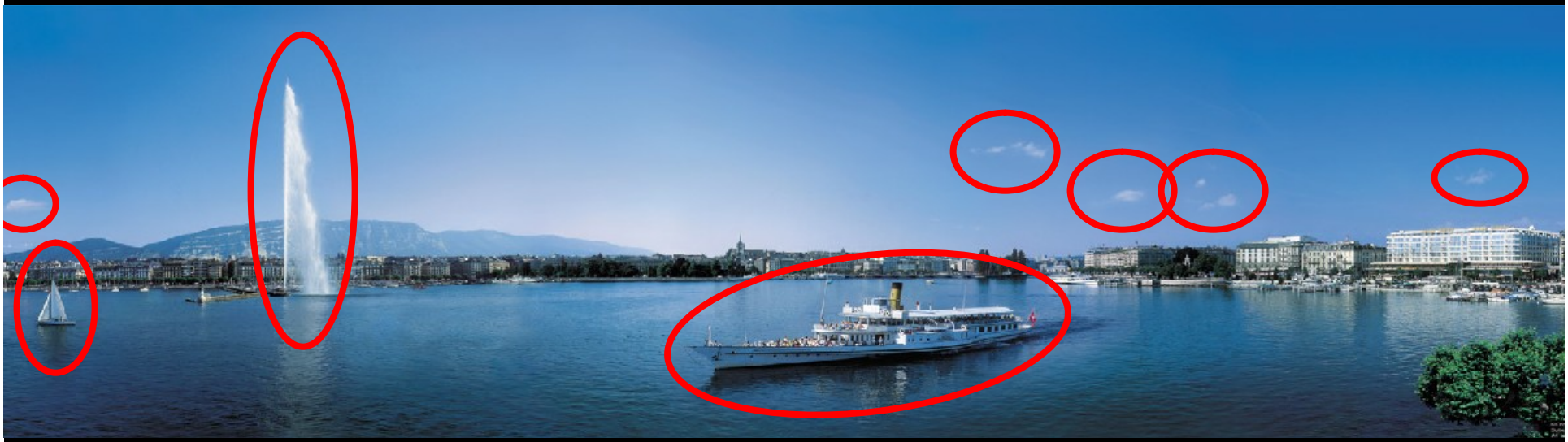


Frerichs I, Dargaville P, Rimensberger PC Intensive Care Med 2003; 29:2312-6

Regional «homogeneity» on the deflation limb



Frerichs I, Dargaville P, Rimensberger PC (in preparation)



The basic tools, do I have them? YES

To use them better you have to think “dynamic”

Look for trends and not for static numbers