Introduction to Mechanical Ventilation Part-1

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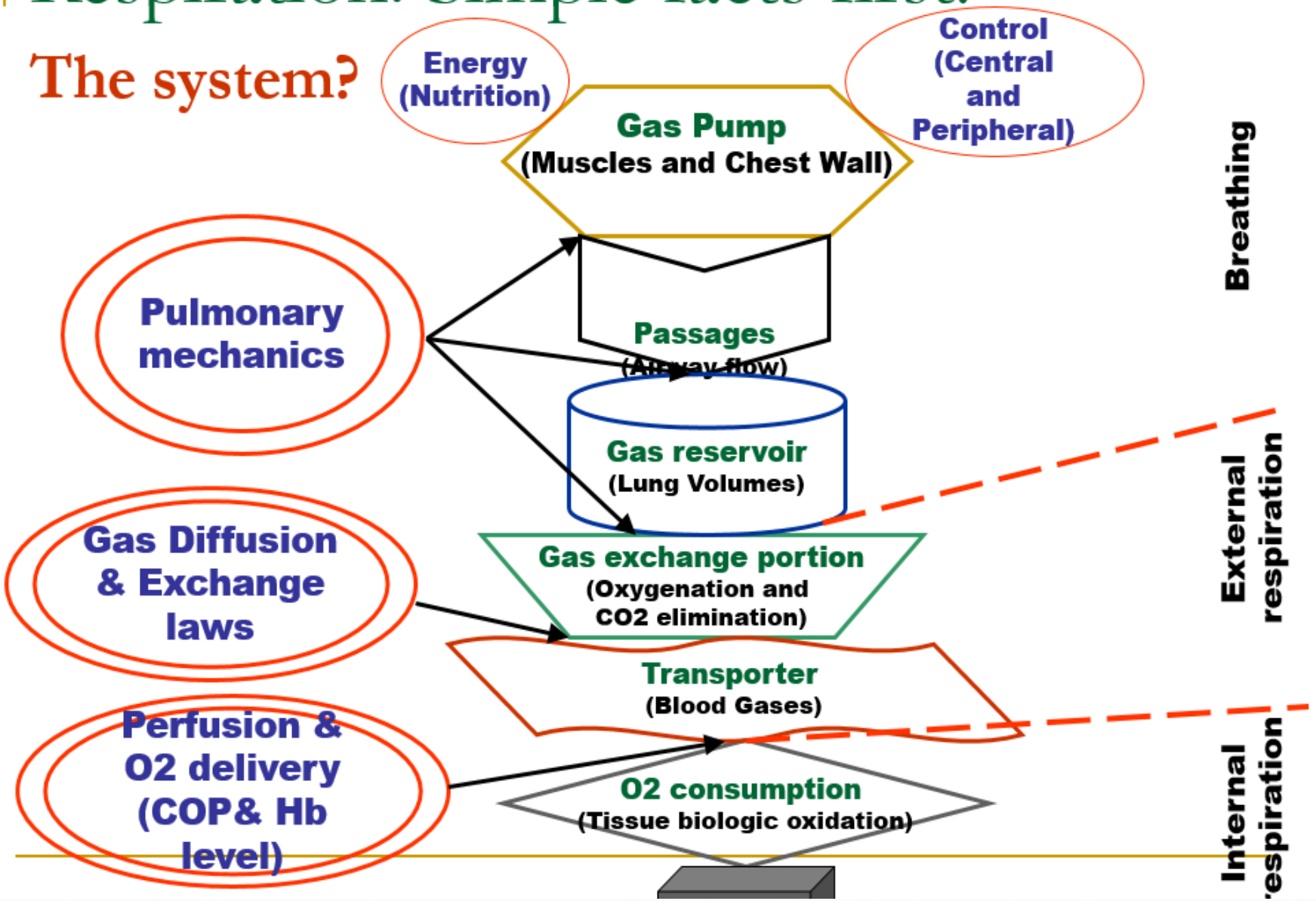
Overview of topics

1. Introduction (mechanics and gas exchange)
2. Ventilator Settings (disease specific)
3. Ventilator types and modes

Respiration: Simple facts first!

The system?

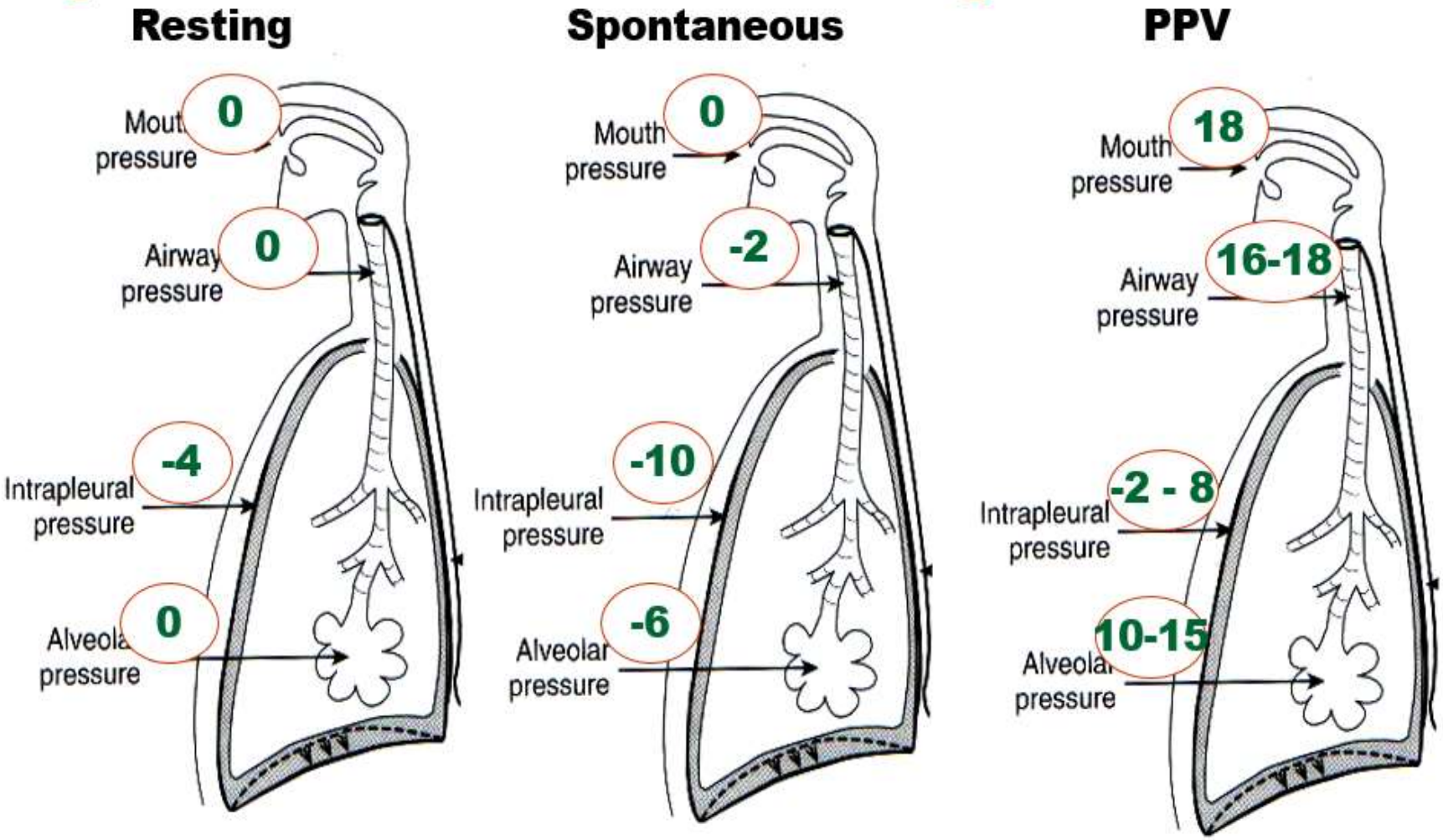


Pulmonary mechanics

- Pressure (elastance, resistance)
- Volume
- Flow
- Time

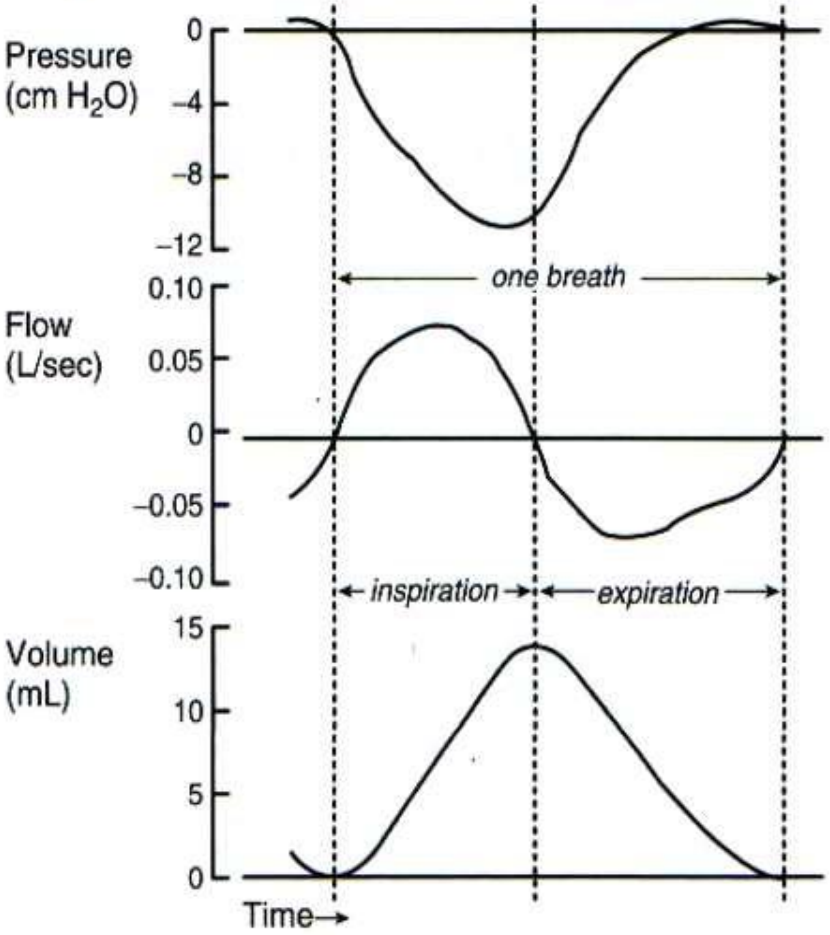
Pulmonary Mechanics

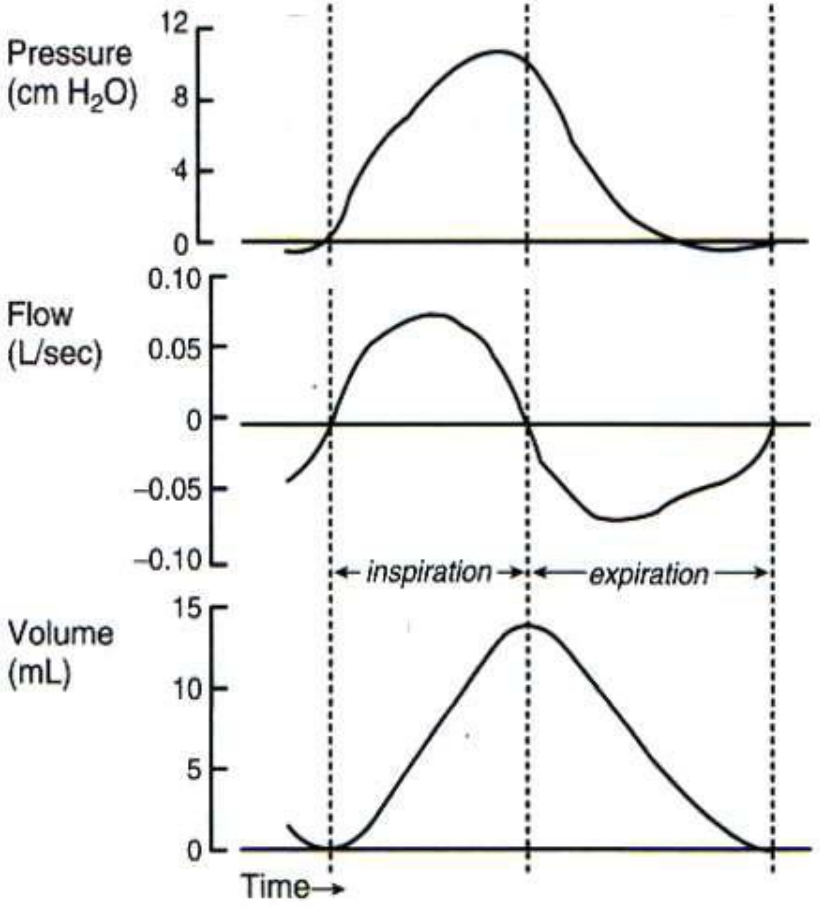
Spontaneous vs. mechanical inspiration



Pulmonary Mechanics

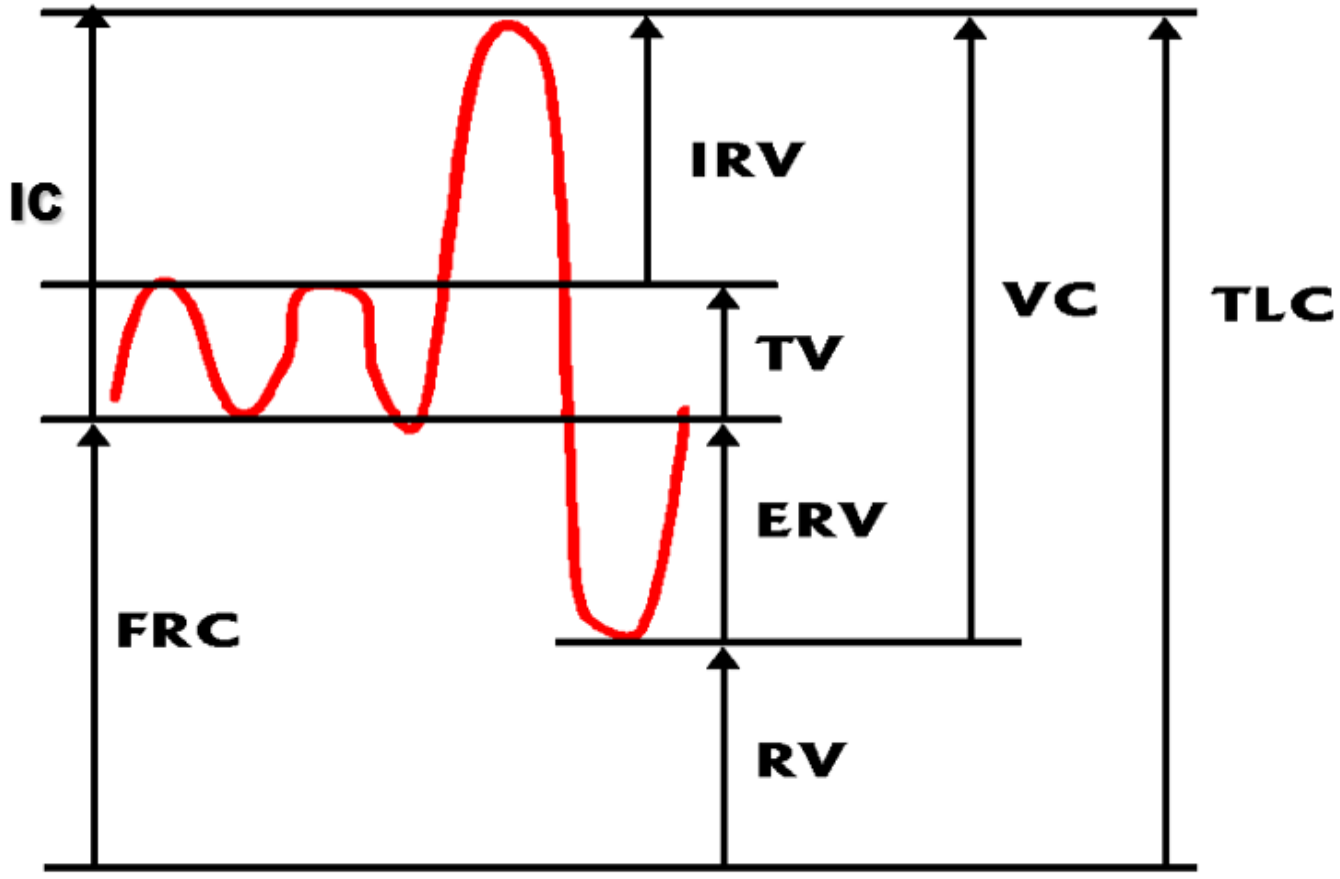
Spontaneous vs. mechanical breathing



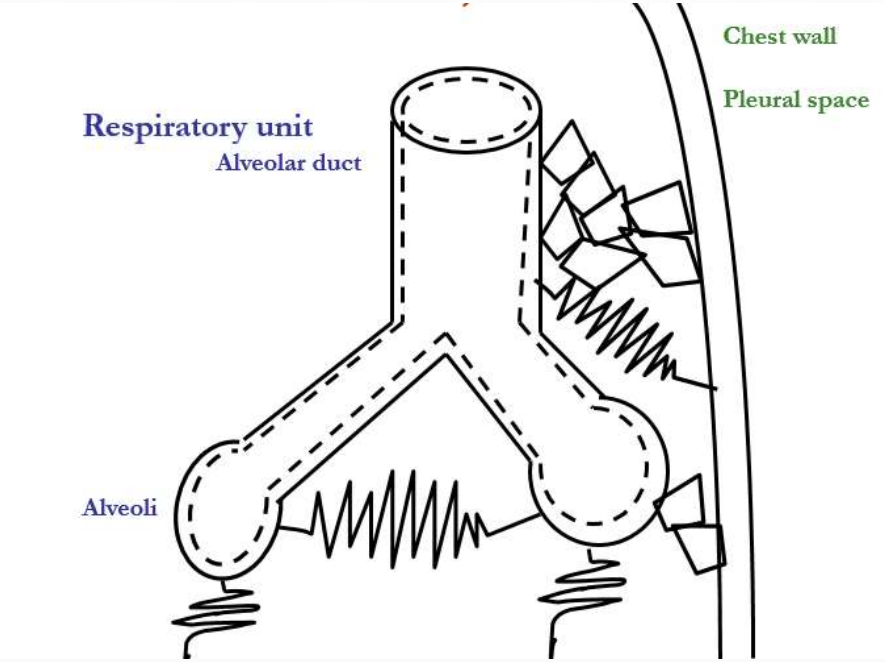


Pulmonary Mechanics

Respiratory Volumes

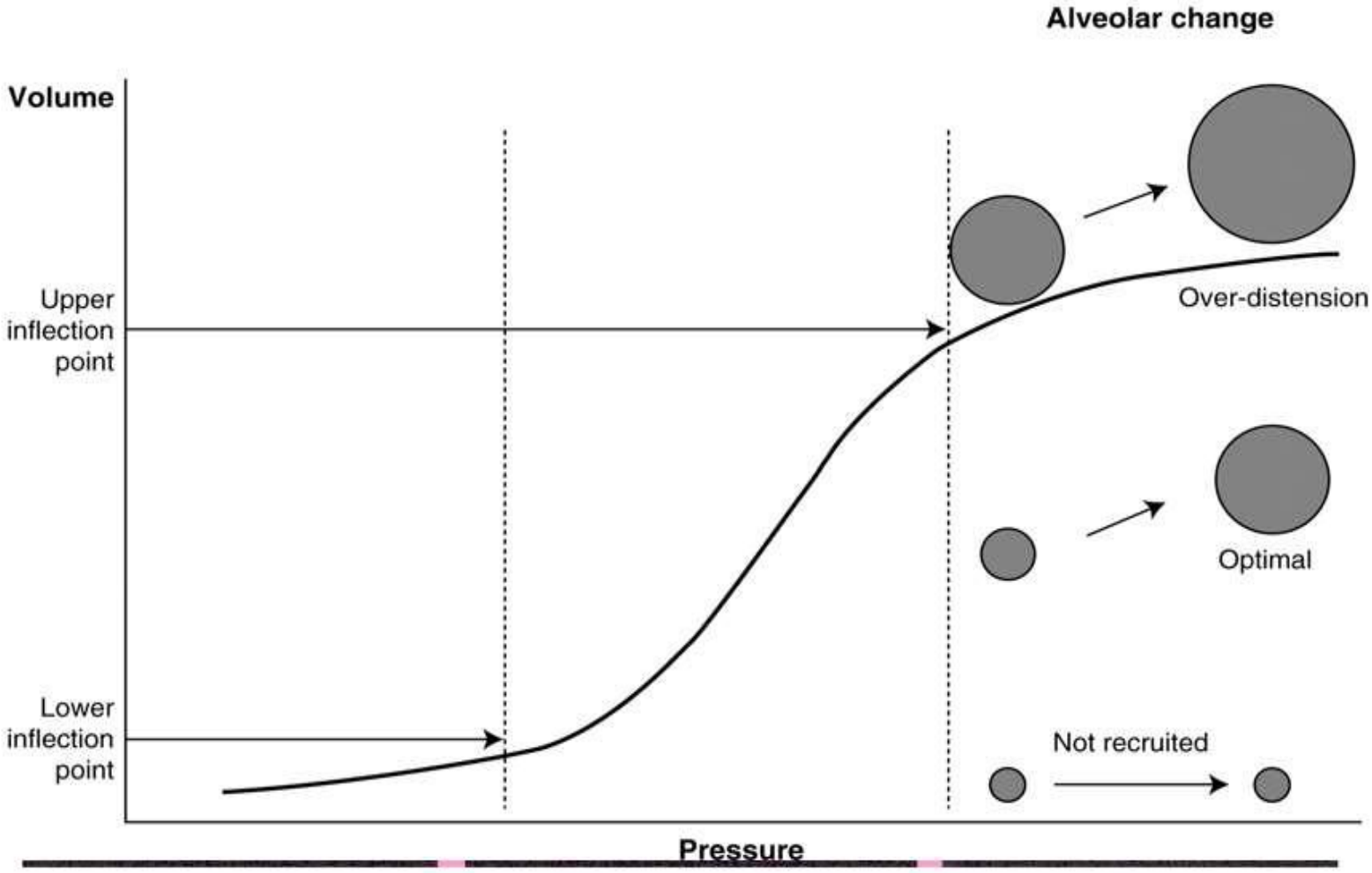


- Compliance: Inverse of elastance
- Change in volume per unit change in pressure



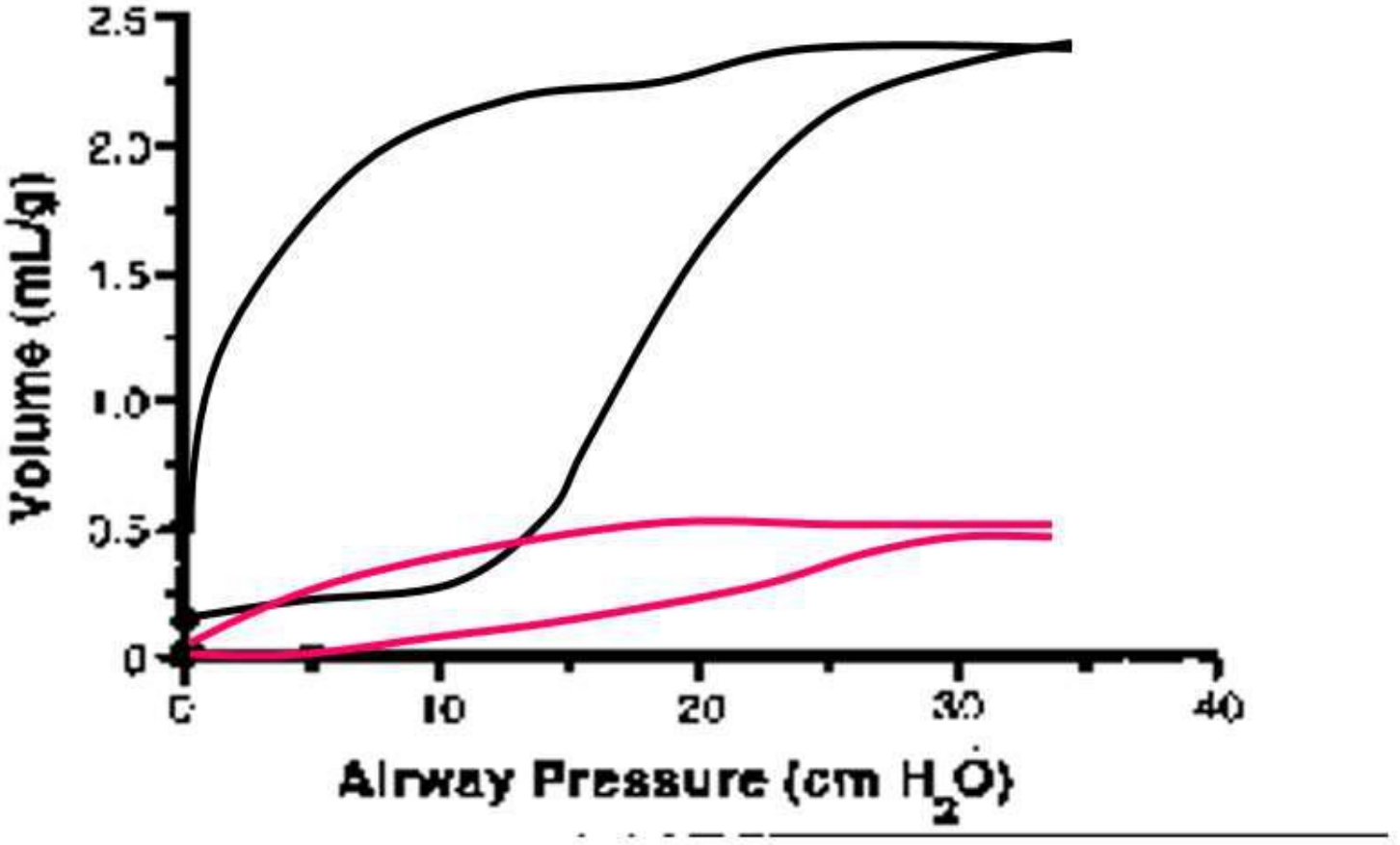
Pulmonary Mechanics

Compliance (upper and lower inclination points)



Pulmonary Mechanics

Compliance (in HMD)



Resistance = Pressure/Flow

Resistance (law)

- Poiseuille's law

$$P = F8nl/ \pi r^4$$

(F= flow; n = viscosity; l = length; r = radius)
(For turbulent flow: l/r5)

- Pressure needed to achieve given flow (to overcome Resistance) in a tubing system is
  - Directly proportional to
    - Flow rate
    - Gas viscosity,
    - Length of the airway
  - and inversely proportional to
    - The fourth power of the radius

Pulmonary Mechanics

Values

Parameter	Unit	Adult	Newborn	HMD	MAS
Pulmonary compliance	mL/cm H_2O/kg	2.5-3	2-2.5	<0.6	<1.0
Chest wall compliance	mL/cm H_2O/kg	<1	>4	-	-
Pulmonary resistance	cm H_2O/L/sec	1-2	20-40	40	>150
Resistive work	g-cm/kg	<10	20-30	30-40	>40

- Time constant

Compliance × Resistance

- Healthy term neonate:
  - C = 0.004 L/cm H_2O; R = 30 cm H_2O/L/sec
  - T = 0.004 x 30 = 0.12 sec
- Time constants Ti % equilibration

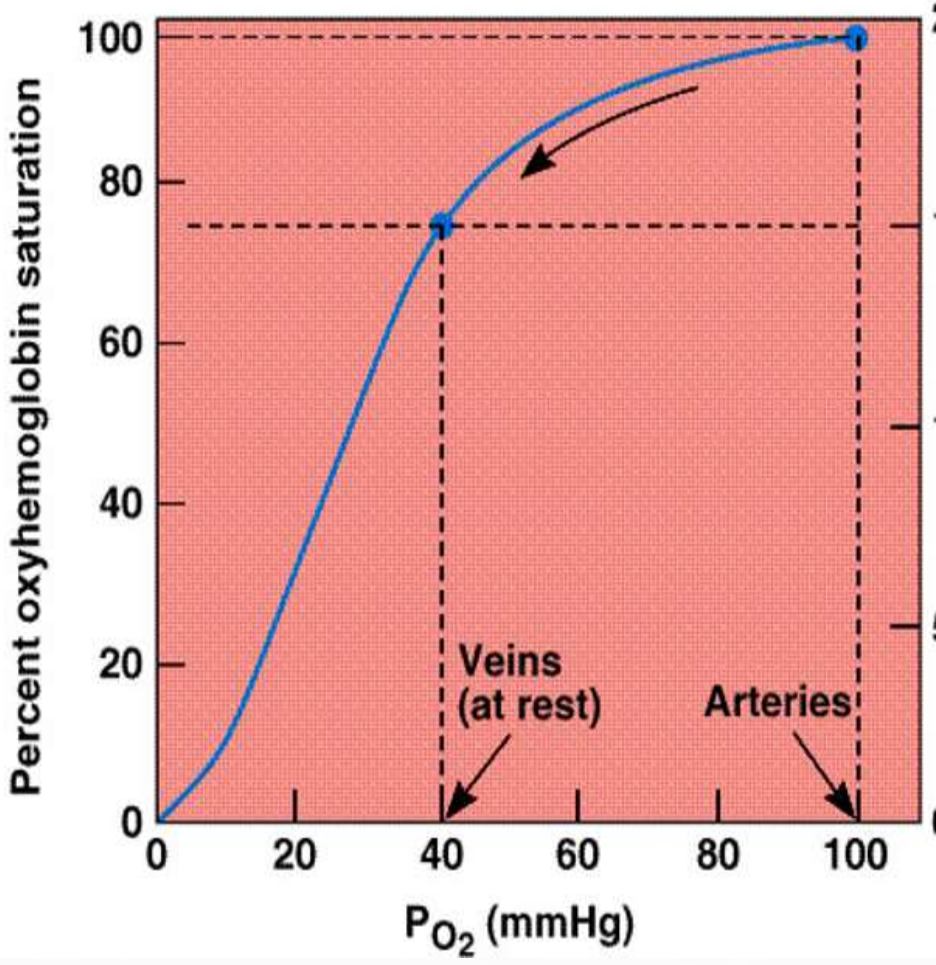
1	0.12	63
2	0.24	86
3	0.36	95
5	0.60	99

- RDS: Shorter time constant

Gas Exchange

Gases transport in the blood

- Oxygen transport in the blood
  - **HB-bound O2**
  - Dissolved in plasma
- Carbon dioxide transport in the blood
  - **Bicarbonate (85%)**
  - Dissolved in plasma (5%)
  - Carried inside red blood cells on hemoglobin as carbamate (at different binding sites than those of O2) (10%)



Hypoxemia

Pathophysiological mechanisms

- Ventilation-Perfusion mismatch (most common)

  Mild RDS, Pneumonia, Aspiration/Atelectasis

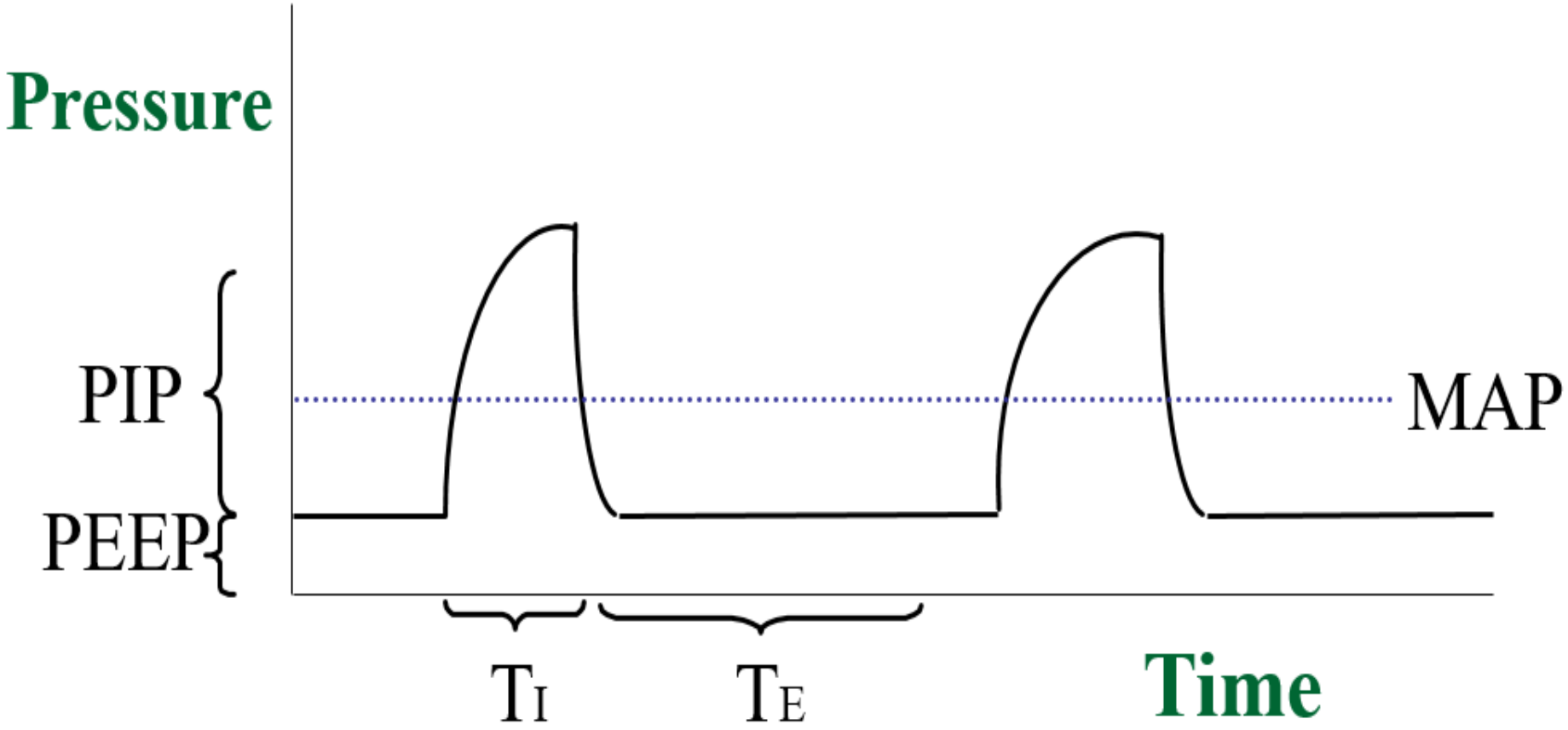
- Alveolar hypoventilation

- Right-to-left shunt

- Diffusion limitation

Oxygenation

Oxygenation during MV (MAP manipulation)



Hypercapnia

Pathophysiological mechanisms

- Hypoventilation

  Central hypoventilation

  Obstruction of main airways

- Increased dead space ventilation

  Disease state (hypoperfused lung)

  Iatrogenic (long ETT, ventilator circuit)

Intervention

Overview of topics

1. Introduction (mechanics and gas exchange)
2. Ventilator Settings (disease specific)
3. Ventilator types and modes

Ventilators parameters (PCV)

Adjust, Monitor and Calculate

- Adjusted
  - PIP
  - PEEP
  - Ti
  - Rate (Te)
  - ± I:E ratio
  - Flow
  - FiO2
  - Trigger
  - ±Targeted VT
- Monitored(alarms)
  - PIP
  - PEEP
  - MAP
  - FiO2
  - Rate (total)
  - ±Rate (spont.)
  - ±VT (insp-Exp)
  - ±MV (total-spont)
- Calculated
  - I:E ratio
  - ΔP
  - T inflation
  - C
  - R
  - TC
  - Others

Disease specific initial settings

Disease	Compliance ml/cm H_2O	Resistance cm H_2O/ml/s	Time Constant (s)	FRC (ml/kg)	$\dot{V}/\dot{Q}$ Matching	Work
Normal term	4–6	20–40	0.25	30 ml/kg	–	–
RDS	↓↓	–	↓↓	↓	↓/↓↓	↑
Meconium aspiration	–/↓	↑/↑↑	↑	↑/↑↑	↓↓	↑
BPD	↑/↓	↑↑	↑	↑↑	↓↓/↓	↑↑
Air leak	↓↓	–/↑	–/↑	↑↑	↓/↓↓	↑↑
VLBW apnea	↓	–	↓↓	–/↓	↓/–	–/↑

Source: manual of neonatal care

↑ = increase; ↓ = decrease; – = little or no change; / = either/or.

Initial setting

- ***There is no standard setting for all cases and even for all newborns with the same disease.***

- ***Adjusting every starting setting to the response of the baby and keeping it adjusted with the changes in the condition is the key of success of mechanical ventilation***


THANK
YOU