Respiratory failure

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Definition and classification

1. Definition:

Failure of gas exchange due to inadequate function of respiratory system

2. Classification

Hypoxemia: lung edema, low FIO2, lung fibrosis

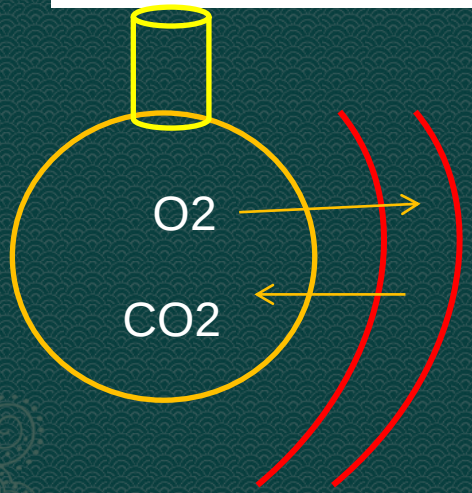
Hypercarbia: excess of CO2 production

Combination of hypoxemia and hypercarbia: COPD

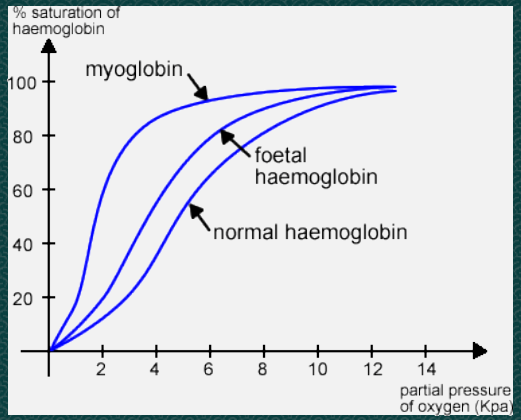
Type I, II, III, IV respiratory failure

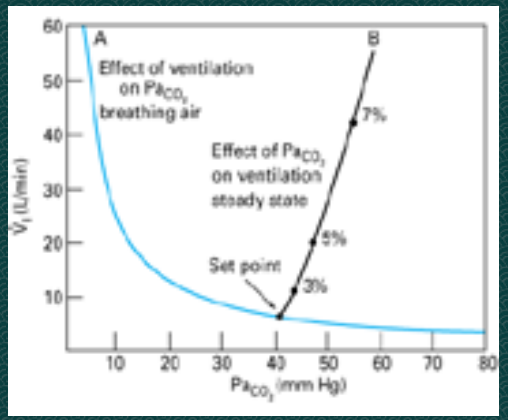
Lung physiology

Brain-stem

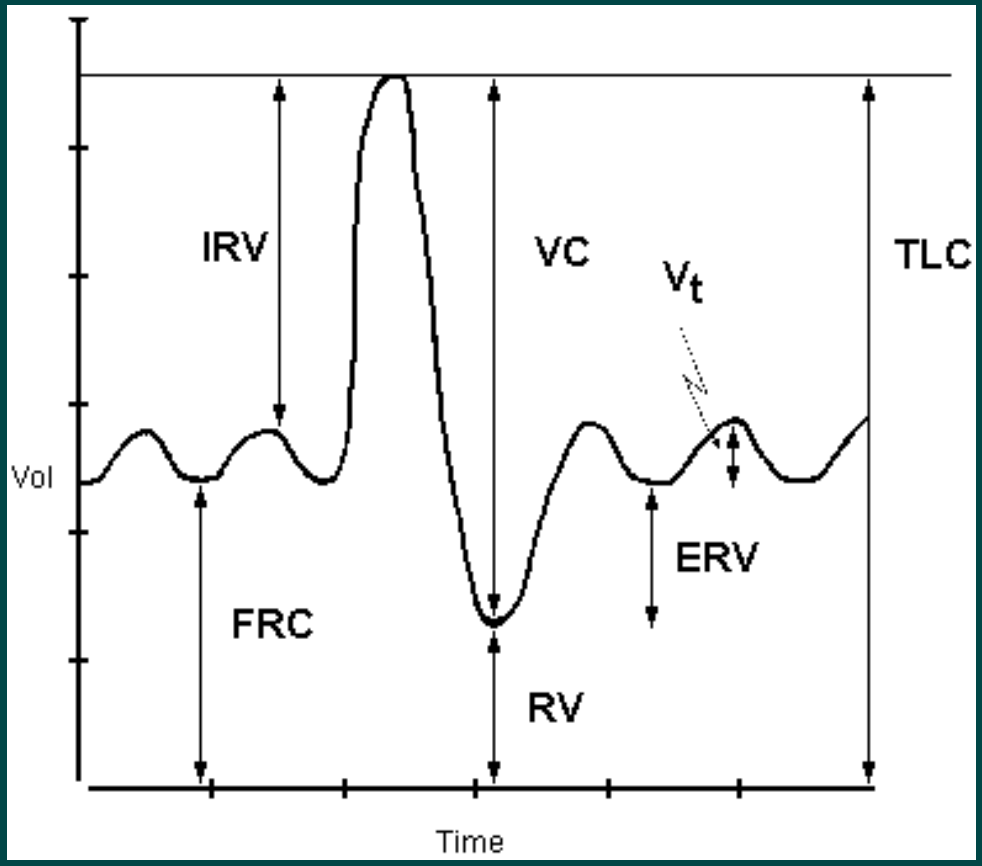


1. Controller: rhythm
2. Muscle: strong
3. Airway: patent
4. Alveolar: dry
5. Vasculature: intact





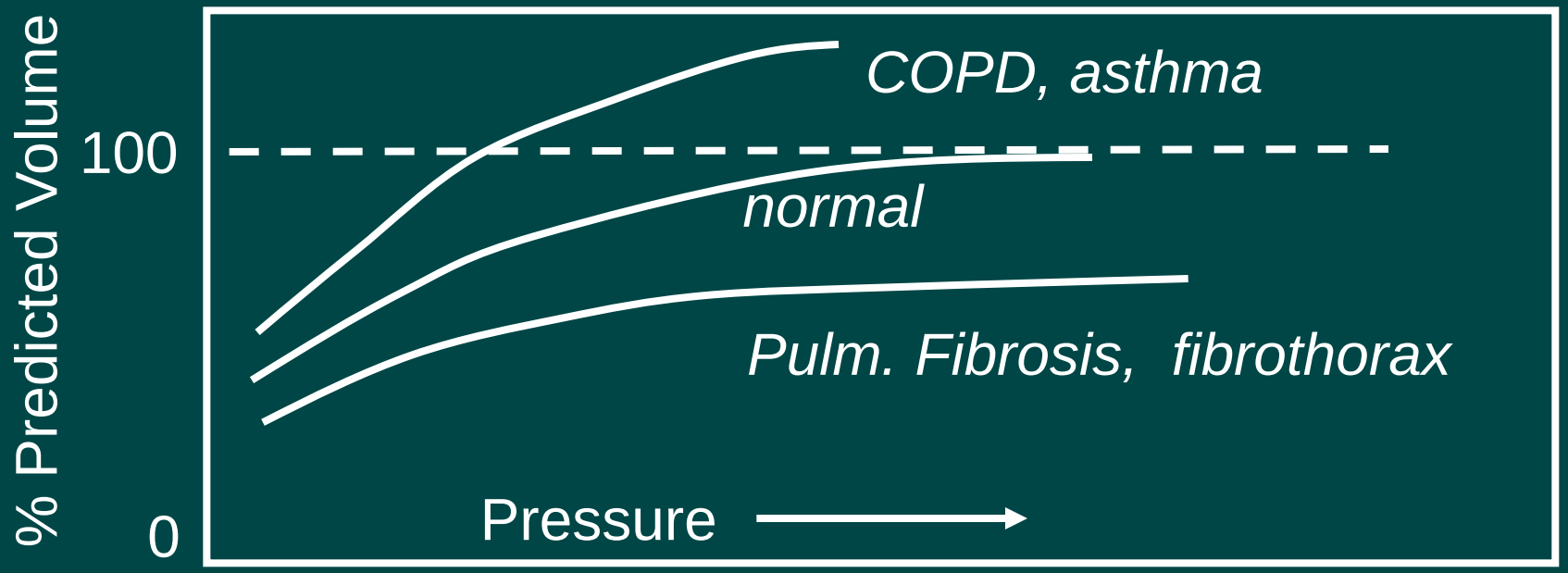
Lung function test



Compliance (C)

Static compliance measured in absence of flow

- C=ΔV/ΔP = 1/E where E=elastance,V=volume, P=pressure
  - $C_{lung} = \Delta V/(P_{airspace} - P_{pleura})$, $P_{pleura} = P_{esophageal}$
  - $C_{total} = \Delta V/(P_{airspace} - P_{atmospheric})$
  - $\frac{1}{C_{total}} = \frac{1}{C_{lung}} + \frac{1}{C_{chest\ wall}}$ $\qquad E_{total} = E_{lung} + E_{chest\ wall}$



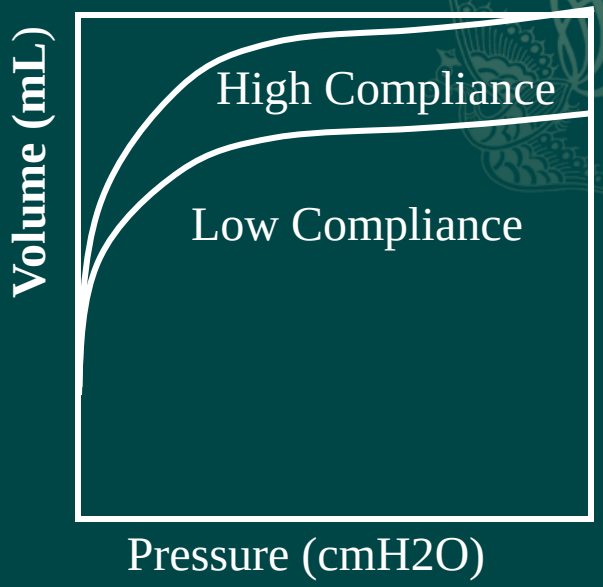
Compliance Calculations

$$C = \frac{\Delta V}{\Delta P}$$

$$C_{resp} = \frac{\Delta V_{lungs}}{\Delta(P_{lungs} - P_{air})} = \frac{2000 mL}{20 cm - 0 cm} = 100 mL/cm$$

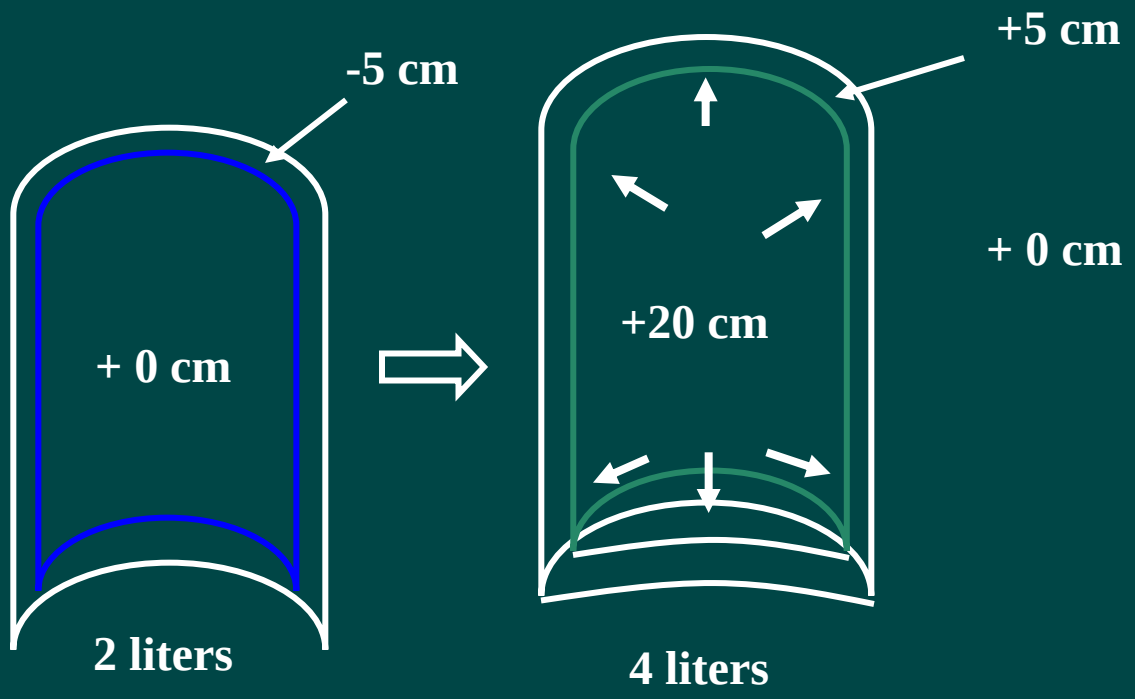
$$C_{lungs} = \frac{\Delta V_{lungs}}{\Delta(P_{lungs} - P_{pleura})} = \frac{2000 mL}{[(20 cm - 5 cm) - (0 cm - (-5) cm)]}$$

$$= 200 mL/cm$$



$$\frac{1}{C_{resp}} = \frac{1}{C_{lungs}} + \frac{1}{C_{chest\ wall}}$$

$$\frac{1}{100} = \frac{1}{200} + \frac{1}{200}$$



Resistance (R) and Time Constant(τ)

Resistance measured in presence of flow

- $R = \Delta P/F$ where $F = flow$
- $P_{Lung} = P_{resistance} + P_{elastic}$

$$\tau = R \times C = \frac{\Delta P}{F} \times \frac{\Delta V}{\Delta P} = \frac{cmH_2O}{ml/\sec} \times \frac{ml}{cmH_2O} = \sec$$

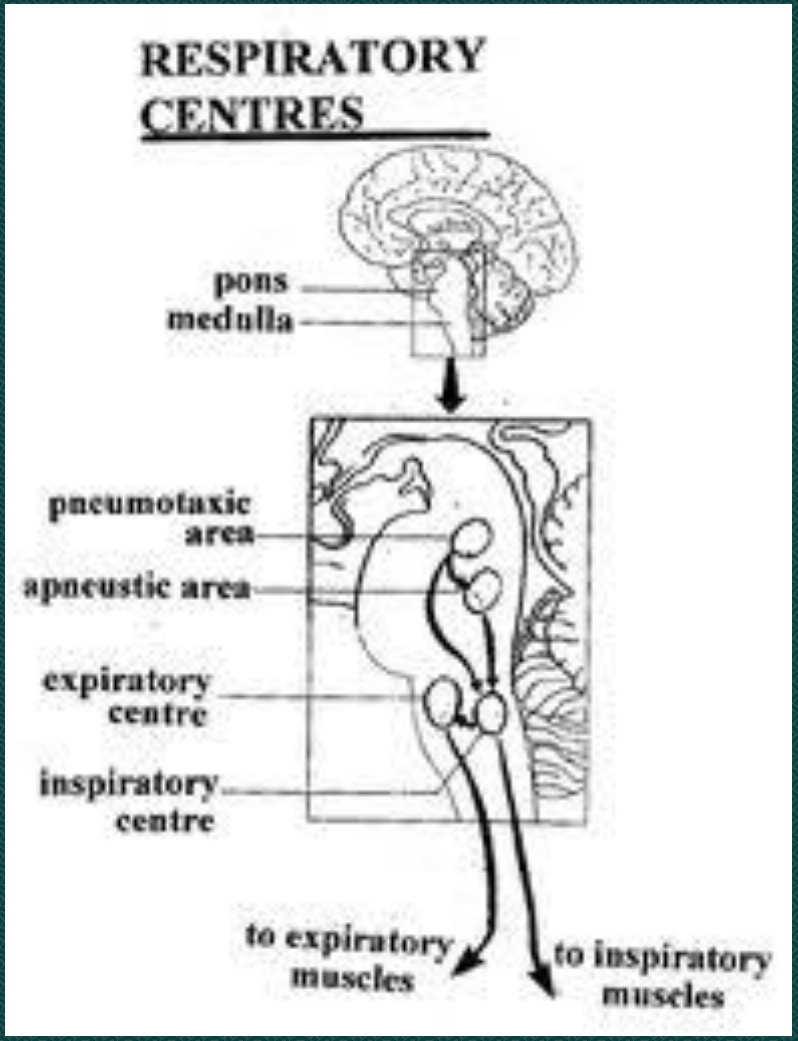
Where τ = time constant tiime it takes for 64% of volume to be exhaled. Normally R=2cmH2O per ml of air per sec and C= 0.1 liter/cmH2O so that τ = .2 sec. About 4 τ (0.8 sec) needed for complete expiration.

Assumption: single unit emptying. Endotracheal tubes and inhomgeneous ventilation can greatly slow emptying – multiple compartments. Anything which increases R or C increases exhalation time (both occur in obstructive lung disease.)

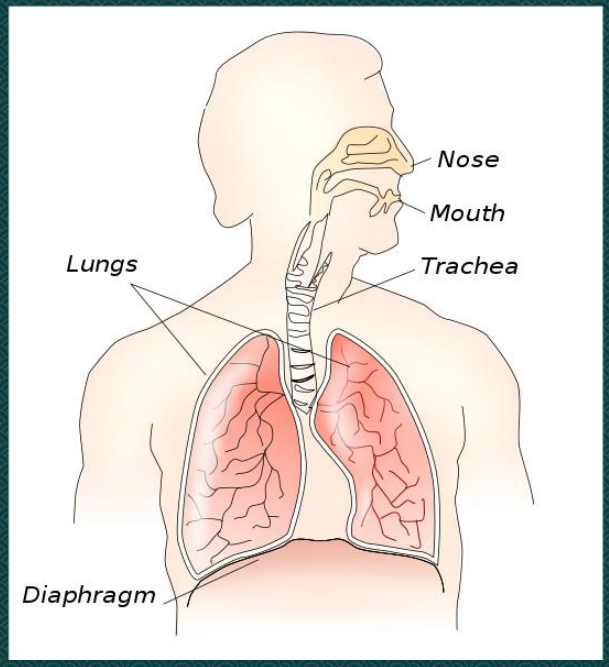
Blood gas analysis

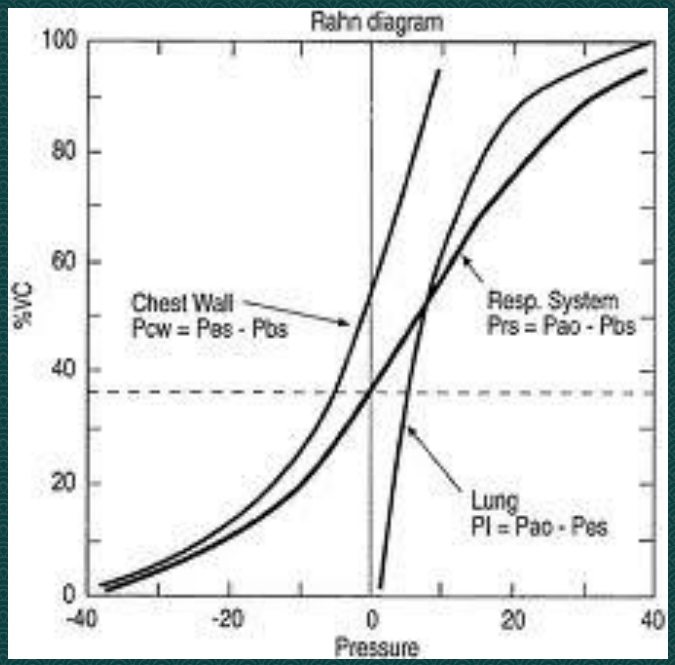
- Normal blood gas: pH 7.4, O2 85, CO2 40, HCO3 25
- Respiratory acidosis: pH 7.3, CO2 80, O2 58, HCO3 30
- Respiratory alkalosis: pH 7.48, O2 86, CO2 30, HCO3 20
- Metabolic acidosis: pH 7.2, HCO3 8, CO2 38, O2 80
- Metabolic alkalosis: pH 7.56, CO2 45, O2 68, HCO3 35

Respiratory rhythm control-nerve system

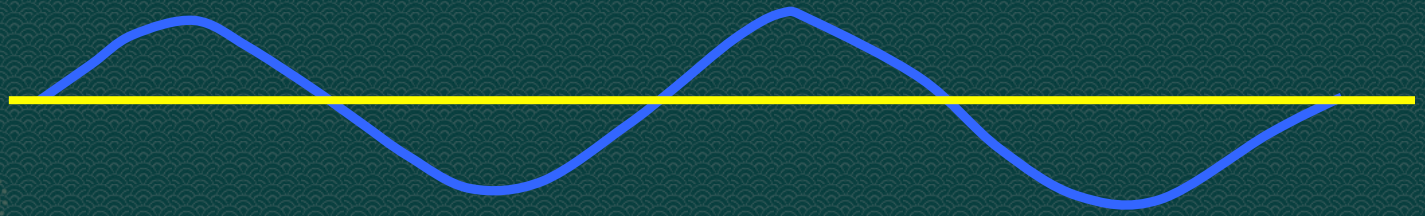


Muscle contraction and relaxation

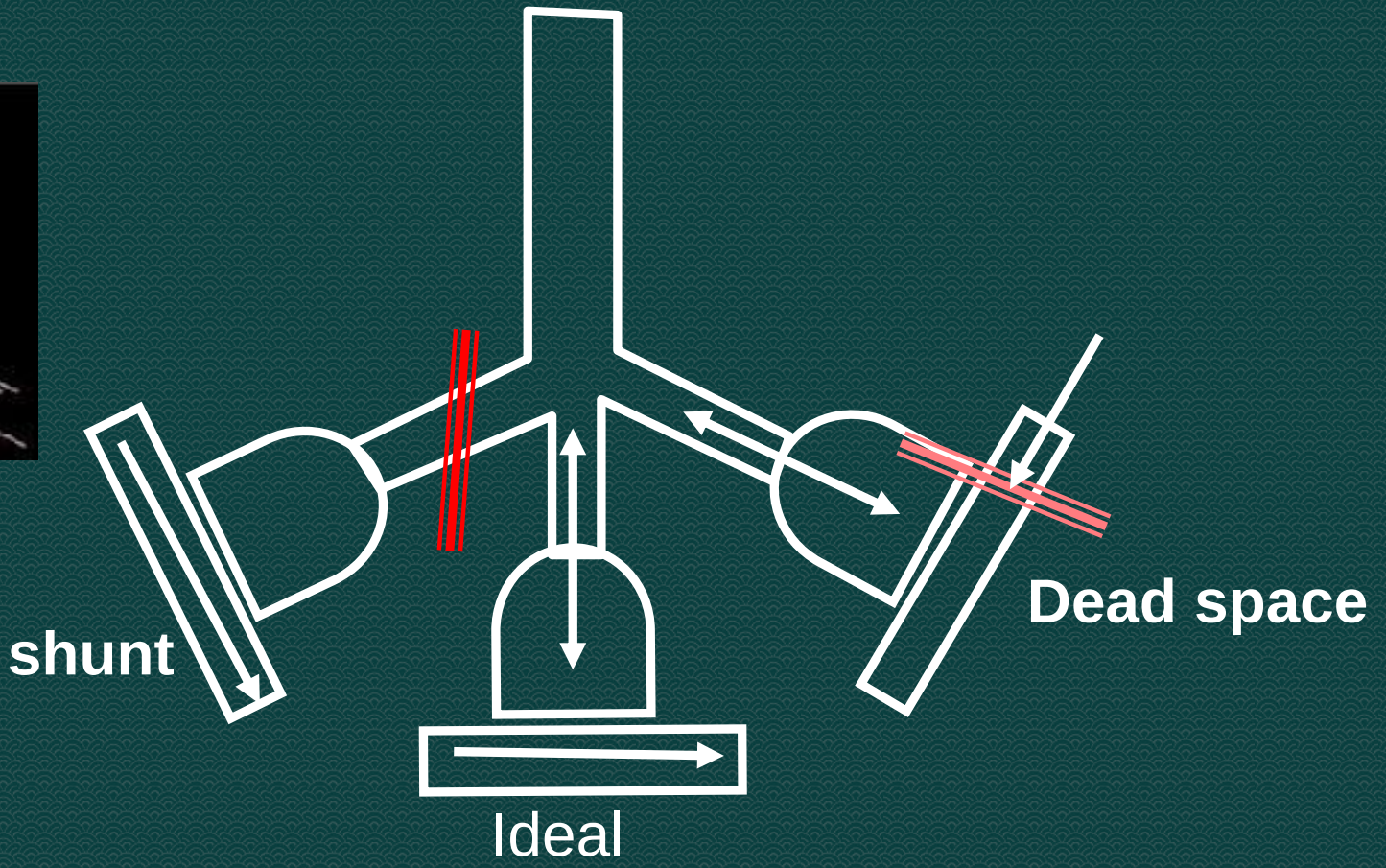




Diaphragm
Intercostals muscle: external, internal intercostals muscle
Accessory muscle: stenocleidomastoid, scalene muscle

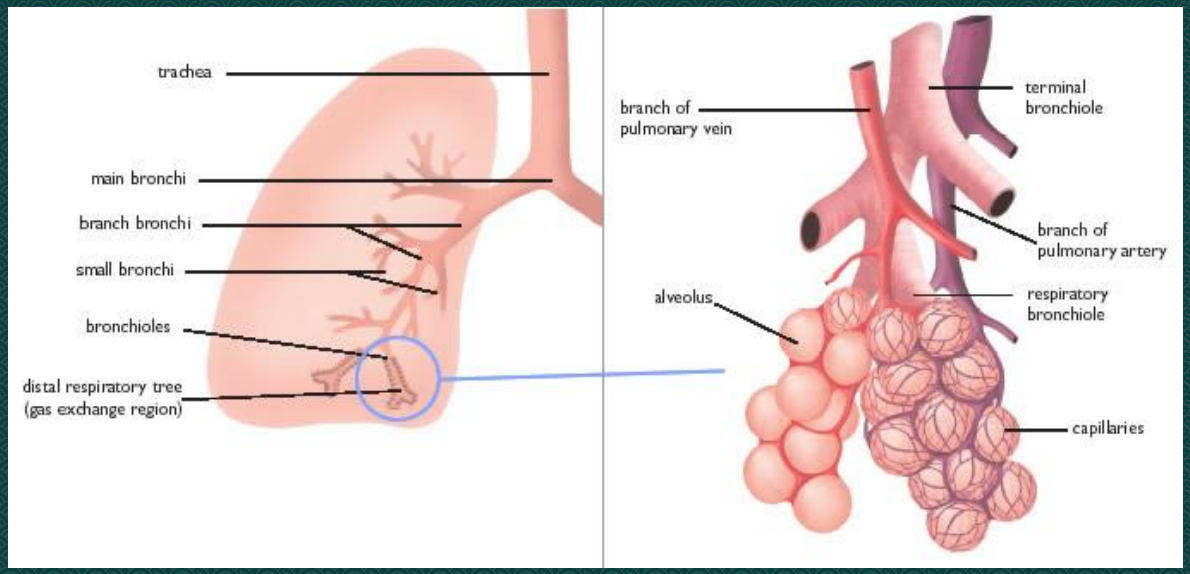


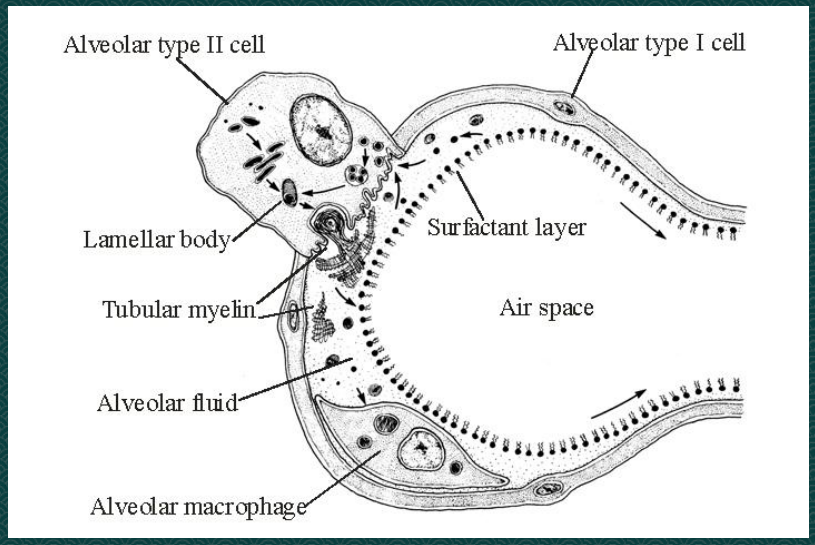
Airway opening



Three compartment model

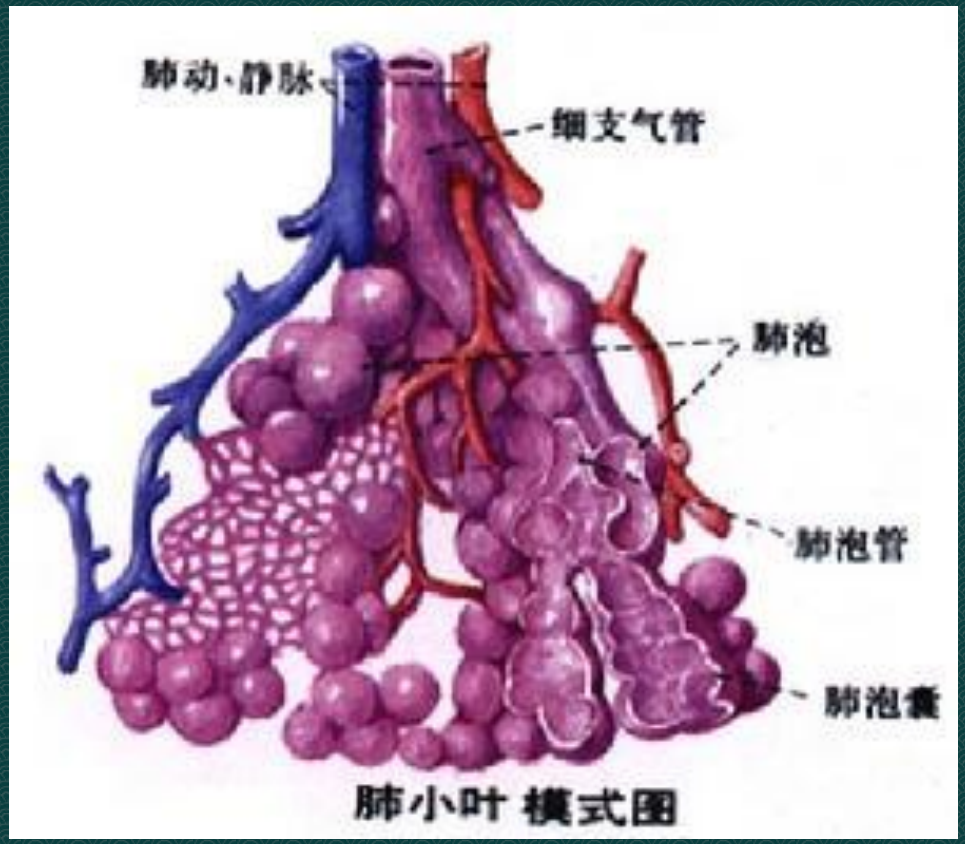
Normal alveolar architecture





Surfactant protein
Alveolar structure
Innate immunity
Epithelium repair
Fluid absorption

Intact vasculature



http://www.google.com.hk/imgres

Clinical evaluation

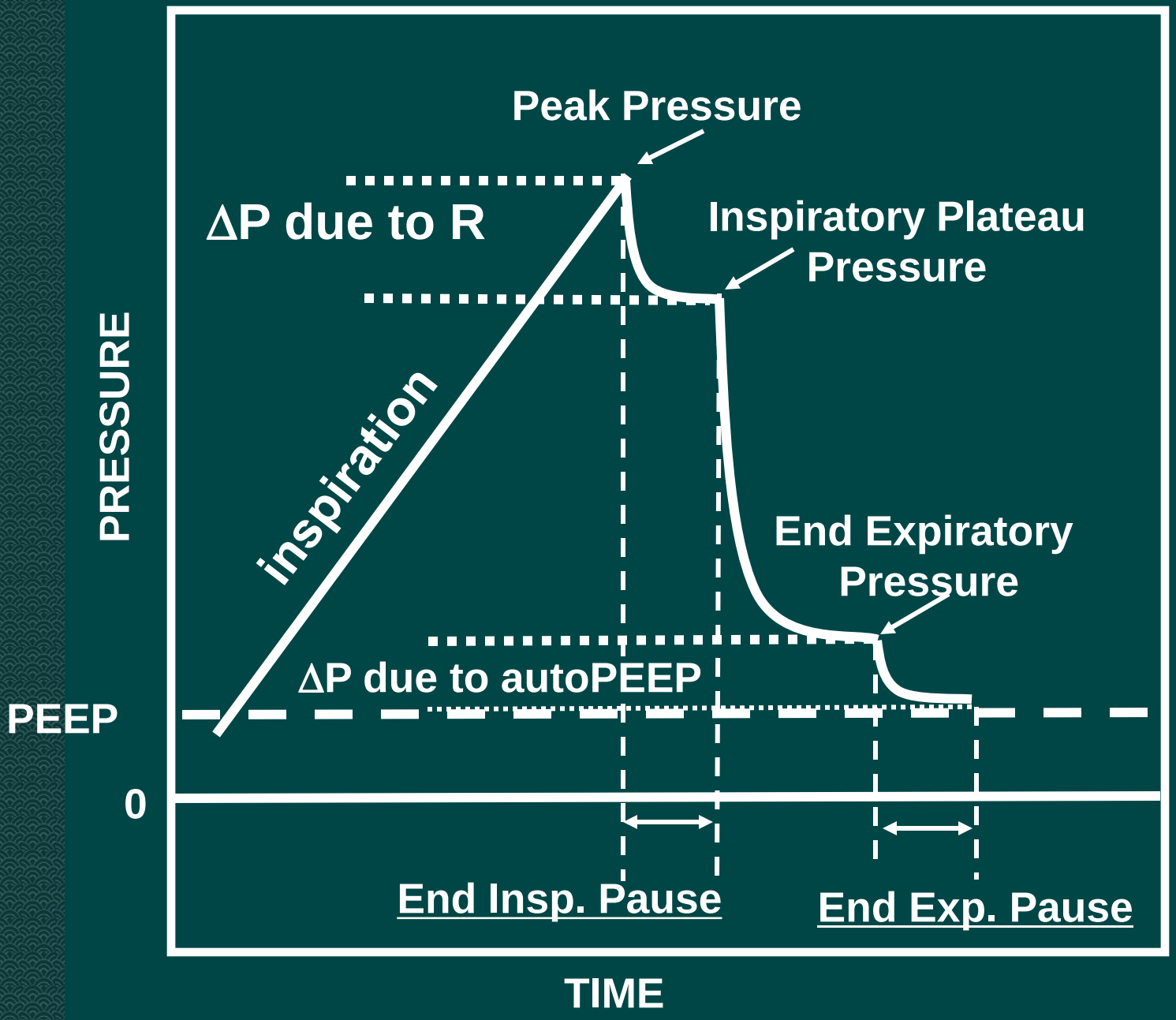
1. Upper airway patency
2. Central and peripheral cyanosis
3. Respiratory rate
4. Respiratory distress
5. Chest wall and movement
6. Palpation and auscultation

Assessment of respiratory system

1. Controller: RR and type
2. Pump: VC, inspiratory force
3. Airway: wheezing, airway resistance, auto-PEEP
4. Alveolar: BGA, compliance, CT, chest x-ray
5. Right heart function: ECG, JVP, Ultra-sound, Swan-Ganz catheter

Treatment

1. Establish physiology stability: airway patent
2. Oxygenation: FiO2, mask, ventilation
3. Adequate ventilation: mechanical ventilation
4. Support therapy: treatment of underlying disease, fluid, electrolytes, nutrition, protection of GI, prevention of HAP.


Peak Pressure
ΔP due to R
Inspiratory Plateau Pressure
inspiration
End Expiratory Pressure
ΔP due to autoPEEP
PEEP
0
PRESSURE
End Insp. Pause
End Exp. Pause
TIME

Quiz: (correct answer: yellow one)
lung function indicates:

1. Oxygenation and CO2 elimination
2. Alveolar fluid clearance
3. Coordinate with heart to deliver oxygen to tissue
4. Airway defense
5. All above

The most important first step to treat respiratory failure

1. Establish airway patency and administrate oxygen
2. Provide airway aerosolization
3. treat underlying disease
4. Adequate antibiotic treatment
5. Mechanical ventilation