Respiratory System

Respiratory Mechanics

Respiratory System:

- Primary function – obtain $O_2$ & eliminate $CO_2$

1. Internal respiration
   - Cellular respiration within mitochondria
   - Respiratory Quotient (RQ or RER)
     \[ RQ = \frac{CO_2 \text{ produced}}{O_2 \text{ consumed}} \]

2. External respiration
   - Entire sequence
     - Mechanical breathing
     - Alveolar gas exchange

Other Functions of Respiratory System

1. Gas exchange between air & circulating blood
2. Movement of air into & out of lungs
3. Protection against dehydration, temperature, pollution (external)
4. Protection from pathogenic microorganisms (internal)
5. Communication
6. Control of blood pH & blood pressure
**Respiratory Mechanics:**

- Air flows from higher to lower pressure gradients!
- 3 major causes:
  1. Atmospheric pressure
  2. Intra-alveolar pressure
     - Intrapulmonary pressure
  3. Intrapleural pressure
     - Intrathoracic pressure

*Figure 13.6 Page 464*

**Lung Integrity:**

1. Intrapleural fluid’s cohesiveness
   - Polar H₂O molecules in intrapleural space have strong attraction
2. Transmural pressure gradient

*Intrapleural Fluid*

*Pressure Gradient*
Air Flow & Intra-alveolar Pressure:
- Changes according to volume
  - Boyle’s Law

Inspiration

Figure 13.12a
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Inspiration

- Contraction of external intercostal muscles
- Elevated rib cage
- Contraction of diaphragm

Expiration

- Relaxation of external intercostal muscles
- Relaxation of diaphragm

Figure 13.12b
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Figure 13.13a
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Before inspiration

- Preinspiratory size of thorax
- Preinspiratory size of lungs

During inspiration

- Size of thorax on contraction of inspiratory muscles
- Size of lungs as they are stretched to fill the expanded thorax

During expiration

- Size of thorax on relaxation of inspiratory muscles
- Size of lungs as they recoil

Equilibrated; no net movement of air
**Elastic Properties of the Lung:**

1. Pulmonary elastic connective tissue

2. Alveolar surface tension
   - Thin liquid film surrounding alveolar sacs
     - Attraction of H₂O molecules

3. Pulmonary surfactant
   - Mixture of lipids & proteins
   - Reduce alveolar surface tension
     - Increase pulmonary compliance (makes inflation easier)
     - Reduce lungs tendency to recoil

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**Lung Volume**

- Maximum capacity ~ 5.7 L (male) & 4.2 L (female)

![Lung Volume Diagram]

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**Factors Affecting Ventilation**

1. Respiratory rate:
   
   \[ \text{Pulmonary ventilation} = TV \times \text{respiratory rate} \]
   
   - Rest = 6L/min
   - Exercise = 150L/min

2. Anatomic dead space
   - Air left in conducting airways (~150mL)
     - Causes alveolar ventilation to be less than pulmonary ventilation
   - On average, only 350mL of “new” air used
Airway dead-space volume (150 ml)

After inspiration, before expiration

During expiration

Fresh air from inspiration

Alveolar air

During inspiration

500 ml expired to atmosphere

150 ml fresh air from atmosphere (left from preceding inspiration)

350 ml expired to atmosphere

150 ml fresh air reach alveoli

150 ml fresh air enter alveoli

350 ml fresh air from atmosphere

150 ml remain in dead space

150 ml "old" alveolar air expired

350 ml "old" alveolar air expired

500 ml "old" alveolar air expired

350 ml "old" alveolar air expired

150 ml remain in dead space

500 ml enter alveoli

150 ml "old" air from dead space (left from preceding expiration)

350 ml fresh air from atmosphere
3. Alveolar ventilation
   \[ Alveolar\ vent. = TV - dead\ space \times respiratory\ rate \]

4. Alveolar dead space
   • Minute volume in healthy lung

5. Local controls acting on smooth muscle
   • Attempts to match airflow & blood flow
     1) Bronchiolar smooth muscle
     2) Pulmonary arteriolar smooth muscle
        ✓ Both stimulated by CO₂ & O₂