Bio& 242:  
Unit 2 / Lecture 2

Processes of the Respiratory System

• Pulmonary ventilation  
  mechanical flow of air into and out of the lungs

• External Respiration  
  exchange of gases between the pulmonary air spaces and the blood

• Internal Respiration  
  exchange of gases between blood and tissues
Structural Portions of the Respiratory System

- **Upper Respiratory System**
  1. warming, moistening and filtering incoming air;
  2. receiving olfactory stimuli;
  3. serving as large, hollow resonating chambers to modify speech sounds.

Structural Portions of the Respiratory System

- **LARYNX**
  - connects the pharynx with the trachea.
  - Contains: the thyroid cartilage
  - epiglottis which prevents food from entering the larynx
  - cricoid cartilage which connects the larynx and trachea,
  - paired arytenoid, corniculate and cuneiform cartilages.
  - True Vocal folds
  - Opening between the true vocal folds called the glottis.
LARYNX

1. thyroid cartilage
2. cricoid cartilage
3. epiglottis
4. arytenoid cartilages
5. corniculate cartilages
6. hyoid bone

• The right lung has three lobes separated by two fissures (horizontal and oblique).
• The left lung has two lobes separated by one fissure (oblique) and has a depression called the cardiac notch.
Structural Portions of the Respiratory System

- **Lower Respiratory System:**
  
  Contains a set of conducting ducts that carry air to the exchange surfaces. You need to know their order.

Structural Portions of the Respiratory System

- **Lower Respiratory System**
  
  Respiratory Portion
Microscopic Anatomy of a Lobule

Pulmonary Ventilation
Inspiration

- **Muscles of Inspiration**
  
  **Primary Muscle:**
  Diaphragm – only muscle active during normal breathing or eupnea

  **Secondary Muscles**
  Active during deep breathing
  - Sternocleidomastoid
  - Scalenes
  - External Intercostals
Pulmonary Ventilation
Expiration

- Muscles of Expiration
  Primary Muscle:
  Diaphragm is inactive
  Secondary Muscles active during deep breathing:
  - Internal Intercostals
  - External Oblique
  - Internal Oblique
  - Transversus Abdominis
  - Rectus Abdominis

Pressure Changes in Pulmonary Ventilation and Boyle’s Law

Pressure is inversely related to Volume
Summary of Inspiratory and Expiratory Events

Factors Affecting Pulmonary Ventilation

- **Surface Tension**
  
  Surfactant decreases surface tension thus preventing alveolar collapse

- **Compliance**
  
  High compliance means the lungs and thoracic wall expand easily
  
  Low compliance means that they resist expansion
Factors Affecting Pulmonary Ventilation

- Decreased Compliance
  1. Tuberculosis – scarring of the lungs
  2. Pulmonary edema - Retention of fluid in lung tissue
  3. Respiratory Distress Syndrome – Lack of surfactant in premature infants
  4. Paralysis of respiratory muscles
  5. Emphysema – destruction of elastic fibers in alveolar walls
Factors Affecting Pulmonary Ventilation

- **Airway Resistance**
  - Any condition or obstruction of airways that increases resistance.
- Chronic Obstructive Pulmonary Disease (COPD)
- Asthma
- Emphysema
- Chronic Bronchitis
• **Smoking during pregnancy increases risk**  
  Children whose mothers smoked during pregnancy were 2½ times more likely to have ADHD than children who weren’t parentally exposed to tobacco.

  • Children with blood lead levels of more than 2 micrograms per deciliter were four times more likely to have ADHD than children with levels below 0.8 microgram per deciliter. The government’s “acceptable” blood lead level is 10 micrograms per deciliter, and an estimated 310,000 U.S. children ages 1 to 5 have levels exceeding that.

  • Based on study estimates, more than 5 million 4-to-15-year-olds nationwide have levels higher than 2 micrograms per deciliter.

From: Exposures to Environmental toxicants and Attention deficit Hyperactivity. By Joe Braum et.al.  
*Environmental Heath Perspectives, Vol 114, Number 12, p 1904*
Lung Volumes and Capacities

Factors Affecting External Respiration

1. Partial Pressure of gases
2. Alveolar surface area
3. Diffusion rate and distance
4. Solubility of each gas and molecular weight of the gas
5. Hemoglobin affinity
Factors Affecting External Respiration

• Dalton’s Law –
Atmospheric pressure is the sum total of all partial pressures of all gases in the atmosphere
• N2 78% 597.4 mm Hg
• O2 21% 158.8 mm Hg
• CO2 >1% .3 mm Hg

Factors Affecting External Respiration

• Dalton’s Law and High Altitude Sickness
• Sea Level: pO2 160 mm Hg
• 10,000ft.: pO2 110 mm Hg
• 20,000ft.: pO2 73 mm Hg
• 50,000ft.: pO2 18 mm Hg
Factors Affecting External Respiration

- Henry’s Law
  
  Quantity of a gas that will dissolve in solution is proportional to the partial pressure and the solubility coefficient (SC) of the gas.

  SC CO₂ = .57  
  SC O₂ = .024  
  SC N₂ = .012

Factors that affect Oxygen Transportation by Hemoglobin

1. pH (blood acidity)
2. Partial pressure of CO₂
3. Blood Temperature
4. 2,3-bisphosphoglycerate (BPG)
The Effect of Blood pH on the Affinity of Hemoglobin for O2

- Increased pH of blood (more basic), the greater the affinity
- Decreased pH of blood (more acidic), the lower the affinity

The Effect of pCO2 on the Affinity of Hemoglobin for O2

- Low pCO2, the higher the affinity
- High pCO2, the lower the affinity
- H2O + CO2
- Bohr Effect

H2O + CO2 → Carbonic Acid (H2CO3) → H+ + HCO3
The Effect of Blood Temperature on the Affinity of Hemoglobin for O2

- Lower the temperature, the greater the affinity
- Higher the temperature, the lower the affinity

The Difference between Fetal and Maternal Hemoglobin for O2 Affinity

- For efficient gas exchange between a fetus and its mother, fetal hemoglobin has a higher affinity for O2 than maternal hemoglobin.
Summary of Gas Exchange during both External and Internal Respiration

- O2 is carried on hemoglobin forming Oxyhemoglobin.
- 7% of CO2 is carried as dissolved CO2
- 25% of CO2 is carried as carbaminohemoglobin
- 70% of CO2 is carried as bicarbonate ions

Haldane effect: The lower the oxyhemoglobin, the higher the CO2-carrying capacity of the blood.
- Deoxyhemoglobin binds more readily with CO2
- Deoxyhemoglobin also acts as a better buffer absorbing more H+, causing more bicarbonate to form.
Nervous Control of Pulmonary Ventilation & the Respiratory Centers

- MRA: Controls the basic rhythm of ventilation
- PA: Transmits inhibitory impulses to the inspiratory area
- AA: Transmits stimulatory impulses to the inspiratory area

Proposed mechanism of ventilation control
Chemical Regulation of Respiration

• Aortic Body: Cluster of chemoreceptors located in the wall of the aortic arch that respond to H+
• Carotid Bodies: Cluster of chemoreceptors located in the walls of the L & R Carotid arteries that respond to H+
• Central chemoreceptors: located in the Medulla Oblongata also respond to H+

Clinical Terms

• Hypercapnia: Arterial Blood PCO2 above 40mmHg
• Hypocapnia: Arterial Blood PCO2 below 40mmHg
• Hyperventilation: Rapid/deep breathing
• Hypoventilation: Slow/shallow breathing
• Hypoxia: O2 deficiency at the tissues
• Hypoxic hypoxia: Due to high altitude, airway obstruction or fluid
• Anemic hypoxia: Deficiency of hemoglobin
• Ischemic hypoxia: Decreased blood flow
• Histotoxic hypoxia: Caused by toxic agent like cyanide which prevents tissues from using O2