Respiratory System

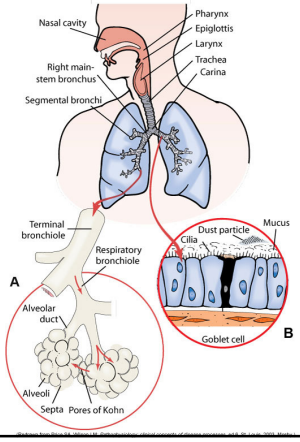
Anatomy & Physiology Review

Definititions

- Respiration: movement of oxygen from atmosphere into cells and return of carbon dioxide to atmosphere
  - Ventilation: movement of air in and out of the lungs
  - External respiration: diffusion of oxygen and carbon dioxide between air and blood in the alveoli
  - Internal respiration: Use of glucose energy to form ATP, with or without oxygen

Ventilation

- Nasal and Oral passages (Nose, pharynx, larnyx)
- Trachea
- Bronchi
- Bronchioles
- Alveoli: final destination
  - No air movement occurs in alveoli
  - Diffusion only



Nose to Bronchioles

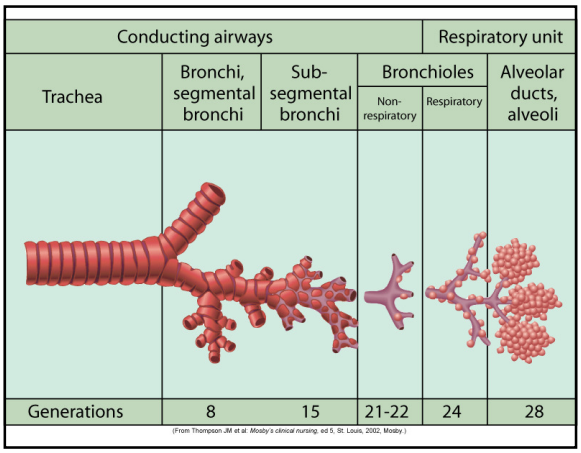
- Lined with ciliated mucous membranes
  - Warm air
  - Mucous
    - Traps fine particles
    - Humidifies air
  - Hairs
    - Trap particles
    - Moves mucous outward
- Larynx
  - Contains vocal cords
  - Epiglottis: protect from food and moisture; cough

Tracheo-Bronchial Tree

- Trachea
  - Semi-rigid incomplete rings of cartilage
  - *ET tube erosion
  - Carina: last ring before branching
    - Heavily innervated: coughing and bronchospasm
- Bronchi
  - Right bronchus: shorter, wider, more vertical
  - Left bronchus: longer, narrower, more horizontal
  - Branch: Lobar bronchi → Segmented bronchi → continue branching to terminal bronchioles (smallest)

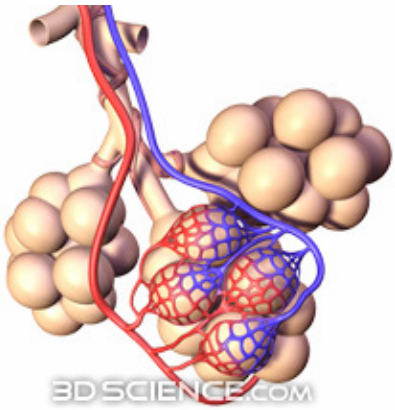
Terminal Bronchioles

- End in Acinus (Functional unit of the lung)
  - AKA “primary lobule” 0.5 – 1 cm diameter
  - Respiratory bronchiole
  - Alveolar ducts
  - Terminal alveolar sacs
    - Grapelike clusters of alveoli
      - Separated by septa
      - Communicate via pores (of Kohn)
      - Membrane thinner than an RBC
      - ~300 million in each lung



Alveoli

- Surrounded by capillary network
- Lined with pneumocytes
  - Type I cover 90% of surface
  - Type II produce surfactant
- Alveoli – gas bubble surrounded by capillaries
  - Tend to collapse on expiration d/t surface tension
  - Surfactant reduces surface tension
- Surfactant
  - Production depends on blood flow
  - Stimulated by deep breaths, sighing



Thoracic Cavity

- Two lungs – separated into lobes, and then segments
  - Left lung has 9 segments
  - Right lung has ten segments
- Pleura – two ply membrane separating lungs from cavity
  - Pleural “space” between membranes does not exist except in pathological situations:
    - Effusion
    - Inflammation
  - Pleura maintain negative pressure within the cavity

Pulmonary Circulation

- Oygenated blood to nourish lungs
  - Bronchial artery
  - Large bronchial veins empty into azygos system and return to vena cava
- Unoxygenated blood to become oxygenated
  - Pulmonary artery
  - Small bronchial veins empty into pulmonary veins and wind up mixing with oxygenated blood ~2-3%
  - Low pressure, low resistance

Pulmonary Pressure

- Pulmonary network extreme distensible
  - Can accommodate more CO without requiring more pressure
- 25/10 mmHg
- MAP 15Hg
- Colloid oncotic pressure is 25mmHg

It's all About Control

- Ultimately about making respiratory muscles contract
  - Muscles are under autonomic and somatic innervation
  - Autonomic fibers originate in “Respiratory Center”
    - Located in Pons and Medulla
    - Respond to changes in central Chemoreceptors
      - Partial pressure of CO2 (PaCO2)
      - Changes in pH
      - Secondarily reductions in PaO2 (must fall from 90-100 to 60mmHg)
  - Stretch reflex

Control of Airways

- Bronchials lined with smooth muscle
  - Parasympathetic tone (Vagus nerve)
    - Bronchoconstriction
    - Increased mucous production
  - Sympathetic stimulation (beta-2 receptors)
    - Relaxation of smooth muscle
    - Bronchodilation
    - Less mucous production
  - Noncholinergic, nonadrenergic inhibitory system
    - Bronchodilation
    - Nitric oxide production

Defenses of Resp Tract

- Mechanical
  - Gag reflex
  - Turbinates
  - Mucociliary escalator
  - Cough reflex
- Chemical
  - Mucous contains IgA, neutrophils, interferons
  - Alveolar macrophages and Surfactant (opsonins)

Physiologic Considerations

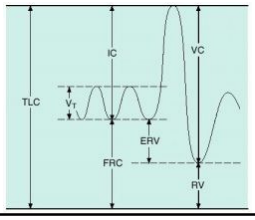
- Gas exchange (O2 & CO2 primarily)
  - Ventilation
  - Transportation
    - Diffusion across alveolar membrane
    - Pulmonary blood distribution
    - Chemical/physical interactions with blood
  - Internal respiration

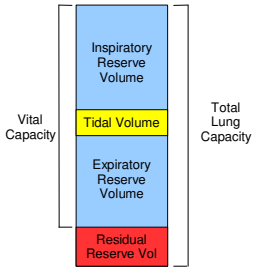
Ventilation

- Movement of air in and out of lungs
- Forced by bellows action of resp muscles
  - Creating partial vacuum and then contraction
  - Diaphragm: descends, expanding thoracic cavity
  - Sternocleidomastoid: lifts sternum
  - Serratus, scalen, external intercostals: lift ribcage
- Measuring Ventilation
  - Pulmonary Function Tests

PFTs

- Measures of Volume
- Measures of Flow
  - FEV1
  - Peak Flow



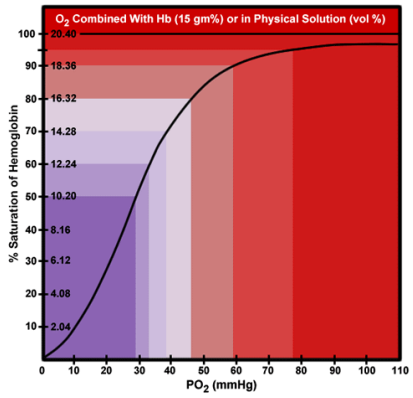


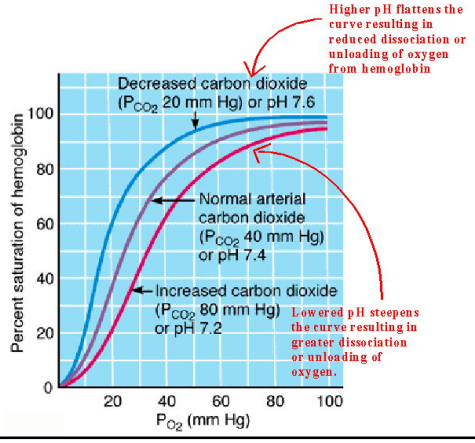
Ventilation-Perfusion Relationship

- V/Q ratio (normally 0.8)
  - V: Rate of Ventilation (4 L/min on average)
  - Q: Output of Heart (5 L/min)
- Extreme imbalances:
  - Dead space (normal ventilation, no perfusion)
    - V/Q = infinity
  - Shunt unit (no ventilation, normal perfusion)
    - V/Q = 0
  - Silent unit (no ventilation, no perfusion)
    - V/Q = 0

Transport in Blood

- Oxyhemoglobin: reversible reaction
  - Dependent on PaO2 (arterial partial pressure)
    - Dependent on PAO2 (alveloar partial pressure of Oxygen)
    - Dependent on solubility of O2 in plasma
  - Dependent on pH
  - Temperature
- Carbon dioxide usually travels in buffered state as Carbonic Acid
  - $CO2 + H2O \leftrightarrow H^+ + H30^-$





Assessment of Respiratory System

- Ventilation measurements
  - Breaths per minute
  - PFTs
- V/Q scans
- Blood Gases
  - PO2, PCO2, pH
- Hemoglobin
  - Amount and saturation