Chapter 35(10 &11) Circulatory and Respiratory Systems

Anatomy & Physiology
Loulousis
Section 1 – The Cardiovascular System

- WHY IT MATTERS!
  - The cardiovascular system provides every cell of the body with the substances needed for survival!!
  - Like a network of highways that transports chemicals to and from all of the cells in the body
  - Nearly every material needed by cells travels through this system
What is it?

- Includes the heart, blood vessels, and blood
- Carries nutrients, oxygen, hormones, and wastes through the body and distributes heat to maintain homeostasis
- Interacts with every body system
The Heart

- Pumping of action of heart required to provide enough force to move blood throughout body
  - Made up of mostly cardiac tissue
- Septum – wall that divides the heart into left and right halves
Blood moves through two separate loops

One loop takes blood from the right side of the heart to the lungs
- There it picks up oxygen and gives off carbon dioxide
  - Blood then returns to the left side

The second loop takes blood from the left side of the heart to the body

Two veins carry oxygen-poor blood to the heart
- Superior vena cava
- Inferior vena cava
Path of Blood Flow in Heart

1. Superior vena cava sends $O_2$-poor blood from upper body to right atrium.
2. Right atrium sends blood to the right ventricle.
3. Right ventricle sends blood to the pulmonary artery.
4. Pulmonary arteries send blood to the lungs.
5. Pulmonary veins return blood to the left atrium from the lungs.
6. Left atrium sends blood to the left ventricle.
7. Left ventricle sends blood to the aorta.
8. Aorta sends blood to the coronary arteries, the brain, and the rest of the body.

Blood from aorta to body
The Heart’s Chambers

- **Atria (singular atrium) – top of heart**
  - Receive blood from the body and lungs
  - Thin walled – just pump blood to ventricles

- **Ventricles – below atria**
  - Pump blood away from the heart
  - Thick walled – pump blood to lungs or rest of body

- **Valves between the chambers** stop blood from moving backward
The Heartbeat

- Most muscle tissue needs a stimulus by nerve directly from brain
  - Heart muscle is different
    - Stimulus happens in the muscle itself (the heart)
- Coordinated contraction of heart’s chambers is started by small group called the sinoatrial (SA) node
  - In upper wall of right atrium
    - Nodes “fire” electrical signals in regular rhythm
      - Each signal following by contraction of heart muscle that causes both atria to contract almost at the same time
- Wave from SA node picked up by the atrioventricular (AV) node in ventricles
  - About 1/10 of a second after atria contract, AV nodes causes the ventricles to contract
    - Delay allows the atria to finish emptying blood into ventricles before the two ventricles contract
How the heart beats

- http://www.youtube.com/watch?v=Wlnq-Pyyi_M
Control of Human Heartbeat

1. Contraction of the Atria  The SA node signals the atria’s muscle to contract. Blood is pumped from the atria into the ventricles.

2. Contraction of the Ventricles  The SA node’s signal is picked up by the AV node, which signals the ventricles to contract.

The SA node is the heart’s natural pacemaker.

After the atria contract, the tricuspid and bicuspid valves close.

The ventricles contract and push blood out of the heart.
Heart Rate

- Pulse is rhythmic stretching of blood vessels leading away from the heart
- Caused by pressure of blood pushed out of heart’s left ventricle
- You can measure a person’s pulse to find their heart rate
  - Number of pulses per minute = number of heartbeats per minute
    - Avg. 70 to 90 per minute for adults
      - Decreases when sleeping
      - Increases during exercise due to increased need of oxygen and nutrients
Abnormal Heart Rhythm

- Too fast, too slow, or irregular
- Artificial pacemaker may be necessary
  - Small, battery operated device that keeps heart in regular rhythm
  - Some are permanently implanted in chest wall
    - Some are external
- Disruptions can be caused by blockage in electrical pathway or by some other defect
  - Pacemaker sends electrical impulses to heart
  - Electrode is placed next to the heart wall, small electrical changes travel through the wire to the heart
Blood Vessels

- Network of vessels for blood flow
- Blood moves from arteries into capillaries and then into veins
Arteries

- Blood vessels that carry blood away from the heart
- Walls have smooth muscle that allow them to expand when blood is pumped into them
- From arteries into smaller vessels called arterioles

Arteries: main transporters of oxygenated blood
Arterioles: diameter is adjusted to regulate blood flow
Capillaries: diffusion occurs across thin walls
Capillaries

- Tiny blood vessels that allow exchange of materials between blood and fluid around cells
- Greatly branched, form networks of capillary beds
- Exchange of material across the walls of capillaries is possible because capillary walls are only one cell thick
  - Diffusion is simple
Veins

- From capillaries into small vessels called venules, then into veins
- Blood vessels that carry blood back to heart
- Veins have thinner layer of smooth muscle than arteries
  - Wider than arteries
    - Gives less resistance to blood flow
      - Veins are farther from heart and do not receive the pulsing pressure arteries do
        - Blood is pushed through veins by muscle contractions in arms and legs
          - One-way valves in veins stop blood from flowing backward during return trip to heart
Major Veins of Body

- Superficial temporal vein
- Facial vein
- Internal jugular vein
- External jugular vein
- Subclavian vein
- Brachiocephalic vein
- Axillary vein
- Brachial vein
- Cepalic vein
- Basilic vein
- Median cubital vein
- Medial antebrachial veins
- Superficial venous palmar arch
- Small saphenous vein
- Deep femoral vein
- Femoral vein
- Great saphenous vein
- Popliteal vein
- Anterior tibial vein
- Posterior tibial vein
- Dorsal venous arch
- Superior vena cava
- Hepatic vein
- Renal vein
- Gonadal vein
- Inferior vena cava
- Common iliac vein
- Internal iliac vein
- External iliac vein
Blood

- Connective tissue
- *Key components:
  - Plasma
  - Red blood cells
  - White blood cells
  - Platelets
Plasma

• Liquid portion of blood
• 55% of total blood volume
  • 90% water/ 10% solutes
    • Solute contain nutrients, wastes, proteins, and salts
      • Salts
        • Maintain osmotic balance
        • Regulate pH of blood
      • Proteins
        • Help form blood clots
        • Protect body from disease
        • Maintain osmotic balance

“Buffy Coat”:
leucocytes & plaquettes
(<1% du total)

Erythrocytes
(45% du total)
Red Blood Cells

- A.k.a Erythrocytes
- Most blood cells are red blood cells (RBCs)
- Carry oxygen
- Biconcave shape
  - Interior packed with hemoglobin
    - Iron-containing protein that binds to oxygen in lungs and carries it to body’s tissues
- Mature RBCs contain no nuclei
  - Cannot make proteins or repair themselves
  - Life span is ~4 months
- New RBCs are constantly produced in red bone marrow
White Blood Cells

- Defend the body against disease
- Larger than red blood cells
- Contain nuclei
- Many kinds, each with different function
  - Neutrophils – take up bacteria at sites of infection and kill them
    - Masses of neutrophils = pus
  - Eosinophils – concentration rises during allergic reactions, except function unknown
  - Basophils – function unknown, stain very dark
  - Lymphocytes – secrete antibodies and assist in rejection of foreign tissue transplants
  - Monocytes – ingest bacteria voraciously
Platelets

- Bits of cytoplasm pinched off from cells in bone marrow
- Important role in blood clotting
- If tear in blood vessel occurs, platelets and plasma take rapid action to stop blood loss
  - Too much loss is fatal
- Steps of blood clotting
  - Platelets cluster at tear
  - Platelets release chemical that causes plasma proteins to form long, sticky chains called fibrin
  - Fibrin and platelets cling to the tear and harden into clot
Platelets cluster at a vessel tear.

The platelets release a chemical that causes plasma proteins to form long, sticky chains called *fibrin*. Fibrin and platelets cling to the tear and harden into a clot.
Blood Clotting Cascade

1. Stimulus: Blood vessel damage
2. Platelets release clotting protein (enzyme)
3. Clotting reaction occurs
4. Fibrin net forms, trapping blood cells and platelets
5. Result: Blood clot
Blood Types

- Determined by presence or absence of markers on the surface of RBCs
- Types in ABO blood group are A, B, AB, and O
  - Letters A and B refer to carbohydrates on the surface of RBCs that act as antigens
    - Antigens – cause immune system to react
  - People with type A blood have the type A antigen on their RBCs
    - Type B has B antigens
    - Type AB has both A and B antigens
    - Type O has neither antigen
Blood Compatibility

- Antibodies are defensive proteins made by immune system

- People with type A blood make antibodies against the B antigen
  - People with type A blood cannot receive type B blood
    - Antibodies would bind to B antigens, and the attack the RBCs
      - Blood cells would burst
        - Kidney shock and failure, etc.

- Type AB – universal recipients
- Type O – universal donors
Fig. 11-6

Blood Typing and Cross Reactions

**Type A**
- A Surface Antigens
- Anti-B Antibodies

**Type B**
- B Surface Antigens
- Anti-A Antibodies

**Type AB**
- A & B Surface Antigens
- Neither Anti-A or Anti-B Antibodies

**Type O**
- No Surface Antigens
- Anti-A & Anti-B Antibodies

- Surface Antigens + Opposing Antibodies → Agglutination (clumping) & hemolysis
Figure 7 This figure shows which antigens and antibodies are present for each blood type. Which blood type produces both A and B antibodies?
Rh Factor

- Protein antigen found on RBCs
- People who have it are Rh+, those who lack Rh-
- When Rh+ baby is born to Rh- mother, mother begins to make Rh antibodies
  - In a future pregnancy, the antibodies may be passed to Rh+ fetus and lead to fetal death
Color of Blood

- Oxygenated blood is scarlet
- Deoxygenated blood is maroon
  - Closer to dark red than blue
- Looks blue because the skin and connective tissue that overlie the veins distort the true color of blood in veins
Lympathic System

- Made up of network of vessels, tiny bean-shaped structures called lymph nodes, and lymph tissue
- Works with cardiovascular system by collecting fluids that leak out of capillaries
  - Returns those fluids to cardiovascular system
- Carry leaked fluid, called lymph back to 2 major veins in the neck
  - Have valves that stop backflow like veins
- Lymph tissue is located in thymus, tonsils, spleen, bone marrow, and others.
• Key element to immune system
• Immune cells in lymph nodes and lymphatic organs help defend body against bacteria, viruses, and other infectious microbes, + cancer cells
• Lymph nodes found in armpits, neck, and groin
  • Can be tender and swell when they are actively fighting infections and filled with white blood cells
Lympathic System

- Tonsils – composed of lymphocytes which produce antibodies
- Thymus – produces lymphocytes that mature into T Cells
- Lymph node – filters fluids, catching bacteria, viruses, and other unknown materials
- Spleen – produces lymphocytes, body’s blood reservoir
- Lymphatic vessel – collect lymph from tissues and carry it to blood stream
- Bone marrow – houses stem cells that transform into blood components
Diseases of the cardiovascular system kill more Americans than all other diseases combined.

- ~1 million deaths or 33% of deaths each year
- Both genes and lifestyle affect your risks
- Four main cardiovascular diseases
  - High blood pressure
  - Arteriosclerosis
  - Heart attack
  - Stroke
High Blood Pressure

- A.k.a. hypertension
- A blood pressure includes two numbers and is written as a fraction
- 120/80 normal for young adult
- Hypertension, or high blood pressure, is an elevation of one or both of these pressure readings to 140 for the 1\textsuperscript{st} number and 90 for the 2\textsuperscript{nd} number.
- Causes the heart to work harder than normal
  - Causes heart to weaken over time
- Increased chance of blood clots leading to heart attack, stroke, kidney failure, or eye damage
- Can usually be controlled by medication, diet, and exercise.
Arteriosclerosis

- Hardening and narrowing of blood vessels
- Caused by high blood levels of cholesterol and fats, high blood pressure, and smoking
  - All increase plaque on artery walls
    - As plaque thickens, artery narrows
      - Blood pressure increases
      - Blood flow and oxygen supply to tissues by artery decreases
Heart Attack

- Aka sudden cardiac death or cardiac arrest
- Caused when blood supply to part of heart is greatly reduced or stopped
  - Happens when one or more arteries become blocked
- Can be caused by plaque buildup
- Can be caused by clot that breaks away and gets stuck in artery
- After a few minutes of no blood supply, cells die from lack of oxygen
- If large enough area affect, it is fatal
- Successful treatment depends on fast response
- Medications and surgery are aimed at increasing blood flow to the heart
Stroke

- Occurs when blood vessel that carries oxygen to brain is blocked by clots
  - Or less commonly, bursts
- Deprive brain of oxygen and tissues die quickly
- Effect of stroke depends on area
  - Senses, motor activity, speech, memory, other thought processes
  - Paralysis or weakness of one side of body is common
- Quick treatment critical
  - Surgery or medication to dissolve clot
• Study published in February 2010 says people with migraines have higher risk of having a stroke or heart attack.
• So migraines are a risk factor for stroke and heart attack
• What’s a migraine? Severe headache, usually occurs on one side of the head
• Symptoms= nausea, vomiting, light or smell sensitivity
• Starts with aura, neurological disorders or sight, speech
• Its an over reaction of blood vessels in the brain, hereditary
• https://www.youtube.com/watch?v=YQSHn847o-M
More Cardiovascular Diseases

- **Aneurysm**
  - Bulging of wall of blood vessel
    - Bulge forms around weakening of blood vessel wall

- **Angina pectoris**
  - Chest pain due to coronary heart disease
  - No treatment
  - Indicator of disease rather than disease itself

- **Arrhythmia**
  - Any deviation in normal heartbeat
  - Usually not serious unless it REALLY speeds up or slows down
  - Most common symptom is trembling in the chest or the feeling that the heart is skipping beats
More Cardiovascular Diseases

- **Endocarditis**
  - Caused by bacterial infection that inflames the lining of the heart
  - Can enter the blood during dental work and injuries that produce bleeding
    - Antibiotics is common practice during dental procedures

- **Congenital heart disease**
  - Defect that occurs when the heart, or blood vessels near the heart, do no develop normally before birth
    - Restricts blood to heart
  - Caused by variety of genetic conditions

- **Congestive heart failure (CHF)**
  - General term used to describe heart’s loss of pumping ability
  - Can be caused by diabetes, high blood pressure, and lung diseases

- **Enlarged heart**
  - Caused by a thickening, or hypertrophy, of the heart muscles
  - Obesity and excessive exercise are two causes
  - More susceptible to heart disease
More Cardiovascular Diseases

- Fibrillation
  - Rapid contraction of either the atria or ventricles of the heart
  - Causes pooling of blood in atria, leading to blot clots

- Murmurs
  - Usually result of defective heart valves
  - Murmur is sound the heart produces when a valve is not properly closing

- Pericarditis
  - Inflammation of pericardium
  - Produces chest pain and is usually accompanied by a fever
  - Last anywhere from weeks to maximum 1 year
More Cardiovascular Diseases

- Rheumatic heart disease
  - Result of bacterial infection called rheumatic fever
  - Starts out as strep throat
    - If left untreated, bacteria can enter the bloodstream and damage organs, including the heart valves
- Prolapse
  - Stretching of heart valves
  - Causes reduced blood-pumping capacity by the heart
- Regurgitation
  - Backflow of blood through a heart valve
  - Mitral valve prolapse – 20% of population in North America
    - Surgery repairs heart valve
Preventing Cardiovascular Disease

- Some risk factors are age, gender, race, and genetics, cannot be changed
- Controllable Risk Factors
  - Physical inactivity
    - Regular exercise helps prevent or control diabetes, obesity, and high blood pressure
  - High blood cholesterol
    - Regular exercise
    - Leads to arteriosclerosis
    - No symptoms until too late
  - Recreational drug use
    - Alcohol and tobacco cause cardiovascular disease
35.3 The Respiratory System

- Brings oxygen, $O_2$, into the body
  - Carries carbon dioxide, $CO_2$, out of the body

*Did you know?
- On average, a person swallows 1 pint of nasal mucus per day – even more if they have allergies
Path of Air

- Air enters the body through the nose or mouth
  - Hairs in nose filter dust out of the air
- From nose, to pharynx
  - Pharynx – serves as passageway for air and food
- From pharynx, through larynx in neck
  - Larynx is the voice box
  - A flap of tissue covers the opening of larynx so when you swallow food, it doesn’t pass into your lungs
- From larynx to trachea
  - Trachea – tube located in chest cavity
- Trachea branch into two smaller tubes, bronchi
  - Bronchi lead to lungs
  - Here, air enters the alveoli
  - Then, oxygen enters the capillaries
Inside a Lung

- Within lung, bronchi (singular bronchus) branch into smaller tubes called bronchioles
  - Cells that line bronchi trap dust and other particles in air
  - Smallest bronchioles end in clusters or air sacs called alveoli
    - Alveoli – tiny air sacs of lungs where oxygen and carbon dioxide are exchanged
      - Surrounded by capillaries of cardiovascular system
      - Actual exchange of gases happen between air of alveoli and blood in capillaries
Lungs/Alveoli

Younger lungs

Alveoli
Diaphragm

- Lungs suspended in chest by diaphragm on the bottom
  - Bound on sides by the ribs
- Diaphragm is powerful muscle that drive breathing
  - Main muscle in respiration
Path of Air

1. Nose or mouth (nasal passageways)
2. Pharynx
3. Larynx
4. Trachea
5. Bronchial tubes
6. Bronchioles
7. Alveoli
Breathing

• Lungs are NOT muscular organs that contract to move air in and out
• Air is moved in and out by changes in pressure in chest cavity
  • Change caused by the diaphragm and muscles between ribs.
    • When muscles contract, the chest cavity expands and air rushes in.
    • When muscles relax, the chest cavity returns to a resting position and air rushes out.
Inhalation and Exhalation

- **Inhalation** – diaphragm contracts and moves downward, rib cage moves up and out
  - Movement increases volume of chest cavity and reduces air pressure
    - Air flows from high to low pressure area
- **Exhalation** – diaphragm and rib-cage muscles relax
  - Decreases volume of chest cavity and increases air pressure
    - Air is forced out of lungs
Gas Exchange and Transport

- Breathing is only 1st step to get O₂ to entire body
- From alveoli, their journey has just begun
- Oxygen moves into the blood, which carries it to rest of body
  - CO₂ also carried in blood gets transported back to lungs, which expel it
- Oxygen not very soluble in plasma
  - Oxygen carried by hemoglobin inside red blood cells
    - CO₂ soluble in water and is carried in the plasma
Respiratory Diseases

- Kill 335,000 Americans each year
- 3rd leading cause of death in US
- Most are caused by smoking
  - Air pollution contributes to lung diseases
Respiratory Diseases

- Asthma – chronic condition of bronchioles and alveoli
  - Airways chronically inflamed and sensitive to irritants

- **18.7 million adults have been diagnosed with asthma (8.7%)**
- **7.0 million children have been diagnosed with asthma (9.4%)**
- Causes about 3,500 deaths per year
**Inflammation**

Asthma triggers irritate the lining of the bronchial tubes, causing them to become inflamed and swollen. Excess mucus makes breathing more difficult.

**Bronchoconstriction**

During an asthma attack, bands of muscles surrounding the bronchial tubes contract, causing the airway to narrow.
Bronchitis

- Bronchitis – inflammation of the bronchioles
  - Causes excess mucus to be made
  - Chronic usually caused by cigarette smoking
  - Usually occurs after a cold (causes coughing)

- **symptoms – shorts of breath, chest pain, etc.
  - Can last up to 2 weeks… some cough for 8

- Chronic (usually in smokers) – most days for about 3 months each year
Bronchitis Visual Explanation

- Bronchial tube
- Section of the Bronchial Tubes
- Cell lining and the cilia
- Mucus gland
- Excess mucus
Pneumonia

- Pneumonia – inflammation of lungs, especially the alveoli
  - Main cause = infection
  - Old or young age at greatest risk

**causes 52,000 (US Only) deaths per year**

- Globally, kills 1.5 million children UNDER 5 each year
- Can be prevented with vaccination
Pneumonia
Tuberculosis

- Tuberculosis – bacteria that attacks the lungs
  - 2 million deaths each year
  - 1 in 3 are infected, only 10% of people infected develop TB
  - On rise due to antibiotic resistance

- **one of world’s deadliest diseases..**
- Latent version is not transmissible
  - Some with latent version can go on to develop TB
Granuloma is a collection of immune cells (they surround and try to contain infection). Granuloma in TB is usually necrotizing.
Emphysema

- Emphysema – results in destruction of elastic fibers in the lungs
  - Smoking cause of 90% of cases
  - Causes loss of flexibility in walls of alveoli

- **AKA (COPD = chronic obstruction pulmonary disease)**
- Hospitalization on a regular basis
Emphysema

- Alveoli with emphysema
- Microscopic view of normal alveoli
Lung cancer – leading cause of death in the world today
- 28% of all cancer deaths each year are attributed to lung cancer
- 90% lung cancer cases from smoking

**Second-hand smoke increases risk of breast cancer**

- Only 15% of lung cancer patients live more than 5 years after diagnosis