Cardiovascular System

Biol 105
Lecture Packet 15
Reading: Ch 12

Outline
I. Functions of cardiovascular system
II. Components of the cardiovascular system
III. Blood Vessels
IV. The heart
V. Regulation of the heartbeat
VI. ECG/EKG
VII. Blood pressure
VIII. Circulatory circuits
IX. Cardiovascular diseases
X. Lymphatic system

Cardiovascular Functions
• Function of the cardiovascular system is to transport blood containing:
  • Nutrients
  • Waste
  • Hormones
  • Immune cells
  • Oxygen

Components of the Cardiovascular system
• Cardiovascular System consists of three components:
  1. Blood
  2. The heart, which pumps blood.
  3. The blood vessels, through which blood flows.

The Heart and Lungs

The Cardiovascular System - Arteries

Blood vessels
• Blood vessels are lined with epithelial cells
• They have a layer of smooth muscles that contract or dilate the vessels
• Blood vessels are covered with a layer of connective tissue
• Inside the vessels is called the lumen.
Vasoconstriction and Vasodilation

- **Vasoconstriction**
  - When muscle contracts and the diameter of the lumen narrows, reducing blood flow

- **Vasodilation**
  - When muscle relaxes and the diameter of the lumen increases, increasing blood flow

The Blood Vessels

- **Arteries**
- **Arterioles**
- **Capillaries**
- **Venules**
- **Veins**

The Blood Vessels – Arteries and Veins

- **Arteries** - Always carry blood away from the heart and usually carry $O_2$-rich blood.
- **Veins** - Always returns blood to the heart and usually carry $O_2$-poor blood.

The Blood Vessels – Arterioles and Venules

- Arteries break down into smaller vessels called arterioles, bringing $O_2$, water, and nutrients to the tissues
- Arterioles break down into small vessels called capillaries
- Blood leaves the capillaries and enters venules
- Venules take $CO_2$, water, and wastes away from the tissues.
- Venules join together to form veins.

The Blood Vessels – Arterioles

- There are sphincter muscles that contract to reduce blood flow to the capillaries
- or they dilate to increase blood flow to the capillaries.

Capillaries

- Small vessels are called capillaries.
- It is here that components ($O_2$, $CO_2$, nutrients, waste) can pass from the blood vessels to other tissues
- Capillaries do not have a smooth muscle layer

Can gas freely pass through the plasma membrane?

- 1. True
- 2. False

Graph showing 50% True and 50% False.
The RBCs stay in the blood vessels but the oxygen leaves the RBCs and the capillaries and goes into the tissues.

The oxygen leaves the capillaries because there is a gradient – there is more oxygen in the capillaries than in the tissues.

Blood flow in capillaries is slow. This is important because it allows time for the exchange of substances between the blood and surrounding tissues.

Substances are exchanged between the blood and tissue fluid across the plasma membrane of the capillary or through slits between capillary cells.

At the arterial end of a capillary, blood pressure forces fluid out of the capillary into the fluid surrounding tissue cells. At the venous end, fluid is drawn back into the capillary by osmotic pressure.
Do RBCs leave the capillaries?

1. Yes
2. No

Pressures and Their Effect on Capillaries

- At the arterial end of the capillaries, blood pressure forces fluid out of the capillary and into the tissue.
- At the venous end, osmotic pressure draws fluid back into the vessel from the tissue.
- Diffusion is the pressure that draws gasses across the capillary.

The Blood Vessels

- Arteries
  - Aorta — largest artery.
  - Arterioles — smallest arteries (whether constricted or dilated affects blood pressure).
- Capillaries — smallest vessels (where nutrient and wastes are exchanged)
- Veins
  - Vena cava — largest veins in the body.
  - Venules — smallest veins.

The Heart

- The heart is composed of four chambers and lies almost in the center of the thoracic cavity.
- Two atria—thin-walled upper chambers that serve as reservoirs for blood.
- Two ventricles—thick-walled lower chambers powering the pulmonary and systemic circuits.
- Septum—separates right and left sides of the heart.

The Heart Valves

- There are valves which keep blood flowing forward:
  - Two atrioventricular valves (AV) — between atria & ventricles, making a “LUB” sound when closing.
  - Two semilunar vales (SL) — base of major arteries making a “DUB” sound when closing.

The Heart

- Pericardium — thick membranous sac surrounding the heart (secretes serous fluid).
- Myocardium — consists of cardiac muscle tissue, which contracts to pump blood.
- The interior of the heart is lined by endocardium.
The Heart

Oxygen-rich blood (to body) Oxygen-poor blood (to lungs)

Oxygen-rich blood (from lungs)
Oxygen-poor blood (from body cells)

Path of Blood Through Heart
- Superior and Inferior vena cava (O₂-poor) → Right Atrium.
- R Atrium → Tricuspid AV valve → Right Ventricle.
- R Ventricle → Pulmonary SL valve → Pulmonary Arteries → Lungs.
- Pulmonary veins (O₂-rich) → Left Atrium.
- L Atrium → Mitral AV valve → Left Ventricle.
- L Ventricle → Aortic SL valve → Aorta → rest of the body tissues.

Cardiac Cycle
- Cardiac cycle - one complete heart beat where both atria contract simultaneously (at the same time) followed by both ventricles contracting simultaneously.
  - a. Systole - when ventricles contract and pump blood out of the heart.
  - b. Diastole - when ventricles relax and receive blood from atria.

Heartbeat regulation - Intrinsic
- Intrinsic Control:
  - Sinoatrial node (SA) (pacemaker) — initiates the heartbeat and causes the atria to contract.
  - Atrioventricular node (AV) - causes the ventricles to contract.

Heartbeat regulation - Intrinsic
- The AV node relays the message to the ventricles using bundles of specialized muscle cells = atrioventricular bundle
  - The bundle divides into smaller bundles of specialized cardiac muscle cells called Purkinje fibers.

Regulation of the Heartbeat
- SA node
- AV node
- Bundle of conducting muscle cells
- Purkinje fibers

SA node initiation
- Atria contract
- Signal reaches AV node
Regulation of the Heartbeat

When the ventricles contract, which valves are closed?
1. AV valves
2. SL valves

Heartbeat regulation - Extrinsic
- Extrinsic Control of Heartbeat
  - The Autonomic Nervous System
    - Sympathetic vs Parasympathetic
  - The Endocrine System - hormones can modify the rate of the heartbeat.
    - Eg. epinepherine

Which part of the autonomic NS controls the heart most of the time?
1. Sympathetic
2. Parasympathetic

Recording the Heartbeat
- Electrocardiogram (ECG) - a recording of the electrical changes that occur in the myocardium during a cardiac cycle.

ECG/EKG
- A typical ECG/EKG consists of three distinguishable waves
  - P wave – Atrial depolarization
  - QRS wave – ventricle depolarization
  - T wave – ventricle repolarization

The ECG/EKG

Pulse
- As the heart pumps blood into the arteries, they expand such that one is able to feel a pulse
- The pulse rate is the same as the heart rate
Blood pressure

- **Sphygmomanometer**
  - Measures blood pressure
  - Can provide early identification of **hypertension**, or high blood pressure, the silent killer

**Which blood pressure would be the highest:**

1. systolic
2. diastolic

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Blood pressure

- **Blood pressure**
  - **Systolic** - when the ventricles contract, sending blood into the arteries
  - **Diastolic** - when the heart relaxes between beats

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Blood flow

- Blood flow in the arteries is from the blood pressure due to the heart pumping.
- The blood pressure in veins is very low

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Veins

Blood flow in veins is dependent upon:

1. Skeletal muscle contraction
2. One-way valves
3. Respiratory movements
One way valves in veins

Valve closed
Valve open
Relaxed calf muscles
Skeletal muscles relax, and blood fills the valves and closes them.

Muscle contraction squeezes the vein, pushing blood through the open valve toward the heart.

Valve closed
Contracted calf muscles

Cardiovascular system circuits

- **Pulmonary circuit** - flow of blood from the heart, to the lungs and back to the heart, powered by the right ventricle.

- **Systemic circuit** - flow of blood through the rest of the body, powered by the left ventricle.

Pulmonary circuit

- Pulmonary arteries—carry \( O_2 \)-poor blood to the lungs.
- Pulmonary veins—carry \( O_2 \)-rich blood from lungs to the left atrium.

Systemic circuit

- Aorta - carries \( O_2 \)-rich blood to all body tissues.
- Vena cava - returns \( O_2 \)-poor blood to the right atrium.

Systemic circuits

- Renal circuit - supplies blood to the kidneys.
- Hepatic portal circuit - supplies blood to the digestive organs especially the liver.

Systemic - Coronary circuit

- Supplies blood to the heart muscle itself.
- Coronary arteries branch off the aorta.
- Coronary arteries can become clogged and by-pass surgery may be necessary.
- Coronary veins return blood to the heart.

Coronary Circuit

![Coronary Circuit](image_url)
This pressure draws fluid back into the capillaries:

1. Blood Pressure
2. Osmotic Pressure
3. Diffusion

Blood flow in veins depends upon:

1. One-way valves
2. Respiratory movements
3. Smooth muscle
4. Skeletal muscle

When ventricles relax and receive blood from atria it is:

1. Systole
2. Diastole

Disorders of the Cardiovascular System:

1. High Blood Pressure
2. Atherosclerosis and coronary artery disease
3. Heart attack
4. Thromboembolism
5. Stroke
6. Aneurism

Disorders – High Blood Pressure:

- High blood pressure is also called hypertension
- Causes:
  - 90% of high blood pressure has no known cause.
  - Can be caused by kidney not being able to balance the sodium concentration. Increased fluid in blood increases blood pressure.
  - Stress can lead to high blood pressure.
  - Obesity can increase resistance in the system.

Disorders – High Blood Pressure:

- Result: high blood pressure causes the heart to work too hard, leads to heart failure, kidney problems, blood vessel problems and death.
- Prevention includes: lower salt intake, lose weight, exercise, and stop smoking.

Disorders - Atherosclerosis:

- Atherosclerosis is a narrowing of the arteries due to fatty deposits and thickening of the wall
- Can lead to heart attack or stroke
- When this occurs in the arteries of the heart muscle, it is called coronary artery disease

Cholesterol:

- Remember that lipoproteins are proteins that carry cholesterol in the blood.
  - Low density lipoproteins (LDL)
  - High density lipoproteins (HDL)

This type of lipoprotein carries cholesterol away from the liver:

1. LDL
2. HDL
Coronary Artery Blockage

- Some of the LDLs can become damaged through oxidative stress. The damaged LDL can get stuck in these coronary arteries.
- The oxidized material can build up and reduce the flow of blood to the heart = coronary artery blockage.
- Inflammation can also play a role in narrowing the vessels by increasing the thickness of the wall.

Atherosclerosis

- Angiography can show coronary artery blockage, which can then be treated with medicines or surgical operations such as angioplasty or coronary bypass surgery.
- See pages 234-236

Disorders - Heart Attack - myocardial infarction

- Heart muscle dies because of an insufficient blood supply during a heart attack (myocardial infarction) and is gradually replaced by scar tissue.
- Can be caused by coronary artery blockage.
- Scar tissue cannot contract, so part of the heart permanently loses its pumping ability.

Disorders - Thromboembolism

- Thromboembolism is a clot that has been carried in the bloodstream but is now stationary.
- Can result in a stroke.
Disorders - Stroke

- Stroke - cranial arteriole bursts or is blocked, reducing blood supply to an area of the brain.
- The result is that a portion of the brain dies, and may result in paralysis or death.

Disorders - Aneurysm

- Aneurysm - weak spot in a blood vessel where it balloons out and may rupture
- May cause a stroke if in the brain or death if in aorta

Aneurysm

The blood supply to the kidneys is the:

1. Hepatic portal circuit
2. Renal circuit
3. Cardiac circuit

Lymphatic System

- Lymphatic system - system that takes excess tissue fluid to the subclavian veins.
- Skeletal muscles and valves keep fluid moving

The Lymphatic System Functions

- Functions
  1. Return interstitial fluid from tissues to the bloodstream
  2. Transport products of fat digestion lacteals
  3. Defend the body against disease-causing organisms and abnormal cells

Components of the Lymphatic System

- Lymph
- lymphatic vessels - including lacteals
- lymphoid organs.
**Lymphoid Organs:**
1. **Lymph nodes** - cleanse lymph of debris and pathogens and store lymphocytes and macrophages to fight infection.
2. **Spleen** - cleanses the blood, remove old blood cells.
3. **Red bone marrow** - produces both B cells and T cells.
4. **Thymus gland** - where T cells mature.
5. **Tonsils** - function to recognize infectious agents entering the body.

**Important concepts**
- What is the function of capillaries?
- What are the chambers of the heart, which are the lower chambers and which are the more muscular chambers?
- What cavity is the heart located in?
- What is the path of the blood through the heart?
- Be able to describe the cardiac cycle.

**Important concepts**
- What are the valves in the heart, where are they located, when are they opened, when are they closed?
- How is the heartbeat is regulated, both intrinsically and extrinsically?
- What records the electrical changes that occur in the myocardium during a cardiac cycle?
**Important concepts**

- What are the three waves on the ECG and be able to describe the events that happen during each of the waves on the ECG?
- What measures blood pressure?
- What causes blood to flow in the arteries and in the veins?
- What are the pulmonary, systemic renal, hepatic portal, and coronary circuits, what tissues to they go to?

**Important concepts**

- What is the function of the aorta, vena cava, pulmonary arteries, pulmonary veins, coronary arteries and coronary veins?
- What is the role of LDL and HDL in coronary artery disease?
- What are causes and effects of the cardiovascular diseases discussed in lecture
- How can you prevent high blood pressure.

**Important concepts**

- What are two treatments of coronary artery blockage
- How is coronary artery blockage detected?
- What are the function of the lymphatic system?

**Definitions**

- Lumen, vasoconstriction, vasodilation, osmotic pressure, blood pressure, low density lipoproteins (LDL), high density lipoproteins (HDL), septum, capillaries, arteries, veins, arteriole, venule, vena cava, aorta, sinoatrial node (SA), atrioventricular node (AV), pericardium, myocardium, endocardium,

**Definitions**

- Cardiac cycle, systole, diastole, atrioventricular bundle, purkinje fibers, extrinsic control, intrinsic control, electrocardiogram, pulse, systolic pressure, diastolic pressure, sphygmomanometer, coronary arteries, renal circuit, hepatic portal circuit, coronary circuit, hypertension, interstitial fluid, lacteal