Chapter 12 – The Heart
Heart Facts

• About the size of your fist
• Widest portion called the base (sits behind 2nd rib)
• Point at bottom = apex
  – points towards the left
Functions

• Pumps blood in one direction
• Keeps oxygen rich and oxygen poor blood separate
• Supplies blood pressure
• Supplies every cell in the body with blood
The Cardiovascular System

- The Heart
  - Located in the mediastinum
- Blood Vessels
  - Pulmonary Circuit
  - Systemic Circuit
Coverings of the Heart

- Deep to Superficial
  - Visceral pericardium
    - Pericardial fluid
  - Parietal pericardium
  - Fibrous pericardium (anchors heart to mediastinum)
Walls of the heart

- Deep to superficial
  - **Endocardium**: lines the heart chambers
    Made of endothelium
  - **Myocardium**: actual cardiac (heart) muscle
  - **Epicardium** = outermost layer
    visceral pericardium
Chambers of the Heart

• Superior Chambers
  – Right Atrium
  – Left Atrium

• Inferior Chambers
  – Right Ventricle
  – Left Ventricle
The Heart: Valves

- Allow blood to flow in only one direction
- Four valves
  - Atrioventricular valves – between atria and ventricles
    - Bicuspid valve (left)
    - Tricuspid valve (right)
  - Semilunar valves between ventricle and artery
    - Pulmonary semilunar valve
    - Aortic semilunar valve
Division between Rt. & Lf Heart

- Pulmonary Circuit (Right Atrium & Ventricle)

- Intraventricular Septum

- Systemic Circuit (Left Atrium & Ventricle)
Right Heart

- Right Atrium receives oxygen poor blood from 3 veins
  1. Superior Vena Cava
  2. Inferior Vena Cava
  3. Coronary Sinus

- Rt. Atrium pumps blood into the Right Ventricle through a valve = Atrioventricular valve (AV)
  - Rt. AV valve is called the TRICUSPID VALVE
Tricuspid Valve – 3 flaps
Right Heart

- Blood enters Rt Ventricle
- Out the rt. ventricle via the Semilunar Valve (pulmonary semilunar)
- Into the pulmonary trunk
- Pulmonary trunk splits to the Rt. & Lf. Pulmonary arteries
- Pulmonary arteries to the lungs
Left Heart

- Oxygen rich blood back to the heart from the lungs in the Pulmonary Veins
- Into the Left Atrium
- Into the Left Ventricle thru Bicuspid Valve
  - Mitral Valve
Left Heart

• Blood is forced (thick wall muscle) out of the left ventricle thru the Semilunar Valve (aortic semilunar)

• Aorta –
  – first branch to the coronary arteries
    • Nourish the heart itself
  – Branches to rest of the body
Operation of Heart Valves

Operation of the AV valves

1. Blood returning to the heart fills atria, putting pressure against atrioventricular valves; the atrioventricular valves are forced open.
2. As the ventricles fill, atrioventricular valve flaps hang limply into ventricles.
3. Atria contract, forcing additional blood into ventricles.

AV valves open

Operation of the semilunar valves

As ventricles contract and intraventricular pressure rises, blood is pushed up against semilunar valves, forcing them open.

Aorta
Pulmonary trunk

Semilunar valves open

As ventricles relax, and intraventricular pressure falls, blood flows back from arteries, filling the cusps of semilunar valves and forcing them to close.

Semilunar valve closed

AV valves closed

Chordae tendineae tighten, preventing valve flaps from evertting into atria.

Figure 11.1(a)

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Heart Sounds

• Beating of the heart that we hear is from the closing of the valves
  • First sound = lub
    – Closing of both AV valves (tricuspid and bicuspid)
  • Second sound = dub
    – Closing of both semilunar valves
• Any extra sounds (murmurs) heard are due to leaky valves
Valve Pathology

- Incompetent valve = backflow and re-pump
- Stenosis = stiff= heart workload increased
- May be replaced
Coronary Circulation

- Blood supply to the heart
- From aorta to left and right coronary branches
- After feeding the heart
- Blood supply returns to right atrium via the coronary sinuses
Blood Flow

• All arteries branch **FROM** the aorta

• All veins branch **INTO** the Superior and Inferior Vena Cava
Gas Exchange
Rt. Atrium

Tricuspid Valve

Rt. Ventricle

Pulmonary Semilunar Valve

Pulmonary Trunk

Pulmonary Arteries

Lungs

Gas Exchange

Pulmonary Veins

Left Atrium
Pulmonary Gas Exchange
Systemic Circulation

- Left Atrium
- Bicuspid Valve (Mitral Valve)
- Left Ventricle
- Aortic Semilunar Valve
- Aorta
- Arteries
- Heart and Body Tissues
- Gas Exchange
- Body Veins
- Superior/Inferior Vena Cava
Conduction System of the Heart

- Intrinsic conduction system: heart contracts automatically
- Heart beats about 2.5 billion times in a lifetime
- About 5 liters of blood is recycled in a heart beat!
Conduction System...

SA node (Sinoatrial node):
- Near upper posterior wall of the right atrium
- Pacemaker of the heart
- Initiates heartbeat and the atria contract
Conduction System...

AV node (Atrioventricular node):
- Near the base of the right atrium
- By the interatrial septum
- Receives input from the SA node
- Passes it to the AV bundle
Conduction system...

AV bundle (Bundle of His)
• In the interventricular septum
• Transfers signal to the Purkinjee fibers

Purkinjee fibers
• In the ventricular walls
• Signal causes ventricular contraction

Intercalated discs (gap junctions)
• Pass signal to every cardiac cell
Sinoatrial node (pacemaker)

Atria

Ventricles

Heart at rest

Atrioventricular node

Bundle of His fibers

Bundle branches

Purkinje fibers
Now, on to the Cardiac Cycle...

- All the events that occur in one heartbeat
- Average Heart Rate = 70 beats/minute
  - Range 60-100 beats/minute
- Both sides of the heart contract together
Overview of the Cardiac Cycle

**Systole:** Contraction of the heart muscle
- First, both atria contract
- Then, both ventricles contract

**Diastole:** Relaxation of the heart muscle
- Both atria relax
- Followed by the relaxation of both ventricles
Atrial Systole: Phase 1

- Both atria contract
- Ventricles are relaxed
- Blood enters both ventricles through the open AV valves
- Semilunar (pulmonary and aortic) stay closed
- AV valves (tricuspid and bicuspid) close – Atrial systole ends
  - First heart sound - lub
- Lasts about = 0.15 sec
Ventricular Systole: Phase 2

- Both ventricles contract
- Both atria are relaxed at this time
- Blood is pushed into the aorta & pulmonary trunk through the semilunar valves
- Semilunar valves close
  - Second heart sound - dub
- Takes about 0.30 sec
Atrial and Ventricular Diastole: Phase 3

- Both Atria and Ventrices are relaxed
- Blood returns to the right atrium via both vena cava (SVC and IVC)
- Blood returns to the left atrium via pulmonary veins
- Blood also flows passively into the ventricles
- Both AV valves are open
- Both semilunar valves are closed
- Takes about 0.40 seconds
Cadiac Output (CO)

• Volume of blood pumped out of a ventricle/minute

• Both ventricles pump out the same amount of blood per minute

• CO depends on heart rate and stroke volume
  – CO = HR X SV
  – HR = heart rate
  – SV = stroke volume (volume of blood pumped by a ventricle/contraction)
Cardiac Output

• CO of an average human = 5.25 L/minute
• This equals the total blood volume in our bodies!
• Can be affected by changes in heart rate or SV
Heart Rate

- Regulated by the cardio-regulatory center
  - Located in medulla oblongata
- Controlled by the autonomic nervous system
- Parasympathetic nervous system
  - Slows heart rate via vagus nerve
- Sympathetic nervous system
  - Increases heart rate
Measuring HR: Pulse
EKG (ECG)

- Electrocardiogram
- Records the electrical activity of the myocardium (layer with the heart muscle)
EKG (ECG)

- **P wave**: Atrial depolarization
  - impulse started at the SA node travels down the atria (atria are about to contract)
- **QRS complex**: Ventricular depolarization
  - Followed by the excitation of Purkinjee fibers
  - Ventricles are about to contract
- **T wave**: ventricular repolarization
  - Ventricles are about to relax
Arrhythmias

• **Bradycardia**
  – HR of fewer than 60 beats/minute

• **Tachycardia**
  – HR of more than 100 beats/minute

• **Fibrillation**
  – Rapid uncoordinated beating
Fetal Circulation

• Exchange of $O_2$ and $CO_2$ takes place in the placenta

• Umbilical vein is $O_2$–rich blood
  – Travels towards the heart of the fetus via the mother and placenta

• Umbilical veins leads to the **ductus venosus** which allow blood to enter the fetal inferior vena cava then into the rt. atrium
Fetal Circulation from the Rt Atrium

- Right atrium - Right ventricle - pulmonary arteries – lungs
  - Only about 10% of the blood flow enters the pulmonary circuit.

OR

- Rt. atrium directly into the left atrium through a detour
  **Foramen ovale** (*oval hole*)
Fetal Circulation from the Rt Atrium

- Right Atrium - right ventricle - pulmonary trunk directly into – aorta via a shunt called the ductus arteriosus,
After Birth

- Umbilical cord is cut
- Baby takes first breath
- Lungs inflate with oxygen
- Rush of oxygen rich blood from lungs into the left atrium causes a flap to cover the foramen ovale
Blood Vessels

• **TUNICS** = layers of tissue

• **LUMEN** = where blood flows
Tunics

• Innermost layer = Tunica interna
  – epithelial tissue

• Middle layer = Tunica media
  – Connective tissue (elastic and collagen fibers) & smooth muscle

• Outermost layer = Tunica externa or adventitia
  – irregular connective tissue, containing both elastic and collagenous fibers
Arteries VS. Veins

- Carry blood away from the heart
- Small arteries = arterioles
- Largest arteries are about as thick as a thumb
- Blood rich in oxygen
  - Except pulmonary arteries
- Flows under high pressure (highest in aorta because close to left Ventricle)

- carry the blood to the heart
- Smallest veins = venules
- Blood low in oxygen
  - Except in pulmonary veins
- Thin walls
- Flows under low pressure (lowest in Vena Cava furthest from left. Ventricle)
- Contains valves in the lumen
Capillaries

- Thin and fragile
- One epithelial cell thick
- Exchange of oxygen and carbon dioxide takes place through the thin capillary wall.
- RBCs inside the capillary release their oxygen which passes through the wall and into the surrounding tissue
- Tissue releases its waste products which passes through the wall and into the red blood cells
Arteriovenous Shunt

• Blood redirected away from capillary beds in areas of low oxygen need at a specific time
Capillary Bed with Precapillary Sphincters
Major Vessels of the Body

• you will need to learn the major arteries and veins of the body and which vessels supply which areas of the body – Please refer to the Blood Vessels Color plate.
Right Subclavian

Rt. Common Carotid

Left Common Carotid

Left Subclavian

Right Brachiophephalic

Ascending Aorta

Descending Thoracic Aorta

DIAPHRAGM

Abdominal Aorta

Aortic Arch
Systemic Arterial System

- Superficial temporal artery
- Posterior auricular artery
- Common carotid artery
- Subclavian artery
- Brachiocephalic trunk
- Axillary artery
- Deep brachial artery
- Brachial artery
- Aorta
- Radial artery
- Interosseous artery
- Ulnar artery
- Deep palmar arch
- Superficial palmar arch
- Descending genicular artery
- External carotid artery
- Internal carotid artery
- Vertebral artery
- Aorta and arch
- Pulmonary artery
- Cardiac artery
- Thoracic aorta
- Celiac trunk
- Superior mesenteric artery
- Renal artery
- Gonadal artery
- Inferior mesenteric artery
- Common iliac artery
- External iliac artery
- Internal iliac artery
- Deep femoral artery
- Femoral artery
- Popliteal artery
- Anterior tibial artery
- Peroneal artery
- Posterior tibial artery
Arteries of the Chest and Upper Extremity
Superficial arteries and veins of face and scalp

- Parietal emissary vein
- Frontal branch of superficial temporal artery and vein
- Parietal branch of superficial temporal artery and vein
- Superficial temporal artery and vein
- Anterior auricular artery
- Occipital artery and vein
- Middle temporal artery and vein
- Posterior auricular artery and vein
- Retromandibular vein
- External jugular vein
- Internal carotid artery
- External carotid artery
- Internal jugular vein
- Zygomaticoorbital artery
- Supraorbital artery and vein
- Supratrochlear artery and vein
- Angular artery and vein
- Infraorbital artery and vein
- Transverse facial artery and vein
- Facial artery and vein
- Lingual artery and vein
- Common carotid artery

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Veins

- **Venules**
  - Very small
  - Contain only tunica intima and tunica externa

- **Medium-sized veins**

- **Large veins**
  - Contain the same 3 layers as arteries
    - Tunica media is much thinner
    - Tunica externa is the thickest layer
Veins with Valves

- Some veins contain **valves** – prevent blood from flowing backwards
Venous System of the Trunk and Upper Limb

- Superior Vena Cava
- Inferior Vena Cava
- Hepatics
- Renals
- Gonadals
- Lumbars
- Common iliac
- Internal iliac
- External iliac

Deep veins
- Venous arches
- Digital

Superficial veins
- Median cubital
- Cephalic
- Radial
- Median antebrachial
Aging and the Cardiovascular System

- Arteriosclerosis
- Atherosclerosis
- Hypertension
- Stroke
- Myocardial Infarction
- Congestive Heart Failure
Atherosclerosis

- Buildup of fatty plaques in the walls of blood vessels.
- Causes – usually high cholesterol diet (LDL’s)
Arteriosclerosis

- Stiffening/hardening of the arteries
- Due to high blood pressure over time/smoking/diet/ atherosclerosis
Hypertension

- When a person’s blood pressure is elevated at all times (140/90 is considered high)
- Caused by stress, diet, inactivity, smoking, salt, alcohol, genetics
Myocardial Infarction/Heart Attack

• Damaged heart tissue due to blockage in the coronary arteries interrupting blood flow to the heart muscle cells
• Caused by high bp, atherosclerosis, poor diet (LDL’s), alcohol, diabetes
Stroke

• Disturbance of blood flow to the brain usually because of a blocked or burst artery

• Caused by smoking, poor diet, hypertension, diabetes, advanced age
Congestive Heart Failure

- The heart stops pumping because the heart muscles have been weakened by a previous attack, virus, or high blood pressure.
- Diabetes/alcohol aggravate the situation.
Keeping your Heart Healthy!

- Don’t smoke
- Get active
- Eat a healthy diet (limit fats)
- Maintain a healthy weight
- Get regular check-ups