Heart

1. General information

A) Located within mediastinum, within the pericardial cavity

B) About the size of a fist

C) Cone-shaped – apex facing left hip

D) Main function is to pump blood

2. Coverings of the heart

A) Surrounded by the pericardium – dual-walled structure

1) Fibrous pericardium

a) Protects heart

b) Anchors it to surrounding structures

c) Prevents overfilling

2) Serous pericardium

a) 2 layers

i) Parietal layer

(a) Attached to fibrous pericardium

ii) Visceral layer (epicardium)

(a) Integral part of the heart wall

b) Pericardial cavity

i) Separates parietal and visceral layers

ii) Filled with pericardial fluid; creates friction-free work area

3. Layers of the heart wall

A) Epicardium

1) Composed of a thin layer of CT

B) Myocardium

1) Composed of cardiac muscle tissue

C) Endocardium

1) Composed of simple squamous epithelium

2) Is continuous with blood vessels entering & leaving heart

4. Chambers of the heart

A) Atria

1) Auricle – exterior extruding surface

2) R & L are separated by the interatrial septum

a) Fossa ovalis – shallow depression found in right atrium; remnant of foramen

ovale

3) Thin-walled – not much contracting

4) Receive blood from veins

a) Right atrium – receives blood from:

i) Superior vena cava – from structures above diaphragm

ii) Inferior vena cava – from structures below diaphragm

iii) Coronary sinus – from heart itself

b) Left atrium – receives blood from:

i) 4 pulmonary veins – from the lungs

B) Ventricles

1) Separated from atria by the atrioventricular septum

2) R & L separated by interventricular septum

3) Within the ventricles, 2 distinct muscle formations exist

a) Trabeculae carneae

i) Internal ridges

b) Papillary muscles

i) Finger-like projections

C) Heart valves

1) Atrioventricular (AV) valves

a) Found between atria & ventricles

b) Name refers to the number of cusps (flaps)

i) Tricuspid valve – between R atrium & ventricle

ii) Bicuspid/mitral valve – between L atrium & ventricle

c) Attached to papillary muscles via chordae tendineae

i) The papillary muscles contract and pull on the chordae tendineae to keep the

AV valves closed during ventricular contraction, therefore preventing the

backflow of blood into the atria

d) Remain open when ventricles are relaxed

2) Semilunar valves

a) Found between ventricle & its corresponding artery

b) Named according to the corresponding artery

i) Pulmonary valve – between R ventricle & pulmonary trunk

ii) Aortic valve – between L ventricle & aorta

c) Remain closed when ventricles are relaxed

5. Pulmonary circulation – by right side of heart

A) De-oxygenated blood moves from the right atrium to right ventricle thru tricuspid

valve

B) Right ventricle into pulmonary trunk thru the pulmonary valve

C) To lungs for gas exchange

1) Occurs in the alveoli – O2 in and CO2 out

D) Oxygenated blood moves back to left atrium via pulmonary veins

6. Systemic circulation – by left side of heart

A) Oxygenated blood moves from the left atrium to left ventricle thru bicuspid/mitral

valve

B) Left ventricle into aorta thru aortic valve

C) To body for gas exchange

1) Occurs in the capillaries within the tissues – O2 out and CO2 in

D) De-oxygenated blood moves back to right atrium via inferior & superior vena cava

7. Coronary circulation – branch of systemic loop

A) Aorta receives blood from L ventricle

B) R & L coronary arteries receive blood from the aorta

1) Right coronary artery

a) Supplies right atrium

b) 2 main branches

i) Marginal artery

(a) Supplies anterior & lateral portions of the right ventricle

ii) Posterior interventricular artery

(a) Supplies posterior side of both ventricles

2) Left coronary artery

a) 2 main branches

i) Anterior interventricular artery

(a) Supplies anterior side of both ventricles

ii) Circumflex artery

(a) Supplies left atrium and all portions of the left ventricle

C) Myocardial capillaries – site of gas exchange

D) Cardiac veins

1) Great cardiac vein

a) Drains the anterior aspect of the heart

2) Posterior, middle, and small cardiac veins

a) Drain the posterior & lateral aspects of the heart

E) Coronary sinus

1) Empties into right atrium

8. Cardiac Muscle Contraction

A) Involves autorhythmic cells and cardiac muscle cells

1) Autorhythmic cells

a) Make up the conduction system

b) Responsible for AP generation & conduction

i) Cells have an unstable resting potential

ii) Hyperpolarization at the end of an AP causes a closing of K+ channels and an

opening of slow Na+ channels = causes movement towards threshold

iii) At threshold, voltage-gated Ca++ channels open = depolarization

iv) At peak voltage, voltage-gated Ca++ channels close and votalge-gated K+

channels open = repolarization

d) Conduction Pathway

i) SA (sinoatrial) node

(a) Considered the heart’s normal pacemaker

(b) Under control of nervous and endocrine systems

(i) Without control it would generate 90-100 AP’s/min = 90-100 b.p.m.

(ii) With control, it will generate about 75 AP’s/min = 75 b.p.m.

(c) Impulse travel to AV node via internodal pathway

(d) Impulses also travels to atrial myocardium via gap junctions (intercalated

discs)

(i) Causes atrial contraction

ii) AV (atrioventricular) node

(a) AV nodal delay

(i) 0.1 sec

(ii) Allows for complete atrial contraction (ventricular filling)

(b) Under nervous & endocrine control as well

iii) Bundle of His (AV bundle)

(a) Electrically connects atria & ventricles

iv) Left & right bundle branches

(a) Carry impulses to the left and right ventricles

v) Purkinje fibers

(a) Start near the apex & moves up thru ventricles

(b) Site of synapse between conduction system & ventricular myocardium

2) Cardiac muscle cells

a) Striated, branching & mononucleated

b) Intercalated discs – cellular junctions that allow ion movement between cells

i) Allow the heart to act as a single, coordinated, functional unit

ii) Longer refractory period than skeletal muscle tissue; cannot undergo tetanus

c) AP generation

i) Depolarization caused by an opening of voltage-gated Na+ channels

ii) Repolarization caused by an opening of voltage-gated K+ channels

iii) Plateau caused by an opening of voltage-gated Ca++ channels, leakage of K+

3) Process of Contraction

a) AP generated in SA node travels to atrial myocardium and AV node

i) causes atrial contraction

b) AP travels from AV node to bundle of His then along bundle branches to the

Purkinje fibers

i) Purkinje fibers synapse with the ventricular myocardium

c) AP travels down the sarcolemma and causes voltage-gated Ca++ channels in

sarcolemma to open

d) Ca++ moves into the cell from the ECF and binds to receptors on the SR

e) This causes an opening of Ca++ release channels in the SR, causing larger

amounts of Ca++ to be released from the SR = calcium-induced calcium release

f) Ca++ binds to troponin initiating contraction (sliding filament mechanism)

9. Cardiac Cycle

A) Series of events occurring during one heartbeat; 4 events occur

1) Atrial & ventricular systole

2) Atrial & ventricular diastole

B) 3 phases

1) Ventricular relaxation

a) Occurs just after blood is ejected from the ventricles

b) Semilunar valves are open & AV valves are closed

c) Characterized by:

i) Ventricular diastole

(a) Causes decreased ventricular P

ii) Closing of semilunar valves

(a) Causes second heart sound, a.k.a. S2 or “dub”

iii) Opening of AV valves

2) Ventricular filling

a) Begins when AV valves open

b) Characterized by:

i) Rapid ventricular filling (80%)

ii) Atrial systole (20%)

c) End diastolic volume (EDV)

i) Volume of blood in the ventricle just prior to contraction

3) Ventricular ejection

a) Characterized by:

i) Ventricular systole

(a) Causes increased ventricular P

ii) Closing of AV valves

(a) Causes first heart sound, a.k.a. S1 or “lub”

iii) Opening of semilunar valves

iv) Ventricular ejection

(a) Stroke volume (~70ml)

v) Atrial filling also occurs during this phase

10. Cardiac Output – total amount of blood pumped by each ventricle per minute

A) CO = SV x HR (5.25L/min)

B) Regulation of Cardiac Output – 2 mechanisms

1) Regulation of Stroke Volume – 3 factors

a) Preload – stretch on the cardiac muscle just before contraction

i) Associated with EDV – end diastolic volume

ii) Frank-Starling Law of the Heart

b) Contractility – strength of contraction

i) Positive inotropic agents

(a) Promote Ca++ movement into cells

ii) Negative inotropic agents

(a) Inhibit Ca++ movement into cells

c) Afterload – pressure the ventricles must overcome to eject blood

2) Regulation of HR

a) ANS Control

i) Cardiovascular center

(a) Composed of 3 centers

(i) Cardioacceleratory center

(ii) Cardioinhibitory center

(iii) Vasomotor center

(b) Receives input from:

(i) Chemoreceptors in aortic arch & bifurcation of common carotid

artery

(ii) Baroreceptors in aortic arch and carotid sinus

(iii) Proprioceptors in skeletal muscles & joints

(c) Sends output signals via:

(i) Sympathetic NS (responds to hypoxia, hypercapnia, acidosis, or low

BP)

(a) Stimulates cardiac accelerator nerves (NE)

(i) Innervate the SA & AV nodes

(ii) Also innervate the ventricular myocardium

(ii) Parasympathetic NS (responds to alkalosis or high BP)

(a) Stimulates the Vagus nerves (ACh)

(i) Innervate the SA & AV nodes but not the myocardium

b) Hormonal Control (low BP)

i) Epinephrine & norepinephrine

c) Other Factors

i) Hypernatremia – blocks Ca++ movement into SA node

ii) Hyperkalemia – inhibits AP generation

iii) Hypercalcemia – increases conc. gradient

iv) Hypocalcemia – decreases conc. gradient

11. Electrocardiogram (ECG or EKG)

A) P-wave

1) Atrial depolarization

B) QRS-complex

1) Ventricular depolarization

2) Atrial repolarization is occurring but is masked

C) T-wave

1) Ventricular repolarization

12. Heart Disorders

A) Valve disorders

1) Heart murmur – abnormal heart sounds

a) Stenosis – valve flaps become stiff and narrowed thereby restricting normal

blood flow

b) Incompetent valve – valves fail to close properly resulting in a backflow of

blood

c) Mitral valve prolapse (MVP) – chordae tendineae are abnormal and/or the

papillary muscle malfunction resulting in the flaps becoming inverted

B) Arrhythmias – abnormal heart rate

1) Tachycardia – more than 100 beats per minute

a) May be caused by elevated temp, certain drugs, stress, or heart disease

2) Bradycardia – less than 60 beats per minute

a) May be caused by low temp, certain drugs, or parasympathetic activation

3) Fibrillation – uncoordinated or quivering heartbeat

a) Caused by damage/defect of conduction system

4) Heart block – inability of impulse to reach ventricles

a) Blockage in the AV node, bundle of His or one of the bundle branches

C) Others

1) Myocardial Infarction (MI) – “heart attack”

a) Infarction – tissue death due to loss of blood supply

b) Often presents with an elevated S-T segment on an EKG

2) Ischemia – decreased blood flow; results in hypoxia

3) Angina pectoralis – chest pain related to coronary problems

4) Endocarditis – inflammation of the endocardium usually of the heart valves

a) Often results from a bacterial infection