Chapter 20: Cardiovascular System: THE HEART

I. GENERAL

A. The circulation (Fig. 20.1)

1. Systemic: To all body except _____________ ______ _______

2. Pulmonary: To _______________ ______ ______

B. Definitions

1. Pulmonary vessels: Vessels of the lungs

2. Systemic vessels: All other vessels

3. Artery: Vessel that carries blood _______________ the heart

4. Vein: Vessel that carries blood _______________ the heart

5. Capillary: Microscopic exchange vessels throughout the tissues which connect tiniest arteries to tiniest veins

C. Function of the heart

D. Blood flow through the heart (Fig. 20.10)

1. Deoxygenated (“blue”) blood flows from: Superior and inferior vena cava and coronary sinus to right atrium, through tricuspid valve to right ventricle, through pulmonary semilunar valve to pulmonary artery to alveoli

2. Oxygenated (red) blood flows from: Lungs to four pulmonary veins to left atrium, through bicuspid (mitral) valve to left ventricle, through aortic semilunar valve to aorta, to all body except _______________ ______ _______
II. CARDIAC MUSCLE

A. Structure (Fig. 20.12)

1. Striated, single nucleus, branched cells
2. Cell-cell contacts via ____________________________

B. Functions

1. Involuntary, twitch contraction, self-stimulatory
2. Cell-cell conduction of depolarization via ____________________________
3. Action potential (Fig. 20.14, p. 693 [694])

|________________ |____________________/   /___________
Skeletal muscle 2 msec   Cardiac muscle 500 msec

   a. Long action potential causes long ____________________________.
      period, which prevents heart from ____________________________.

   b. Heart can only undergo _____________________ contractions.

4. Heart requires oxygen and prefers _______________ _________ as fuel

C. Skeleton of the heart (Fig. 20.11)

1. Supports openings of heart
2. Attaches cardiac muscle
3. Insulates atria from ventricles. Significance: Action potential cannot
easily move from _____________________ to _____________________.
III. AUTORHYTHMICITY (SELF-EXCITATION) OF THE HEART

A. Depolarization (action potential) __________________________ contraction

B. Conducting system of the heart (Fig. 20.13)
   1. Sinoatrial node (S-A node)
   2. Atrial muscle cells
   3. Atrioventricular node (A-V node)
   4. Atrioventricular bundle
   5. Left and right bundle branches
   6. Purkinje fibers
   7. Ventricular muscle cells

C. The pacemaker (Fig. 20.15)

IV. THE EKG (Fig. 20.16)

A. Electrical Events of Heart Cycle
   1. Atrial depolarization (signals atrial ________________________)
   2. Atrial repolarization (signals atrial ________________________)
   3. Ventricular depolarization (signals ventricular _________________)
   4. Ventricular repolarization (signals ventricular _________________)

B. Effect: Small, detectable currents flow over body. Why?
   1.
   2.
C. Recording the EKG:

1. Electrical leads on surface of the body pick up electrical activity from the heart

D. Typical EKG (Fig. 20.16)

1. P wave: Record of ________________________ _____________________

2. QRS complex: Record of ________________________ _____________________

3. T wave: Record of ________________________ _____________________

E. Arrhythmias detectable by EKG (Table 20.1, p. 696; Fig. 20.17, p. 697 [698])

1. Bradycardia

2. Tachycardia

3. A-V node block (dropped ventricular beats)

4. Premature ventricular contraction
   
   *Ectopic focus*

5. Ventricular fibrillation
V. THE CARDIAC CYCLE (Fig. 20.18)

A. Def: Events throughout one "beat" of the heart

B. Time

0.1 sec 1) Atrial systole, ventricle diastole
0.3 sec 2) Ventricle systole
0.4 sec 3) Atrial diastole, ventricle diastole

0.8 sec

Rest times? A =

V =

C. Diastole: Cardiac cells _______________; volume ___________, pressure ________, chamber _________________.

D. Systole Cardiac cells _______________; volume ___________, pressure ________, chamber _________________.

E. Passive response of valves to pressure (Fig 20.9):

1. If $P_A > P_v$, _______________ valves ________________.

2. If $P_v > P_{GA}$ _______________ valves ________________.

3. If $P_v > P_A$ _______________ valves ________________.

4. If $P_{GA} > P_v$, _______________ valves ________________.
F. Sequence of cardiac cycle (Fig. 20.18)

1. Atrial systole (Ventricles are in _______________________) (Item #5)
   a. A-V valves already open.
   b. Flow _____________ —> _______________. Why?
   c. _____________ of ventricular filling occurs now.

2. Ventricular systole (Atria are in __________________.) (Items #1 and 2)
   a. A-V valves _______________ —> Heart sound #1, "lubb"
   b. Why?
   c. S-L valves ________________
   d. Why?
   e. Flow _____________ —> _______________. Why?

3. Ventricular diastole (Atria are in ____________________.) (Items #3 & 4)
   a. S-L valves _______________ —> Heart sound #2, "dupp"
   b. Why?
   c. A-V valves ______________
   d. Why?
   e. _____________ ventricular filling now

G. Summary of heart sounds

1. Sound #1, lubb: ________________/Sound #2, dupp ________________

2. Heart sounds occur at beginning and end of

   _______________ _________________  Heart murmurs
VI. CARDIAC OUTPUT

A. Def: Flow out of one ventricle of the heart per minute
   1. Flow = volume of fluid moving/time
   2. C.O. = 5 liters/minute (rest)
   3. C.O. = stroke volume x heart rate
   3. C.O. = S.V. x H.R.

B. Def.: Stroke volume = S.V. = Amount of blood leaving one ventricle per beat
   1. S.V. = end diastolic volume (E.D.V.) - fullest - end systolic volume (E.S.V.) - emptiest
      135 ml - 65 ml = 70 ml = S.V.
   2. If S.V. increases, C.O. ________.

C. Cardiac reserve: Maximal increase in C.O. during exertion

VII. REGULATION OF THE HEART

A. Intrinsic regulation: Factors affecting C.O.
   1. Venous return equals cardiac output (V.R = C.O.)
   2. Starling’s law of the heart: increased filling —> increased “preload” —> more forceful systole —> ________ S.V. —> ________ C.O.
   3. Increased venous return —> ________ C.O.
   4. Significance:
   5. Explanation (Fig. 9.21): 
B. Extrinsic regulation: Factors affecting C.O.

1. General principles
   a. C.O. = S.V. x H.R.
   b. If H.R. increases, C.O. ____________.
   c. Response of weak heart, (with ___________ S.V.), even at rest?
   d. Response of athletic heart (with ___________ S.V.), even at rest?

2. Parasympathetic control (Fig. 20.22)
   a. Cardioregulatory center of medulla

      Vagus nerves

      ACh—>_________________________ receptors of S-A node ——>

      _____ H.R.—> _____ C.O.

   b. ACh causes ___________________ polarization of S-A node

3. Sympathetic control (Fig. 20.22)
   a. Cardioregulatory center of medulla

      Sympathetic nerves

      Norepinephrine —> ________________________ receptors of S-A

      node, A-V node, and cardiac muscle

   b. NE _____ rate of depolarization of pacemaker cells—>_____ H.R.

   c. NE increases permeability of SA node and cardiac muscle cells to

      Ca**, which _______ H.R. and _____________________ heart,

      ________ S.V., and _________ C.O.
4. **Hormonal control (Fig. 20.22)**
   a. Epinephrine (E) and norepinephrine (NE)
   b. Source: __________________ _________________
   c. Stimulus for release:
   d. Effect: _______ H.R. _______ S.V. _______ C.O

C. **Baroreceptor reflex (Fig. 20.23)**
1. Increased C.O. —> _______ blood pressure (B.P.) Therefore, response to blood pressure which is too low is to _______ C.O.
2. **Aortic and carotid sinus baroreceptors (Fig. 20.22)**
   a. Location:
   b. Significance:
   c. Function:

Decreased B.P. _______ B.P.

_______ C.O.

Less stretch of baroreceptors

Medulla cardioregulatory center _______ H.R., _______ S.V.

_______ Vagal activity

_______ Sympathetic nerves
d. If blood pressure is too high?
D. Chemoreceptor reflex (Fig. 20.24)

1. Review relationship of ventilation rate to blood flow to lungs
   a. Increased CO$_2$ causes _______ in pH (___________ acid)
   b. How does pH drop affect ventilation rate? ______________
   c. Does blood flow to lungs match ventilation rate? Yes/No

2. Therefore, if CO$_2$ increases, H.R. and S.V. should _____ to _____ C.O.

   Increased CO$_2$,

   _______ formation of carbonic acid

   _______ pH

   _______ blood flow to lungs

   ____________ of chemoreceptors in medulla _______ C.O.

   ______________

   ______ parasympathetic activity _______ H.R.,_______ S.V.

   ______ sympathetic activity

3. Decreased O$_2$ _______ H.R.

E. Other influences on heart

1. Excess potassium ion (K$^+$)

2. Calcium ion (Ca$^{++}$) (calcium channel blockers)

3. Body temperature