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A & P II Test 2

I. Blood Vessel Histology (see handout)
- A. the artery
  - 1. 3 layers:
    - a. tunica intima/tunica interna- innermost layer
      - 1. 3 layers:
        - A. endothelial layer
          - 1. one layer of simple squamos cells
            - a. connected to basement membrane which is made of collagen
          - 2. faces the lumen
        - B. fine areolar connective tissue
          - 1. contains collagen fibers
        - C. elastic connective tissue
          - 1. contains elastic and collagen fibers
    - b. tunica media- middle layer
      - 1. thickest layer
      - 2. consists of multi-unit smooth muscle
        - A. postganglionic sympathetic neurons directly innervate the muscle
      - 3. contains elastic fibers
      - 4. has capillaries of vaso vasorum in order to get oxygen
      - 5. 4 hormones can cause contraction of smooth muscle:
        - A. norepinephrine
          - 1. due to direct sympathetic nervous stimulation- released by the postganglionic neuron
          - 2. norepi can also come from the adrenal medulla
        - B. ADH (antidiuretic hormone)/vasopressin
          - 1. produced by the hypothalamus
          - 2. causes vasoconstriction
        - C. angiotensin
          - 1. its inactive form, angiotensinogen, is produced by the liver
          - 2. activation of angiotensinogen to angiotensin occurs in the plasma
          - 3. it's a powerful vasoconstrictor
        - D. seratonin
          - 1. produced by platelets
          - 2. causes vasoconstriction
    - c. tunica externa/tunica adventitia- outermost layer
      - 1. adventitia means connective tissue of layer blends into surrounding connective tissue
        - A. this locks the structure into position
        - B. outside connective tissue=adipose and fine areolar
      - 2. contains collagen and elastic fibers
      - 3. has some smooth muscle
      - 4. has its own arterial supply, capillaries of vaso vasorum, and venous drainage
        - A. this is b/c this layer can't receive oxygen from lumen b/c artery is too thick
        - B. therefore, this layer has its own blood supply
        - C. vaso vasorum=vessels of vessels- they're the capillaries of this layer
          - 1. looks like hole in artery, could have RBC's inside
      - 5. has lymph vessel drainage

B. the arteriole
1. referring to terminal arteriole- near capillary bed
2. same layers as artery, except no elastic layer
3. has no vaso vasorum b/c thinner than artery and can obtain oxygen directly from lumen
4. surface area increases as arteries branch into arterioles

C. the capillary
1. 3 types:
a. continuous
1. found in skeletal muscle tissue
2. consists of one endothelial cell
A. the cell of the cap loops around and encloses itself, forming a tight junction
B. the cell is squamos
1. oxygen and carbon dioxide readily diffuse
2. glucose and other polar substances need to be transported from the lumen to the interstitial fluid to release nutrients to other tissues
a. need a pump or carrier molecule
b. fenestrated
1. capillary is made up of 2 endothelial cells
2. there's a space between them with little windows called fenestrations
A. this allows for more exchange between the lumen and interstitium
3. found in endocrine glands, such as the pancreas and the thyroid
A. in pancreas, there are red/purple speckles called Isles of Langerhan
1. Isles=cluster of cells
2. pancreas makes pancreatic juices, insulin, and glucagon
3. fenestrated capillaries are near the Islands
4. fenestrations are big enough to dump out hormones
5. when focus on pancreas on high power, can see cells of the Island w/ red speckles=cap
B. in thyroid, see many circles called follicles filled w/ a goo called thyroglobin
1. thyroglobin=glycoprotein that temporarily stores hormones (when blood levels too high or low)
2. each follicle is a ring of nucleated cuboidal cells
3. can see capillaries near the follicle=fenestrated capillaries of the thyroid
c. discontinuous
1. consists of a few endothelial cells w/ some fenestrations in b/t them and some fixed macrophages calles Kupffer cells
A. fixed macrophages are found in liver, spleen, alveoli of lungs, and lymph nodes
2. found in the liver and spleen
A. in most organs, RBC's do not come in contact w/ surrounding tissue; they're held in cap
B. but in liver and spleen, RBC's are dumped into spaces called sinusoids which are next to the cells of the organs, so RBC's are in direct contact w/ organ cells
1. in liver, nucleated cells are hepatocytes, spaces in b/t cells are sinosoids , and RBC's are in sinusoids

D. the venule
1. has only 2 layers:
a. tunica adventitia- has smooth muscle
b. endothelium

E. the vein
1. has the same layers as the artery, except there is no fine areolar layer
2. consists of tunic adventitia, tunica media, and tunica intima composed of elastic and endothelial layers
a. the tunica media has direct sympathetic nervous stimulation
b. tunica media and tunica adventitia do not have vaso vasorum
3. differences b/t the artery and the vein:
a. artery is thicker than vein and has thicker tunica media
1. therefore, artery has vaso vasorum and vein does not b/c receives oxygen from lumen
b. artery is round and vein is squished flat b/c easily distendable b/c thinner walled
c. artery has fine areolar layer and vein does not

F. pathology of blood vessels
1. atherosclerosis
a. artery has fat/lipid deposits and calcium deposits in the tunica media
1. lipid deposits look like spaces and calcium deposits look like purple speckles
b. this makes the vessel unable to bend=brittle, so call it hardening of arteries
2. thrombosis
a. artery has blood clot=thrombus
3. aneurysm
a. tunica media is weakened which means arterial wall is weakened
1. weakening caused by:
A. high blood pressure which stretched wall
B. congenital defects in walls
b. this causes balloon to come out of the wall which can cause vessel to pop
1. this can cause instant death if it's a strategic vessel like the basilar artery at the base of the foramen magnum or the aorta
2. when aneurysm bursts, person can bleed out internally
c. an aneurysm is dangerous b/c it can go undetected b/c no symptoms
d. can do surgery if caught in time by chance
e. on slide, can tell aneurysm if tunica media is not homogeneous b/c there are gaps
4. varicose vein
a. vein has buildup of connective tissue, filling up lumen, leaving only a small crescent opening

II. The General Plan of Circulation

A. in general, blood moves from heart to arteries to arteriole to capillaries to venules to veins to the heart
1. circulatory system is closed which means RBC's stay inside vessels
a. WBC can move outside vessels- diapedesis
2. arteries bifurcate as they move away from the heart, becoming progressively smaller
a. they carry blood away from the heart
3. capillaries coalesce into veins, becoming progressively bigger
a. veins carry blood to the heart

B. more specifically (see handout)
1. oxygenated blood moves from the aorta of the heart to the arteries
a. the bulge represents all the blood in the arteries at any given moment
b. the dotted line means the size of the arterial system can vary- can get bigger or smaller
2. blood then goes to systemic capillaries
a. oxygen diffuses out to the mitochondria and carbon dioxide diffuses in
1. mitochondria have the least oxygen and most carbon dioxide in body
3. deoxygenated blood goes to the veins
a. veins have larger bulge than arteries b/c thinner walled, so easily distendable
b. the dotted line means the size of veins can be adjusted on demand

4. deoxygenated blood then enters right atrium and goes to the right ventricle
5. then deoxygenated blood goes to the pulmonary artery
    a. all arteries carry oxygenated blood, except pulmonary arteries
    b. all veins carry deoxygenated blood, except pulmonary veins
6. blood goes to pulmonary capillaries
    a. oxygen diffuses from lungs into capillaries
    b. carbon dioxide diffuses from capillaries into lungs
7. oxygenated blood then goes to pulmonary veins back to right atrium
8. blood goes to right ventricle and up the aorta and cycle starts again

C. lymph vessel drainage
1. it's an alternate circulatory system that goes from the systemic capillaries to the vena cava
2. at systemic capillaries, many things diffuse from and to the capillaries
    a. at arteriole end, oxygen, water, hormones, ions, vitamins, and nutrients diffuse out of cap
    b. at venous end, carbon dioxide, water, and NPN's diffuse into cap- but not e/t is returned
3. lymphatic system returns the excess substances back to the heart
    a. the lymph system has straight parts and nodes
    b. the nodes contain WBC (lymphocytes and macrophages) and capillaries
        1. WBC's purify the lymph from bac b/f it's returned back to circulation
            A. but WBC's will let cancer cells go by b/c don't recognize them as foreign, making lymphatic system the cancer superhighway
        2. capillaries are an additional mix point to exchange b/t plasma and interstitial fluid
            A. monocytes and neutrophils can come in to fight infection, but bac can't leave
            B. fluids of body are practically the same e/w b/c of mix pts

III. Where's the Pressure? (see handout)

A. blood pressure goes downhill as blood leaves the aorta and travels through the arteries and cap to the veins
1. blood pressure starts off high 120/80 as blood leaves the heart through the aorta
2. by the time blood reaches cap, there's practically no blood pressure
3. the blood pressure is considered zero by the large veins and vena cava (b/c furthest from heart)

B. blood pressure has 2 numbers
1. higher number=systole
    1. occurs when left ventricle contracts
2. lower number=diastole
    1. occurs when left ventricle relaxes

IV. Where's the Blood? (see handout)

A. surface area of blood vessels
1. as vessels move away from the heart (aorta—>arteries—>arterioles—>capillaries)...
    a. number of vessels increases (as aorta bifurcates into arteries)
    b. surface area increases
        1. surface area of cap is great for maximum exchange between plasma and interstitial fluid
    c. diameter of vessels decreases
        1. muscle and adventitia thickest by aorta, but thins until gone by cap
2. as vessels move from cap toward the hear (cap—>venules—>veins—>vena cava)
    a. number of vessels decreases (as cap coalesce into veins)
    b. surface area decreases
    c. diameter of vessels increases

V. Stroke Volume vs. Cardiac Output
- A. stroke volume- volume of blood ejected from left ventricle/beat
  1. normal stroke volume is about 70-75 mL/beat
  2. it depends on condition of heart, size of person, size of heart...
- B. cardiac output- volume of blood ejected by left ventricle/min
  1. calulate it by multiplying stroke volume (mL/beat) by heart rate (beats/min)
     - a. ex: if at rest, SV=70mL/beat and HR=70 beats/min, CO=4900 mL/min
     - b. CO can change b/c HR can go up due to exercise and SV can go up
     - c. if HR goes up to 100 and SV goes up to 90, CO goes up to 9000 mL/min
     - d. difference b/t volume that can be pumped out and volume that is pumped out=cardiac reserve
       1. cardiac reserve=amt that can be pumped above the resting volume
  2. venous return=volume of blood entering right atrium/min
     - a. CO=venous return, so if CO goes up, venous return goes up (unless s/t's wrong, ex: severed leg)

VI. The Heart and Great Vessels (see handout)
- A. diagram key
  1. SVC
  2. IVC
  3. right atrium
  4. right atrioventricular valve/tricuspid
  5. chordae tendinae (heartstrings)
  6. right ventricle
  7. right semilunar valve/pulmonary semilunar/pulmonic semilunar
  8. pulmonary trunk
  9. right pulmonary artery
  10. left pulmonary artery
  11. papillary muscle
  12. left pulmonary veins
  13. right pulmonary veins
  14. left atrium
  15. left atrioventricular valve/bicupid/mitral
  16. left ventricle
  17. coronary sinus
  18. interventricular septum
  19. interatrial septum
  20. left semilunar valve/ aortic semilunar
  21. ascending aorta
  22. arch of aorta
  23. descending aorta
  24. myocardium
  25. epicardium/visceral pericaridum
  26. endocardium
  27. brachiocephalic artery (27a- right subclavian artery)
  28. right common carotid artery
  29. left common carotid artery
  30. left subclavian

B. extra info on diagram
1. valves
a. they're flaps/leaflets
1. the AV valves are held in place by chordae tendinae
2. the chordae tendinae are attached to the wall by papillary muscles
b. they point in the direction of blood flow (ex: into ventricle)
c. when a ventricle contracts, the AV valve gets pushed closed, and blood is pushed through the semilunar valve
1. valves prevent backflow and ensure a unidirectional flow of blood
2. the chordae tendinae prevent the valves from swinging open in the opposite direction
d. when a ventricle relaxes, the semilunar valve is pushed close to prevent backflow of blood
2. major arteries
a. brachiocephalic artery comes off the arch of the aorta only on the right side of the heart
1. it goes to the right arm and right side of the head
a. the common carotid artery branches off it and goes to the right side of the head
b. the brachiocephalic eventually becomes the right subclavian artery as it moves toward the right arm
3. layers of the heart
a. epicardium/visceral pericardium is a serous membrane
b. myocardium is a muscle layer
c. endocardium covers the the valves, chords, and chamber surfaces
4. coronary sinus
a. found on the right side of the heart
b. it's a vein that drains the myocardium into the right atrium

VII. Coronary Vessels (see handout)
A. the coronary arteries are the first branches of the ascending aorta
1. they're found on the surface of the heart (superficial), plunging into the myocardium
2. they provide blood for the myocardium of the heart during diastole
a. when ventricles contract (systole), blood can't enter the myocardium b/c the cells of the myocardium are squished flat
1. during systole, blood moves through brachiocephalic and other arteries
b. but when ventricles relax (diastole), blood can't go back through the left semilunar valve, so it enters the coronary arteries
1. this way heart gets oxygenated blood first
2. this is impt b/c heart is responsible for pumping blood e/w
c. myocardium can't receive oxygen directly from lumen b/c it's too thick
d. branches of left coronary artery:
1. anterior: anterior interventricular artery
2. posterior: circumflex artery
e. posterior branches of right coronary artery:
1. dorsal interventricular artery
2. marginal artery

B. veins in the myocardium
1. some drain directly into right atrium
a. ex: the coronary sinus drains the myocardium (found on the right side of the heart)
2. thesbian veins drain into right ventricle or left ventricle
a. when deoxygenated blood is drained into left ventricle, it's called shunting b/c deoxygenated blood is added to oxygenated blood (of left side of heart)
1. this is insignificant b/c 75 mL of oxygenated blood already there and only adding 1 mL of deoxygenated blood, so partial pressure of arterial oxygen goes down very little
2. this is a normal shunt

VIII. Views of the Heart (see handout)

A. external view- diagram key

1. (structure) right oracle
2. (tissue) adipose tissue
3. (layer) epicardium
4. (structure) coronary sulcus
5. (region) apex
6. (region) base
7. (structure) left oracle
8. (vessel) pulmonary trunk

B. internal view #1- diagram key

1. (chamber) right atrium
2. (structure) septum
3. (chamber) right ventricle
4. (layer) epicardium
5. (layer) myocardium
6. (layer) endocardium
7. (chamber) left ventricle
8. (chamber) left atrium

C. internal view #2- diagram key

1. (valve) right semilunar valve
2. (valve) right atrioventricular valve
3. (structures) chordae tendinae
4. (valve) left AV valve/bicuspid/mitral
5. (valve) left semilunar valve
6. (vessel) ascending aorta

D. extra info

1. oracles (mean dog's ears)
    a. they're flaps on the surface of the heart=extensions off the atrium
    b. when venous return is high, the right atrium can receive more blood b/c of the oracle
2. the pulmonary trunk is the most anterior vessel
3. ventricular walls
    a. the left ventricular wall is thick and muscular b/c it's responsible for pumping blood everywhere
    b. the right ventricular wall has a thin myocardium b/c only pumps blood to the lungs which are right next to the heart
4. valves
    a. the right semilunar valve is at the base of the pulmonary trunk- can only see it when cut trunk
    b. valves denote atria from ventricles
        a. atria- superior to valves, ventricles- inferior to valves
    c. the septum denotes right from left

IX. Arterial Distribution

A. diagram key

1. ascending aorta
2. arch of aorta
3. l. subclavian
4. l. vertebral
5. l. common carotid
6. l. external carotid
7. l. internal carotid
8. r. common carotid
9. r. vertebral
10. r. internal carotid
11. r. external carotid
12. brachiocephalic
13. intercostal arteries
14. descending aorta
15. coronary arteries
16. r. axillary
17. r. subclavian
18. r. brachial
19. r. radial
20. r. ulnar
21. celiac trunk
22. gastric
23. splenic
24. common hepatic
25. superior mesenteric
26. renal arteries
27. inferior mesenteric
28. r. common iliac
29. l. common iliac
30. r. external iliac
31. r. internal iliac
32. l. internal iliac
33. r. femoral
34. r. uterine
35. l. uterine
36. r. pulmonary VEINS
37. l. pulmonary VEINS
38. SVC

B. extra info
1. normal vs anomaly
a. the larger the structure, the more consistent it is b/t ppl
b. smaller structures vary more- connect differently
c. normal- pattern seen by 95% of population
d. anomaly- a/t dif from normal pattern (but does not damage the person)
1. ex- some cats have 2 IVC's
2. some cats have left and right common carotid arteries separate instead of together
2. where arteries deliver blood
a. intercostal arteries- chest wall (b/t ribs)
b. coronary arteries- heart
c. celiac trunk- has 3 branches:
1. gastric artery- stomach
2. splenic artery- spleen
3. common hepatic artery- liver
d. superior mesenteric artery- small intestine
e. renal arteries- kidneys
f. inferior mesenteric artery- large intestine
g. common iliac arteries- toward legs
h. internal iliac arteries- lower abdominal wall and uterus (structures of lower pelvis)
g. uterine arteries- uterus
h. external iliac and femoral arteries- toward legs
i. internal carotid arteries- brain (through carotid canal)
j. external carotid- muscles and skin of face (outside cranial cavity)
k. vertebral arteries- enter head through foramen magnum
l. axillary arteries- armpit

X. Venous Distribution
A. diagram key
1. r. internal jugular
2. r. external jugular
3. r. subclavian
4. r. axillary
5. r. cephalic
6. r. basilic
7. SCV
8. accessory hemiazygos
9. intercostal veins
10. accessory hemiazygos
11. hemiazygos
12. azygos
13. hepatic
14. IVC
15. r. renal
16. l. suprarenal
17. l. ascending lumbar
18. r. ascending lumbar
19. r. common iliac
20. r. femoral
21. r. internal iliac
22. brachiocephalic veins

B. extra info
1. accessory hemiazygos veins and hemiazygos veins are at left posterior wall
2. azygos vein is on right side of body
3. ascending lumbars are posted on posterior walls

XI. Blood Flow Problems
A. right lung to left hand
1. right pulmonary vein
2. left atrium
3. bicuspid valve
4. left ventricle
5. left semilunar valve
6. ascending aorta

7. arch of aorta
8. left subclavian artery
9. left axillary artery
10. left brachial artery
11. left radial artery
12. left superficial palmar arch

B. right cerebrum to spleen

1. right great cerebral vein
2. right superior sagittal sinus
3. right transverse sinus
4. right sigmoid sinus
5. right internal jugular vein
6. right brachiocephalic vein
7. SVC
8. H-L-H
    a. right atrium
    b. tricuspid valve
    c. right ventricle
    d. right semilunar valve
    e. pulmonary trunk
    f. right pulmonary artery
    g. right lung
    h. right pulmonary vein
    i. left atrium
    j. bicuspid valve
    k. left ventricle
    l. left semilunar valve
9. ascending aorta
10. arch of aorta
11. descending aorta
12. celiac trunk
13. splenic artery

C. left hand to small intestine

1. left palmar venous arch
2. left basilic vein
3. left axillary vein
4. left subclavian vein
5. left brachiocephalic vein
6. SVC
7. H-L-H
8. ascending aorta
9. arch of aorta
10. descending aorta
11. superior mesenteric artery

D. right foot to stomach
1. right dorsal venous arch
2. right anterior tibial vein
3. right popliteal vein
4. right femoral vein
5. right external iliac vein
6. right common iliac vein
7. IVC
8. H-L-H
9. ascending aorta
10. arch of aorta
11. descending aorta
12. celiac trunk
13. left gastric artery

E. right kidney to left cerebrum
1. right renal vein
2. IVC
3. H-L-H
4. ascending aorta
5. arch of aorta
6. left common carotid artery
7. let internal carotid artery
8. left anterior cerebral artery

F. left foot to left 4th intercostal space
1. left dorsal venous arch
2. left anterior tibial vein
3. left popliteal vein
4. left femoral vein
5. left external iliac vein
6. left common iliac vein
7. IVC
8. H-L-H
9. ascending aorta
10. arch of aorta
11. descending aorta
12. left 4th intercostal artery

G. right ventricle to left teste
1. right semilunar valve
2. pulmonary trunk
3. right pulmonary artery
4. right lung
5. right pulmonary vein
6. left atrium
7. bicuspid valve
8. left ventricle
9. left semilunar valve
10. ascending aorta
11. arch of aorta
12. descending aorta
13. left testicular artery

H. left lung to right hand
1. left pulmonary vein
2. left atrium
3. bicuspid valve
4. left ventricle
5. left semilunar valve
6. ascending aorta
7. arch of aorta
8. brachiocephalic artery
9. right subclavian artery
10. right axillary artery
11. right brachial artery
12. right radial artery
13. right superficial palmar arch

I. right hand to left kidney
1. right palmar venous arch
2. right basilic vein
3. right axillary vein
4. right subclavian vein
5. right brachiocephalic vein
6. SVC
7. H-L-H
8. ascending aorta
9. arch of aorta
10. descending aorta
11. left renal artery

J. left atrium to right atrium via placenta
1. left atrium
2. bicuspid valve
3. left ventricle
4. left semilunar valve
5. ascending aorta
6. arch of aorta
7. descending aorta
8. right common iliac artery
9. right internal iliac artery
10. right uterine artery
11. uterus
12. right arcuate artery
13. right radial artery
14. right spiral arterioles
15. right endometriole arterioles
16. maternal capillaries
17. right endometriole venules
18. right uterine vein
19. right internal iliac vein
20. right common iliac vein
21. IVC
22. right atrium

XII. Portal Circulation
- A. circulation to the liver
  - 1. the common hepatic artery carries oxygen to the liver capillaries
  - 2. oxygen diffuses out of the capillaries, carbon dioxide diffuses in
    - a. RBC's are dumped into sinusoids where the RBC's are in direct contact w/ hepatocytes
  - 3. the hepatic vein carries deoxygenated blood from the liver to the IVC to the heart
- B. circulation to the small intestine
  - 1. the superior mesenteric artery carries oxygenated blood to the capillaries in the jejunum of the SI
  - 2. oxygen diffuses out of the capillaries, carbon dioxide diffuses in
    - a. in addition, e/t absorbed by the small intestine diffuses into the cap
      - 1. ex: glucose, nutrients, vitamins, amino acids, drugs, and alkaloids (poisons from foods)
  - 3. the hepatic portal vein carries deoxygenated blood to the capillaries of the liver
    - a. e/t diffuses out of capillaries and is processed by the liver b/f being used by the body
      - 1. ex: liver detoxifies alkaloids and drugs and processed glucose
- C. 2 cases:
  - 1. high sugar in lumen of SI
    - a. then there will be high sugar in hepatic portal vein
    - b. there will be reference range sugar in hepatic vein
      - 1. this is b/c liver stores the sugar as glycogen through glycogenesis (anabolic reaction)
  - 2. low sugar in lumen of SI
    - a. then there will be low sugar in hepatic portal vein
    - b. there will be reference range sugar in hepatic vein
      - 1. this is b/c liver breaks glycogen into glucose through glycogenolysis (catabolic reaction)
      - 2. liver also turns amino acids and fatty acids into glucose through gluconeogenesis
- D. portal circulation is 2 cap beds in line w/ each other
  - 1. things are added by 1st cap bed and carried to the 2nd via portal circ where they are then released
  - 2. ex: hypothalamus releases releasing and inhibiting factors into portal circ which carries them to anterior pituitary to control ant pit hormones

XIII. Shunting
- A. shunting=adding deoxygenated blood to oxygenated blood
- B. 2 ex of normal shunts:
  - 1. thesbian vein drainage (explained b/f)
  - 2. bronchiol drainage
    - a. pulmonary circulation
      - 1. the pulmonary artery passes through the bronchiol tree to get to the alveoli to get oxygen
      - 2. the pulmonary veins return from the alveoli through the bronchiol tree carrying oxygen
    - b. bronchiol tree circulation
      - 1. the bronchiol tree receives oxygen from the bronchiol artery which comes off the arch of the aorta
        - A. the alveoli of lungs receive oxygen from breathing air b/c they're only one cell layer thick
      - 2. cap in the bronchiol tree release oxygen to the bronchiol tree
      - 3. then bronchiol venous drainage is added to the pulmonary vein (alveolar drainage) which is carrying oxygenated blood toward the heart b/c there's no bronchiol vein
      - 4. this is shunting b/c deoxygenated blood from bronchiol drainage is being added to the oxygenated blood of the pulmonary veins
        - A. this is not a problem since bronchiol tree has a lot of cartilage which is avascular, so it has very few RBC's and very little blood, so there's very little drainage, and very little deoxygenated blood is being added to pulmonary vein
        - B. the oxygen from the bronchiol tree diffuses into the cartilage

C. ratio of V/Q in the body is normally one
1. V=ventilation, Q=blood flow
2. if there's a V/Q mismatch, then shunting must be going on in the body- arterial pressure of oxygen is lower than reference range (means s/t is wrong)
a. ex of problem w/ Q: if s/o has a pulmonary embolism- a blockage in the lung
1. then no oxygen will be picked up in the area past the blockage, so blood coming back from that lung is only partially oxygenated
2. then when blood is added to left atrium, some deoxygenated blood is added- shunting
b. ex of problem w/ V: if s/o swallows a marble
1. then ventilation is blocked, so less oxygen getting to the alveoli of the lungs, so can't give oxygen to pulmonary veins
2. this causes deoxygenated blood to be added to oxygenated blood in left atrium- shunting
3. it's normal for V/Q to be affected a little (distribution of gases in the lungs is not equal)
a. ex: when ppl stand up or sit down, apex of lungs are squished which means alveoli are squished which affects ventilation
b. ppl can breathe in deeply which expands lungs and opens up apical alveoli, resulting in more oxygen being added to the pulmonary veins (apical alveoli only open at high volume)

XIV. Fetal Circulation (involves a lot of shunting)
A. maternal circulation
1. deoxygenated blood from mother goes to maternal cap in placenta where oxygen is released
2. deoxygenated blood returns from maternal cap to mother's heart
B. fetal circulation
1. oxygen diffuses from maternal cap into fetal cap in placenta
2. umbilical vein carries oxygenated blood to IVC
3. then have 2 shunts:
a. deoxygenated blood returning from lower extremities of fetus gets added to oxygenated blood from umbilical vein
b. then SVC adds deoxygenated blood to right atrium when IVC is adding the mixed blood
1. shnting leads to a drop in arterial pressure of oxygen, but fetus can withstand this b/c not really using his muscles
4. blood then goes from right atrium to left atrium through foramen ovale=hole in septal wall
a. since baby's lungs aren't working, there's no reason to have pulmonary circulation 1st
5. some blood trickles from right atrium to right ventricle and goes up the pulmonary trunk
a. there's a connection b/t the pulmonary trunk and aorta called the ductus arteriosus, so blood is further diverted to organs other than the lungs
6. the mixed blood is dumped into the aorta from the left atrium and goes through ascending aorta, arch of the aorta, descending aorta to the umbilical artery where blood gets oxygen from the fetal cap in the placenta (cycle begins again)
a. there are other arteries coming off the aorta where blood circulates, too
7. the foramen ovale and ductus arteriosus are not shunts unless they remain patent (open) after birth
a. how foramen ovale can be a shunt:
1. foramen ovale closes after birth and becomes fossa ovalus
2. then blood ricochets off the fossa ovalus and through tricuspid valve into right ventricle, starting pulmonary circulation
3. in some ppl, foramen ovale doesn't close completely
A. severe problem- completley open foramen ovale leads to severe shunting
B. less severe problem- pinhole opening leads to a little shunting

b. how ductus arteriosus can be a shunt:

1. after birth, ductus arteriosus becomes ligamentum arteriosunm- a flap of connective tissue that holds the pulmonary trunk and aorta in position
2. if ductus doesn't close, babies will be okay until they start to walk and then it hurts b/c they're circulating poorly oxygenated blood
3. can do an ABG- arteriole blood gas- to check if there's a problem w/ pressure of oxygen
   A. draw blood from an artery (usually radial artery) and measure the pH, arterial pressure of oxygen and carbon dioxide, and bicarbonate levels

8. only minor shunts remain after left and right circulation of the heart are separated
   a. ex: thesbian and bronchiol drainage

XV. Extra Information

A. what can cross capillaries?

1. small things- ions (ex: Cl-), glucose, oxygen, carbon dioxide
   a. big things like proteins can't (ex: albumin)

B. BBB=blood-brain-barrier

1. it's a unique capillary system made up of endothelial cell mem of adjacent capillary cells
   a. the outer mem of the lipid bilayers fuse tog to form tight junctions
      1. tight junctions restrict movement of materials into CSF
2. BBB regulates what enters CSF
   a. neurons in CSF need to be protected against polar amino acids like glycine which would act as neurotransmitters, so their movement needs to be restricted
   b. nutrients can cross BBB
      1. glucose is necessary to feed nerve cells, so it's actively transported
   c. some antibiotics don't cross BBB; some do- need to take this into accout if need to get drugs into nervous system

C. collateral circulation

1. this refers to alternate circulatory patterns
2. this occurs when there is additional blood vessel growth
   a. angiogenesin is the hormone that stimulates blood vessel growth
   b. then blood vessels can connect to each other, forming anastomes
   c. this establishes collateral circulation
3. collateral circulation can be established when there's an embolism in the heart, blocking th flow of blod
   a. new blood vessels can grow and connect to each other, forming anastomes, so blood can still pass through the heart using a new pathway (collateral circulation) and bypass the blocked pathway