CIRCULATORY SYSTEM

RITA CAREY-NITA

Circulatory System

- Circulatory System consists of:
  - Heart
  - Blood vessels
- Vessels: are a series of connected hollow tubes that begin & end at the heart
- They form a pathway through the body
- The heart & blood vessel form a circuit or circulation ensuring one way movement of blood

Types of Circulation

- Pulmonary circulation:
  - carries blood form the right ventricle of the heart to the lungs & back to the left atrium of the heart
  - Transports unoxygenated blood to the lungs, where O_2 is taken up & CO_2 is unloaded
- Systemic Circulation:
  - Larger circulation that provides blood to the body
  - Carries oxygenated blood & vital nutrients to cells of the body & picks up CO_2 & waste from cells

Arteries

- Arteries
  - Large blood vessels that carry blood away from the heart
  - Larger arteries repeatedly branch to form smaller arteries
  - They are distributed throughout the body
  - The smallest of arteries are arterioles
  - They carry oxygenated blood

Artery Function

- Arteries:
  - AKA: Conductance Vessels
  - Walls are thick, tough & elastic so they can withstand the pressure pumped from the ventricles
  - Conduct blood from the heart to the arterioles
  - Hence the name conductance vessels

Arterioles Function

- Arterioles:
  - AKA: Resistance Vessels
  - Smallest of the arteries
  - Composed of mostly smooth muscle so they can contract & relax changing their diameter & resistance of blood flow
  - A wider vessels creates less resistance
  - A narrower vessel creates more resistance

Capillaries

- Capillaries:
  - AKA: Exchange Vessels
  - Blood flows from arterioles into capillaries
  - Connect arterioles to venules
  - Most numerous of all blood vessels
  - Close to all cells in the body providing them with continuous O2 & vital nutrients
  - Thin vessel wall made up of simple squamous epithelium

Capillary Function

- Act as Exchange Vessel
  - Allows oxygen, water & dissolved substances to diffuse from blood into tissue spaces to cells
  - Allows CO_2 & waste to diffuse from cells & tissue spaces for transport to organs for excretion
    - Substance include: oxygen—water—electrolytes—glucose—other nutrients—carbon dioxide—waste
  - Large number of capillaries supplies all cells of body ensuring continuous nourishment

Capillary Exchange

- The capillary blood flow is slow
- Numerous capillaries & slow blood flow within results is more exchange
- Holes in capillary walls allow only certain substances to leave & enter
  - i.e. plasma proteins cannot cross so they stay in vessel while water & glucose exit vessel

Capillary Exchange

- Two processes for exchange:
- Diffusion: substances move from an area of high concentration to an area of low concentration
  - The concentration of oxygen is higher in the capillary than in the tissue so it moves to tissue
  - The concentration of carbon dioxide is higher in the tissue & lower in the capillaries so it moves into the capillaries

Capillary Exchange

- Filtration-Osmosis:
  - The push-pull of exchange
  - Filtration:
    - Pressure from heart pushes water & dissolved substances through the holes of the capillaries into the interstitium
  - Osmotic pressure:
    - Water & dissolved waste move into the capillaries by osmosis
    - Osmotic pressure in the capillaries is higher than the interstitium, because plasma proteins are trapped in the capillaries, water & waste products are pulled into capillaries

Capillary Exchange

- The amount of water pulled into the capillary & the amount let out must be equal or dehydration or edema can occur
- Constant balancing act

Venules

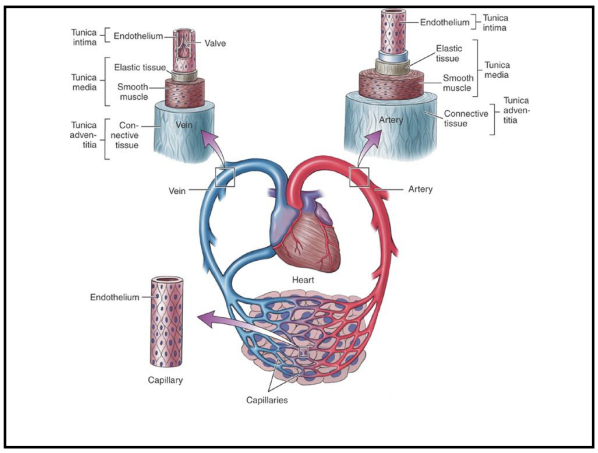
- Venules:
  - AKA Capacitance vessels
  - Capillaries converge to form venules
  - Blood flows from the capillaries to venules
  - Venule walls are slightly thicker than capillary walls
  - Venules converge to form larger veins

Veins

- Veins:
  - Veins carry deoxygenated blood back to the heart
  - Veins converge into two large veins that carry the deoxygenated blood to the right atrium
  - A vein wall are thicker than the venule wall
  - The tunica media of veins are thinner than of arteries because there is less pressure within veins
  - Veins contain one way valves that direct the blood toward the heart preventing backflow of blood
  - Veins also store blood

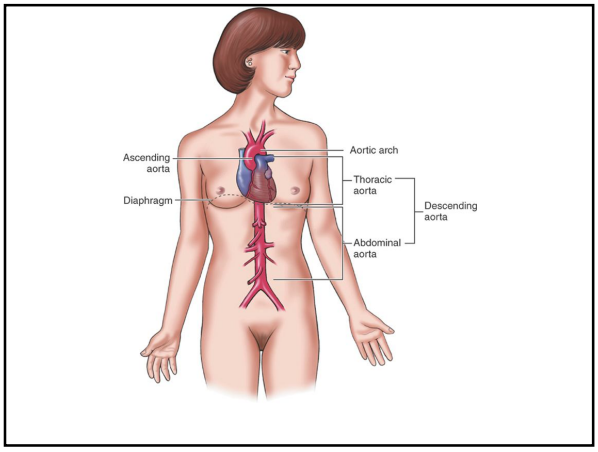
Blood Vessel Walls

- Veins & arteries walls have 3 layers of tissue:
  - Tunica intima:
    - innermost layer that is endothelial lining
    - Slick, shiny surface that is continuous with endocardium
    - Blood flows smoothly along suface
  - Tunica media:
    - Middle layer is the thickest layer & is composed of elastic tissue & smooth muscle
    - Large arteries are primarily elastic tissue so they can stretch
    - Smallest arteries are primarily smooth muscles allowing them to contract & relax changing their diameter
  - Tunica adventitia:
    - Outer layer made up of connective tissue
    - Supports & protects the blood vessel



Major Arteries of Sys. Circulation

- Aorta:
  - Originates from the left ventricle
  - Extends upward from LV in an archlike fashion then descends just behind the heart, in front of the vertebral column, penetrating the diaphragm as it descends into the abdomen
  - It ends in the pelvic cavity as it splits (bifurcates) into to iliac arteries
  - The aorta is divided into segments:
    - Ascending aorta: arises from LV to arch
    - Aortic arch: as named
    - Descending aorta: descends into thorax & abdomen
      - Thoracic aorta & Abdominal aorta



Branches of the Aorta

- All systemic arteries are either direct or indirect branches of the aorta
- Branches of the Ascending Aorta:
  - Arises from the LV, beginning at the aortic semilunar valve & aortic arch
  - Right & Left coronary arteries branch from the ascending aorta.
  - The coronary arteries are distributed throughout the heart & supply oxygen to the myocardium

Branches of the Aortic Arch

- The aortic arch extends from the ascending aorta to the descending aorta & gives rise to the following large arteries:
  - Brachiocephalic artery: large artery that supplies the right side of the head, neck, shoulder & upper extremity
  - Left common carotid artery: extends forward from the highest part of the aortic arch & supplies the left side of the head & neck
  - Right common artery arises from the brachiocephalic artery & supplies blood to right head & neck
  - Left subclavian artery supplies blood to the left shoulder & upper arm

Branches of Descending Aorta

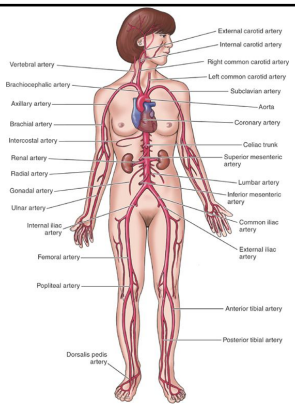
- The thoracic aorta is the upper portion of the descending aorta extending from the aortic arch to the diaphragm
- Intercostal arteries arise from the aorta & supply the intercostal muscles of the ribs
- Other small arteries supply the organs of the thorax

Branches of Descending Aorta

- Abdominal Aorta extends from the thoracic aorta to the lower abdomen & branches.
  - Celiac trunk is short artery that further divides into three smaller arteries:
    - Gastric artery: supplies stomach
    - Splenic artery: supplies spleen
    - Hepatic artery: supplies liver
  - Two mesenteric arteries are the superior & inferior segments
    - Superior mesenteric artery supplies most of the blood to the small intestine & part of the large intestine
    - Inferior mesenteric artery supplies the large intestine

Branches of Descending Aorta

- Abdominal Aorta:
  - Two renal arteries supply the right & left kidney
  - Gonadal arteries & lumbar arteries supply gonads & lower back & buttocks
- Distal Aorta bifurcates into:
  - Right & Left common iliac arteries which supply the thigh & lower extremities
  - Femoral, popiteal, anterior & posterior tibial & dorsal pedis arteries supply the legs & feet



Major Veins of Sys Circulation

- Veins that are visible are called superficial
- Deep veins are deeper & run parallel with the well protected & deeper arteries
- The names of the deep veins are the same as the arteries with a few exceptions

Venae Cavea

- Veins carry blood from all parts of the body to the venae cavea for delivery to the heart
- The veins converge & empty into the venae cavea

Vena Cava

- Largest vein in the body is the vena cava
- Divided into superior vena cava & inferior vena cava
- Superior vena cava receives blood from the head, shoulders & upper extremities
- Inferior vena cava from all regions below the diaphragm
- Both empty into the Right Atrium

Veins that empty into IVC

- Tibial & peroneal drain calf & foot region
- Posterior ***tibial*** drains into the ***popiteal*** vein of the knee & then into the ***femoral*** vein of the thigh
- The ***femoral*** vein enters the pelvis as the ***external iliac*** vein & empties into the ***common iliac*** vein that continues as the ***IVC***

Vein that empty into IVC

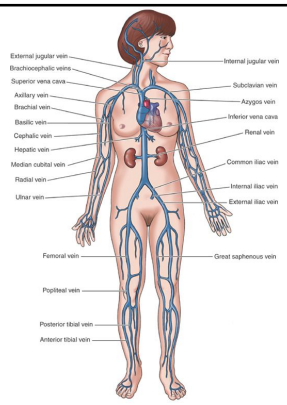
- ***Great saphenous veins*** are the longest veins of the body
- Beginning at the foot, ascending along the medial side & merging with the ***femoral vein*** in the thigh to become the external iliac vein
- These veins receive drainage from superficial veins of the leg & thigh region

Vein that empty into IVC

- The internal & external iliac veins unite to form the common iliac veins
- The common iliac veins converge to form the inferior vena cava
- The inferior vena cava ascends through the abdomen & thorax to the right atrium of the heart

Vein that empty into IVC

- Renal veins drain from the right & left kidney directly into the IVC
- Hepatic veins drain the liver & are part of a larger circulation within the liver called the hepatic circulation



Special Circulation

- Certain Organs require Special circulation:
  - Head & brain
  - Liver
  - Fetal circulation

Circulation to Brain & Head

- Brain requires continuous blood supply
- Irreversible brain damage occurs in only a few minutes without oxygen
- Supplied by two routes:
  - Carotid arteries
  - Vertebral arteries

Arteries of Head & Neck

- Right common carotid artery arises form the brachiocephalic artery
- Left common artery arises directly from the aortic arch
- These common arteries bifurcate into the external & internal carotid arteries
- The external carotid arteries supply the superficial area of the neck, face & scalp
- The internal carotid arteries extend to front part of the base of the brain once inside divides into numerous branches supplying most blood to the brain

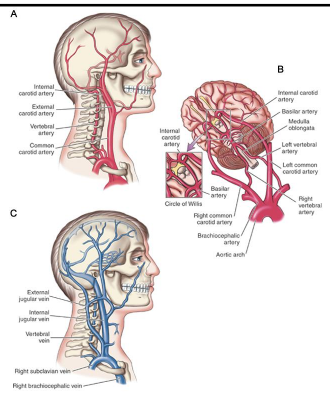
Arteries of the Head & Neck

- Vertebral arteries pass upward toward the brain from the subclavian arteries toward the back of the neck
- Joins the basilar artery which branches supplying areas of the brain stem & cerebellum
- The basilar artery also anastomose with branches of the internal carotid forming a circle of arteries at the base of the brain called

  Circle of Willis which penetrates the brain tissue providing rich blood supply

Venous Drainage of Head & Brain

- External & Internal Jugular Veins are the two major veins that drain blood from the head & neck
- The external jugular veins are more superfical & drain blood from the posterior head & neck region & empty into the subclavian veins
- The internal jugular veins drain most of the blood from venous sinuses of the brain
- The internal jugular veins join with the subclavian veins to form the brachiocephalic veins & empty in to the superior vena cava



Hepatic Circulation

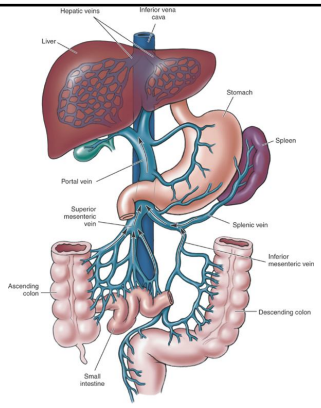
- The blood supply of the liver is unique to the organ
- Purpose is:
  - End products of the organs of digestion are brought to liver for metabolism; nutrients are extracted
- Three groups of blood vessels are involved:
  - Portal vein
  - Hepatic vein
  - Hepatic artery

Hepatic Circulation

- Portal vein is large vein that carries blood from organs of digestion to the liver
- Forms a union with superior mesenteric vein & splenic vein
- Superior mesenteric vein receives blood from the small intestine & first part of large intestine
- Splenic vein receives blood from the stomach, spleen & pancreas
- Inferior mesenteric vein drains the last part of the large intestine & then drains into the splenic vein

Hepatic Circulation

- Hepatic artery:
  - is a branch of the celiac trunk which branches off of the abdominal aorta
  - Carries oxygen rich blood to the liver
- Hepatic Vein:
  - Drains blood from the liver to the inferior vena cava to the heart



Fetal Circulation

- To be discussed in OB

Function of Circulatory System

- The circulatory system maintains an adequate flow of blood to every cell in the body
- It does so by blood pressure
- Blood is pushed through the arterial blood vessels primarily because of the pressure produced by the ventricles of the heart
- Blood pressure is the force blood exerts against the walls of the blood vessels
- The body must maintain normal blood pressure

Measurement of Blood Pressure

- Normal BP 120/80 mmHg
- Blood pressure in large arteries is caused by the pumping activity
- When ventricles contract, a volume of blood is ejected out of the ventricle into the artery
- Systolic pressure is the pressure in the arteries at peak of ventricular contraction; represented by the top number
- Diastolic pressure is pressure in the large arteries when the ventricles of the heart are relaxing; represented by bottom number

Measurement of Blood Pressure

- Pulse pressure is the difference between the systolic & diastolic pressure
- You minus the systolic from the diastolic
- BP can range from 100-140 systolic & 60-90 diastolic in an adult
- Children run lower
- Measured using sphygmomanometer & stethoscope
- Listen over the brachial artery for Korotkoff sounds which are sounds caused by blood flow through the artery

BP in different blood vessels

- BP is highest in the aorta because it is closest to the LV
- Blood pressure gradually declines as it moves away from larger arteries to smaller arteries then capillaries then venules then veins
- The difference in pressure causes blood to flow from the arterial side of circulation to the venous side

Venous Blood Return to Heart

- Blood in veins cannot return to the heart without assistance.
- Three mechanism assist:
  - Skeletal muscle action
  - Respiratory movement
  - Constriction of veins

Venous Blood Return to Heart

- Skeletal muscle action:
  - Contraction of large skeletal muscles assist with blood flow to the heart; skeletal pump
  - Valves prevent backflow of blood
- Respiratory Movements:
  - Changes in intrathoracic pressure assists the return of blood to the heart; respiratory pump
- Venoconstriction:
  - affected by hormones & Sympathetic Nervous system
  - constricts vein increasing venous return to heart

Vessels affect on BP

- As heart pumps, blood moves from an area of higher pressure to an area of low pressure
- Arterioles are the smallest arterial vessels & are made up of smooth muscle that can contract & relax affecting BP
- Vasodilation decreases resistance of in the blood vessels; when vascular resistance decreases, BP decreases
- Vasoconstriction increases resistance in the blood vessels; when vascular resistance increases, BP increases
- Both the heart & blood vessel affect BP

Determining BP

- BP = cardiac output x vascular resistance
- Cardiac ouput:
  - Amount of blood pumped from the LV each minute
  - Determined by heart rate & stroke volume
  - Increase in either/both increases C.O. ↑ BP
  - Decrease in either/both decreases CO ↓ BP

Determining BP

- Vascular Resistance:
  - Caused by relaxation & contraction of arterioles
  - Several factors affect arterioles:
    - Sympathetic Nervous System
    - Hormones
    - Pharmacologic agents

Determining BP

- Sympathetic Nervous System
  - Arterioles are supplied by fibers of the SNS
  - When the sympathetic nerves fire, arterioles vasoconstict increasing vascular resistance & elevating BP
- Epinephrine & Angiotensin cause vasoconstriction & elevate BP; called vasopressors
- Pharmacologic agents cause elevated BP & are used in shock situations

Mechanism for Normal BP

- Baroreceptors:
  - Reflex that consists of:

Receptors—sensory nerves—medulla oblongata—motor nerves

  - Baroreceptors are pressure receptors located in the walls of the aortic arch & carotid sinus that sense changes in BP
  - Sensory nerves carry the information along cranial nerves IX & X
  - Medulla Oblongata interprets the information & tells the heart & blood vessels what to do
  - Motor nerves of autonomic nervous system carry the information to the heart & blood vessels

SNS affects on BP

- Sympathetic Nervous System affect BP
  - SNS nerves supply the SA node, AV node & ventricular myocardium
  - Stimulation of these nerves causes the SA node to fire more quickly increasing heart rate
  - SA node firing also causes the ventricular myocardium to contract more forcefully, increasing stroke volume
  - Both of these responses increase cardiac output & blood pressure
  - Peripheral blood vessels also vasoconstrict ↑ resistance & BP

PNS affects on BP

- Parasympathetic Nervous System:
  - Affect the SA & AV node also but does not affect the ventricular myocardium or peripheral blood vessels
  - Stimulation of the PNS decreases heart rate which decreases cardiac output & BP
  - When the PNS is active the SNS is silent which also attributes to vasodilation

Fast Acting Mechanism

- Secretion of epinephrine & norepinephrine from the medulla of the adrenal gland is a fast acting mechanism that affects BP
- These hormones increase cardiac output & cause vasoconstriction & increase in BP

Slow Acting Mechanism

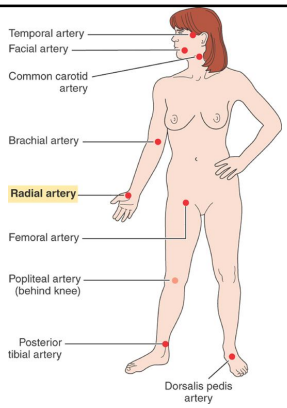
- Renin-angiotensin-aldosterone mechanism is slow acting & affects BP
- Activation of this mechanism increases blood volume & causes vasocontriction
- This will be reviewed in the Urinary System

Distribution of Blood Flow

- Resting state:
  - 20% to skeletal muscles—19% to kidney— 24 % to abdomen– 9% skin—28% other
- Active state:
  - 71% to skeletal muscles—3.5% to abdomen & kidney—11% skin—11% other
- Blood diverts to the area in need during active state & then returns when at rest

Pulse

- Pulse is the pressure wave created when the ventricles pump blood into the arteries
- Common Arterial sites to feel & hear pulse include:
  - Common carotid artery
  - Brachial artery
  - Radial artery
  - Femoral artery
  - Popiteal artery
  - Posterior tibial artery
  - Dorsalis pedis



Pulse

- Assessing pulse for:
  - Regular rhythm
  - Regular rate
  - Strength
  - Absence of pulse
- Assessment of a patients pulse can tell about underlying condition