LECTURE 3: CARDIOVASCULAR SYSTEM - BLOOD VESSELS

INTRODUCTION

To fully grasp the circulatory system and the processes that may progress to heart disease, it is vital that one comprehend the functioning of blood vessels. Concepts such as tissue perfusion, flow dynamics, and capillary exchange are building blocks to understanding the everyday workings of the circulatory system. Blood flows through a network of blood vessels that extend between the heart and peripheral tissues (cells throughout the body) and back from peripheral tissues to the heart. As we learned in our previous lecture, those blood vessels can be organized into a **pulmonary circuit**, which carries deoxygenated blood to the lungs for gas exchange and then after the gas exchange delivers the oxygenated blood back to the heart, and a **systemic circuit**, which delivers oxygenated blood to the peripheral tissue (cells throughout the body) and transports deoxygenated blood from the peripheral tissue back to the heart. Each circuit begins and ends at the heart, and blood travels through these circuits in a sequence i.e. blood returning to the heart from the pulmonary circuit should complete the systemic circuit before returning to the pulmonary circuit again.

In a general sense, a vessel is defined as a hollow utensil for carrying something: a cup, a bucket, a tube. Blood vessels, then, are intricate networks of hollow utensils (tubes) that transport (carry) blood throughout the entire body. Located throughout the body, the blood vessels are hollow tubes that circulate the blood. There are three types of blood vessels: arteries, capillaries and veins. During blood circulation, the arteries carry blood away from the heart. The capillaries allow for the exchange of material and connect the arteries to veins. Finally, the veins carry the blood back to the heart.

If you took all of the blood vessels out of an average child, and laid them out in one line, the line would be over 60,000 miles long! An adult's vessels would be closer to 100,000 miles long.

The network of blood vessels of the circulation can be compared to a highway system. Suppose a spring water factory (lungs) deliver the fresh spring water (oxygenated blood) to a distribution center (heart). The distribution center distributes the spring water based on orders received from household (cells). The distribution company delivers the spring water (oxygenated blood i.e. deliver oxygen) to the households (cells) and in exchange collects from the households empty bottles of spring water (deoxygenated blood i.e. collects carbon dioxide). Suppose the distribution company is located by a large freeway. The pathway of delivery would be as follow: All the deliveries leave the distribution center through the large freeway (aorta). At different exits, delivery guys exits the large freeway to a smaller highway (distributing arteries) depending on where in the towns (organs) they have deliver the water to. Again depending on the destination, delivery guys will exist from highway to local roads (arterioles) and then they will turn into a street (capillaries) that connects to their driveway. At the street (capillaries) delivery man makes stops and exchanges the full bottle of spring water (oxygen) with an empty one (carbon dioxide). After the exchange the delivery man has drive back to local road (venule), and then lesser highway (small veins) and then to large freeway (large veins e.g. vena cava) until he gets back to the distribution center (heart).
OVERVIEW
1. The blood vessels form a closed system of tubes that carry blood away from the heart, transport it to all the body tissues and then return it to the heart.
2. These vessels include arteries, arterioles, capillaries, venules, and veins i.e. the three principal categories of blood vessels are arteries, veins, and capillaries.
3. Arteries are the efferent vessels of the cardiovascular system — they carry blood away from the heart.
4. Veins are the afferent vessels, carrying blood back to the heart.
5. Capillaries are microscopic, thin-walled vessels that connect the arteries to the veins and allows for exchange of material and gas exchange.
6. Blood flows through the blood vessels from the heart to the cells and from the cells back to the heart in the following order:
   a. Elastic Arteries e.g. Aorta, pulmonary artery
   b. Muscular Arteries ((Distributing Arteries)
   c. Arterioles (smallest arteries)
   d. Capillaries – the only vessels that allow exchange
   e. Venules (smallest veins)
   f. Medium Veins
   g. Large Veins e.g. vena cava, pulmonary vein
7. As blood flows from the aorta toward the capillaries and from capillaries toward the vena cava:
   a. Pressure decreases
   b. Flow decreases
   c. Resistance increases

TYPES OF BLOOD VESSELS:
Arteries and veins differ in the structure and thickness of their walls. The walls of arteries and veins contain three distinct layers: tunica intima; tunica media; and tunica externa. Tunica intima or tunica interna is the innermost layer of the blood vessel. This layer includes the endothelial lining (simple squamous epithelium) and underlying connective tissue (basement membrane) containing elastic fibers. Tunica media is the middle layer, that contains smooth muscle tissue and loose connective tissue. Commonly this layer is the thickest layer. When the smooth muscle contracts, the blood vessel diameter decreases = vasconstriction; and when smooth muscle relax, the blood vessel diameter increase = vasodilation. Tunica externa is the outermost layer of the blood vessel, and consist of connective tissue (elastic fibers and collagen fibers). In arteries contain collagen fibers with scattered bands of elastic fibers, in vein it is thicker then tunica media and contain elastic fibers and smooth muscle. NOTE: Layered walls give them strength and Elasticity permits changes in vessel diameter.
1. There are three general classes of blood vessels in cardiovascular system
   a. Arteries carry blood away from the heart
   b. Capillaries allow diffusion of material (nutrients and gas)
   c. Veins deliver the blood back to the heart
ARTERIES
1. Arteries carry blood away from the heart. As arteries enter peripheral tissues they branch repeatedly and the branches decrease in diameter. The smallest arterial branch is called arteriole. There are three types of arteries: elastic arteries; muscular arteries and arterioles.
   a. Elastic arteries
      i. Elastic arteries are large vessels that deliver blood away from the heart. The pulmonary trunk, aorta and their major arterial branches (e.g. common carotid, subclavian and common iliac) are elastic arteries. These arteries are capable of stretching and recoiling (elastic capable) as the heart beats and arterial pressure changes and transport large volume of blood.
      ii. Strong and thick-walled vessels
      iii. Walls have all the three layers: tunica interna, media and externa.
      iv. Carry blood that is under great pressure i.e. during ventricular systole pressure within artery increase, so fibers stretch and arteries increase in diameter. During diastole pressure within artery decreases, so fibers recoil artery get its original size. Expansion in systole and recoiling in diastole slows the drop in pressure and leads to smooth blood flow.
      v. Branch and give rise to medium size vessels called muscular arteries.
   b. Muscular Arteries
      i. Muscular arteries or medium size arteries distribute blood to the body organs and muscular system.
ii. The wall of this arteries also have three layer
iii. May unite with branches of other arteries supplying the same region forming anastomoses
   (i.e. providing alternate routes).

c. Arterioles
   i. Arterioles are very small arteries, and they have poorly defined tunica externa,
      and tunica media i.e. they consist of only tunica interan (one or two layers of smooth muscle cells).
   ii. Deliver blood to capillaries in tissues
   iii. Play a major role in regulating blood flow to the capillaries, and therefore regulate blood
        pressure (ANS):
           1. Vasoconstriction (contraction) = decrease vessel volume = decreased blood flow =
              increased blood pressure.
           2. Vasodilation = increases vessel volume = increased blood flow = decreased blood
              pressure.

CAPILLARIES

2. Capillaries are the smallest, thinnest blood vessels, their walls are composed of only a single layer of
   endothelium and basement membrane; they are the only blood vessels that permit exchange of material
   (oxygen, CO2, nutrients) between the blood and surrounding interstitial fluid. Because capillary walls are
   thin diffusion occur quickly. NOTE: recall the information from Anatomy and physiology (diffusion is
   movement of molecules from area of high concentration to area of low concentration).
3. Connect arterioles to venules
4. The structure of the capillaries vary among tissues and consequently affect permeability. Two major types
   of capillaries are continuous capillaries and fenestrated capillaries.
   a. Continuous capillaries = small openings between the endothelial cells i.e. the plasma membranes
      form a continuous, uninterrupted ring around the lumen; found in skeletal, smooth, cardiac muscle,
      CT’s and lungs. Most capillaries are continuous capillaries.
   b. Fenestrated capillaries = large openings between the endothelial cells i.e. the endothelial plasma
      membranes contain pores (holes); found in endocrine glands, glomeruli of kidneys and villi of small
      intestine.
      i. Sinusoids) = fenestrated capillaries with largest openings between the endothelial cells i.e.
         contain spaces between the endothelial cells with basement membranes being incomplete or
         absent; found in liver, spleen, and red bone marrow
5. Capillary Bed
   a. Capillaries form networks called capillary bed. Single artirole give rise to dozens of capillaries that
      empties into several venules
   b. The entrance to each capillary is guarded by precapillary sphincter (band of smooth muscle)
   c. Contraction of sphincter leads to reduction of capillary diameter thus reduce blood flow
   d. Capillary bed contain several direct connections between arteioles and venules
   e. Capillary bed may get blood from more than one artery
   f. Anastomosis is the joining of two tubes e.g. joining of 2 artery that supply a capillary bed. Arteriol
      anastomosis act as an insurance: If one artery is blocked still capillary circulation will continue by
      receiving blood from the other artery.
6. Regulation of Capillary Blood Flow
   a. Precapillary sphincters (smooth muscles) control blood entry into capillary beds
   b. Metabolic need controls precapillary sphincter:
      i. Opens when cells are low in oxygen and nutrients i.e. if muscle or organ is active and need
         more oxygen the sphincters open wide and blood flow to that region increases and delivers
         more blood (more blood means more oxygen)
      ii. Closes when metabolic needs are met i.e. when there is no need for oxygen, sphincters close
          and the blood is diverted to another region where it might be needed.
7. Exchange in the Capillaries:
   a. Gases, nutrients, and wastes are exchanged between blood in capillaries and tissues fluids.
Capillaries allow exchange between interstitial fluid and blood by: Active and passive transportation

i. **Diffusion**
   1. Most common type of exchange
   2. Substances include oxygen, CO₂, glucose, & hormones
   3. Lipid-soluble substances pass directly through endothelial cell membrane.
   4. Water-soluble substances must pass through fenestrations or gaps between endothelial cells.

ii. **Vesicular transport** (endo/exocytosis)

iii. **Filtration**
   1. Hydrostatic (blood) pressure pushes small solutes and fluid out of capillary. Plasma proteins generally remain in blood.
   2. Colloid osmotic pressure (osmosis) draws fluid back into capillary
   3. Net affect is fluid loss at the beginning of capillary bed but most is regained by the end of the capillary bed i.e. because net inward pressure in venular capillary ends is less than net outward pressure at the arteriolar ends of capillaries, more fluid leaves the capillaries than returns. This mean that at the beginning of the capillaries hydrostatic pressure is high inside the capillaries and low in the interstitial fluid, thus fluid and material (nutrient, oxygen, CO₂) is pushed out of the capillary into the interstitial fluid. Because plasma proteins stay in the capillaries, as more and more fluid leaves the capillaries, toward the end of the capillaries (close to the venules) the colloid pressure increases, and fluid flows back into the capillary from the interstitial fluid. NOTE: more water (fluid) leaves the capillaries during filtration than gets retrieved through reabsorption. The difference flows through the tissues and enters lymphatic vessels, that eventually returns the fluid back to the bloodstream.

**VEINS**
Veins carry blood toward the heart and they holds the greatest volume of blood. From the capillaries, blood enters small veins called venules. Number of venules join together (they unite) and form a medium size vein. Medium size veins unite and form large veins as they travel from the peripheral tissue to the heart. Veins are large and therefore serve as a blood reservoir, especially in the skin. When venous pressure is too low, sympathetic reflexes stimulate smooth muscles in the walls of veins to contract. When smooth muscles in the walls of the veins are stimulated to contract blood pressure increases.
1. **Venules**  
   a. Venules are the smallest veins and they collect blood from capillary beds  
   b. Venules extend from capillaries and merge together to form medium size veins.  
   c. **Thin-walled** vessels with 3 tunics  
   d. Carry blood under **low pressure**

2. **Medium size veins**  
   a. In this veins tunica media is thin and contains few smooth muscle cells.  
   b. In this veins the blood pressure is low, thus to ensure the flow of blood they contain valves to prevent the backflow of the blood.

3. **Large veins**  
   a. Large veins include superior and inferior vena cava. Their wall consist of all three layers (tunica interna, externa, and media).

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**BLOOD DISTRIBUTION THROUGHOUT BODY:**  
1. 60-70% in systemic veins and venule  
2. 10-12% in systemic arteries and arteriole  
3. 10-12% in pulmonary vessels  
4. 8-11% in heart  
5. 4-5% in systemic capillaries.

**BLOOD PRESSURE**  
1. Definition: Blood pressure = the pressure exerted by blood on the wall of blood vessel.  
2. Definition: **Pulse** = the pressure wave that travels through arteries following left ventricular systole.  
   a. Strongest in arteries closest to heart  
   b. Commonly measured in radial artery at wrist  
   c. Normal pulse = 60-100 bpm  
   d. Tachycardia > 100 bpm  
   e. Bradycardia < 60 bpm.

3. Measuring blood pressure  
   a. Instrument used is called a **sphygmomanometer**.  
   b. Brachial artery is typically used.

4. **Arterial Blood Pressure:**
a. In clinical use, we most commonly refer to arterial blood pressure, because the blood pressure in the veins is essentially insignificant.
b. Arterial blood pressure is produced primarily by heart action, and it rises and falls with phases of the cardiac cycle.
c. The arterial blood pressure rises to its maximum during systole (ventricular contraction) and falls to its lowest during diastole (ventricular relaxation).
d. In a normal adult at rest, the BP = 120 mm Hg/ 80 mm Hg. or 120/70

5. Factors that Influence Arterial Blood Pressure
   a. Heart action, blood volume (BV), resistance to flow, and blood viscosity influence arterial blood pressure (BP).
      i. **Heart Action** (cardiac output) – cardiac output is the volume of blood pumped by each ventricle each minute i.e. the volume of blood that is circulating through the systemic (or pulmonary) circuit per minute. Cardiac output is affected by: stroke volume (amount of blood ejected with each contraction i.e. the more blood is ejected with each contraction the higher the cardiac output); heart rate (number of heartbeat in one minute i.e. the higher the heartbeat the more ventricles contract per minute and the more blood is ejected = higher cardiac output). NOTE: Heart rate in a fetus is about 145, in a newborn about 140, and in an adult about 70.
      ii. **Blood Volume** (BV)
         1. Direct relationship (increase in BV, increases BP)
      iii. **Peripheral Resistance** (PR)
         1. Resistance is the opposition to blood flow primarily due to friction. This friction depends on three things: Blood viscosity (↑ viscosity: ↑PR: ↑ BP) ; Total blood vessel length (↑ blood vessel length: ↑ PR: ↑ BP); and Blood Vessel Radius (↑ radius: ↓ PR: ↓ BP).

6. Control of Blood Pressure:
   a. Blood pressure is determined by cardiac output and peripheral resistance. Maintenance of normal blood pressure therefore requires regulation of these two factors. Altering of cardiac output or peripheral resistance, alters blood pressure directly.
      i. To alter cardiac output, either heart rate or stroke volume should be changed
      ii. To alter peripheral resistance, either viscosity, vessel length, or vessel radius should be changed. Viscosity is the resistance to flow caused by interactions among the molecules and suspended materials in a liquid. Whole blood has a viscosity about five times that of water, due to presence of plasma proteins and blood cells.
   iii. Mechanical, neural, and chemical (hormone) factors affect stroke volume and heart rate.
       1. **Mechanical Factors Affecting Blood Pressure**
          a. Venous return (preload). Heart can only pump the blood that is returned to it. Increased preload = increase output i.e. as blood flows into the heart, it must be pumped out. During increased exercise venous return increases.
       2. **Neural Regulation**:
          a. The cardiovascular (CV) center and vasomotor center are located in the medulla of the brain stem.
          b. Baroreceptors (or pressoreceptors) that detect changes in BP in aorta and carotid arteries
          c. Chemoreceptors that detect changes in key blood chemical concentrations (H^+, CO_2, and O_2). Higher concentration of CO2, means oxygen was used and more waste product (CO2) thus increase heart rate to deliver fresh oxygen.
       3. **Hormonal Control**
          a. Several hormones affect blood pressure by acting on the heart, altering blood vessel diameter, or adjusting blood volume.
b. **Epinephrine and norepinephrine** increases rate & force of contraction = increase in cardiac output = increases BP

c. **Antidiuretic hormone (ADH)** increases reabsorption of water by the kidneys tubules, and causes vasoconstriction of arterioles = increases blood pressure.

d. **Aldosterone** increases Na\(^+\) and water reabsorption in the kidney tubules, which increases blood volume, which in turn, increases blood pressure.

e. **Atrial natriuretic peptide (ANP)** is secreted by atrial muscle fibers when increased blood volume stretches them. ANP inhibits release of some of the above hormones (e.g. ADH, Aldosterone) and causes vasodilation of arterioles and promotes the loss of salt and water in urine = decreases blood pressure.

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b. Low Blood pressure stimulates release of renin by juxtaglomerular cells

i. Renin converts Angiotensinogen to Angiotensin I

ii. Angiotensin I is converted into Angiotensin II

iii. Angiotensin II stimulate:

1. Release of Antidiuretic hormone (ADH)

2. Stimulates thirst

   a. Increased thirst promotes water absorption across the digestive tract and
increase water consumption.
3. Secretion of aldosterone by adrenal gland
4. Aldosterone and ADH promote fluid retention

PATHS OF CIRCULATION
The blood vessels form a closed system of tubes that carry blood away from the heart, transport it to all the body tissues and then return it to the heart. The two major circuits include the pulmonary circuit and systemic circuit.
1. **Pulmonary Circuit** = the vessels that carry blood from the right ventricle to the lungs, and the vessels that return the blood to the left atrium: pulmonary trunk → right and left pulmonary arteries (deoxygenated blood) → capillaries in lungs → right and left pulmonary veins (oxygenated blood) → left atrium
2. **Systemic Circuit** = the vessels that carry blood from the heart to body cells and back to the heart. **Arterial System** carries blood from heart to body cells and **Venous System** carries blood from body cells back to the heart.

**ARTERIAL SYSTEM**
1. The **aorta** is divided into the following regions: **ascending aorta; aortic arch; thoracic aorta;** and **abdominal aorta.** The abdominal aorta terminates at the brim of the pelvis and branches into each leg = common iliac arteries.
2. **Principal Branches of the Aorta** - There are many arteries that branch from these regions of the aorta and supply blood to many areas of the body. The arteries you will need to know are listed below, and the body part they supply with blood, follows in parentheses:
   a. **Branches of the ascending aorta:**
      i. right **coronary artery** (myocardium)
ii. left coronary artery. (myocardium)

b. Branches of the aortic arch: three arteries branch from the aortic arch (Brachiocephalic, Left common carotid and left subclavian)
   i. Brachiocephalic artery (right side of head and right arm)
      1. Right subclavian artery. (right arm):
         a. Brachial artery (upper arm)
            i. Radial artery (lateral forearm)
            ii. Ulnar artery (medial forearm)
      2. Right common carotid artery (right side of head)
         i. Left common carotid artery (left side of head):
            iii. left subclavian artery (left arm); Branches follow same pattern as right subclavian artery.

c. Branches of thoracic aorta
   i. intercostals (intercostal/chest muscles);
   ii. bronchial arteries (bronchi of lungs)
   iii. esophageal arteries (esophagus)

d. Branches of abdominal aorta:
   i. Celiac trunk (artery) provide blood to the liver, spleen and stomach
      1. common hepatic artery (liver)
      2. left gastric artery (left stomach)
      3. splenic artery (spleen)
   ii. Superior mesenteric (small intestine, cecum, ascending/transverse colon, pancreas
   iii. Renal arteries (kidneys)
   iv. Gonadal arteries (ovarian/testicular)
   v. Inferior mesenteric (descending/sigmoid colon, rectum)

e. Branches of Common Iliac Arteries (right and left):

VENOUS SYSTEM
Veins return blood to the heart after gas, nutrient, and waste exchange. They usually follow pathways that are parallel and in the opposite direction to the arteries that supplied that particular region with blood. The veins you’ll need to learn are identical to the arterial list with the following exceptions:

1. Jugular veins (head)
   a. external jugular vein (face and scalp)
   b. internal jugular vein (brain)

2. Superior vena cava (formed by the union of the left and right brachiocephalic veins = head, neck, shoulder and upper limbs).

3. Coronary sinus (cardiac veins)
   a. cardiac veins (capillaries of myocardium).

4. Hepatic vein (drains hepatic portal system):
   a. Hepatic portal vein (drains gastric, mesenteric and splenic veins = Nutrients from the digestive tract enter the hepatic portal vein and then delivered to the liver)
      i. Gastric vein (stomach)
      ii. Mesenteric veins (intestines)
      iii. Splenic vein (spleen)
      iv. These veins do not drain directly into the inferior vena cava. Instead, the blood drained from these abdominal organs travels to the liver via the portal vein i.e. all the nutrients absorbed from the intestine is delivered to the liver first and then the liver distributes them.

5. Inferior vena cava (drains veins from abdominal & lower limbs).

LIFE SPAN CHANGES
1. Aging takes a toll on the cardiovascular system
   a. Signs of CV disease may appear long before symptoms
      i. Cholesterol deposits in arteries as one ages.
ii. Accumulation causes hypertension and cardiac disease (see below).
  b. Autopsies performed on soldiers killed in the Korean and Vietnam wars revealed significant plaque buildup in arterial walls of otherwise healthy young men.

2. Heart and blood vessel disease increases exponentially with age.
   a. About 60% of men over age 60 have at least one narrowed coronary artery.
   b. The same is true for women over age 80.

3. Cardiac cells are replaced by fibrous connective tissue and fat as one ages.
4. Blood pressure increases with age, while resting heart rate decreases.
5. Moderate exercise correlates to lowered risk of heart disease in the elderly.

<table>
<thead>
<tr>
<th>Major Blood Vessel Summary Table</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of Blood Vessel</strong></td>
</tr>
<tr>
<td>Function (i.e. direction of blood flow in terms of heart)</td>
</tr>
<tr>
<td>Wall structure (layers and layer components)</td>
</tr>
<tr>
<td>Concentration of gases (oxygen and carbon dioxide)</td>
</tr>
<tr>
<td>Pressure of blood carried</td>
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</table>

Summary of Structure and Functions of Blood Vessels

<table>
<thead>
<tr>
<th>Structure</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arteries</td>
<td>The walls (outer structure) of arteries contain smooth muscle fibre that contract and relax under the instructions of the sympathetic nervous system. Transport blood away from the heart Transport oxygenated blood only (except in the case of the pulmonary artery).</td>
</tr>
<tr>
<td>Arterioles</td>
<td>Arterioles are tiny branches of arteries that lead to capillaries. These are also under the control of the sympathetic nervous system, and constrict and dilate, to regulate blood flow. Transport blood from arteries to capillaries; Arterioles are the main regulators of blood flow and pressure.</td>
</tr>
<tr>
<td>Capillaries</td>
<td>Capillaries are tiny (extremely narrow) blood vessels, of approximately 5-20 micro-metres (one micro-metre = 0.000001 metre) diameter. There are networks of capillaries in most of the organs and tissues of the body. These capillaries are supplied with blood by arterioles and drained by venules. Capillary walls are only one cell thick (see diagram), which permits exchanges of material between the contents of the capillary and the surrounding tissue. Function is to supply tissues with components of, and carried by, the blood, and also to remove waste from the surrounding cells ... as opposed to simply moving the blood around the body (in the case of other blood vessels); Exchange of oxygen, carbon dioxide, water, salts, etc., between the blood and the surrounding body tissues.</td>
</tr>
<tr>
<td>Venules</td>
<td>Venules are minute vessels that drain blood from capillaries and into veins. Many venules unite to form a vein. Drains blood from capillaries into veins, for return to the heart.</td>
</tr>
<tr>
<td>Veins</td>
<td>The walls (outer structure) of veins consist of three layers of tissues that are thinner and less elastic than the corresponding layers of arteries. Veins include valves that aid the return of blood to the heart by preventing blood from flowing in the reverse direction Transport blood towards the heart; Transport deoxygenated blood only (except in the case of the pulmonary vein).</td>
</tr>
</tbody>
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**Summary Comparison between Arteries and Veins**

<table>
<thead>
<tr>
<th>Arteries</th>
<th>Veins</th>
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<tbody>
<tr>
<td>Transport blood away <strong>from</strong> the heart</td>
<td>Transport blood <strong>towards</strong> the heart</td>
</tr>
<tr>
<td>Have thicker wall</td>
<td>Have thinner wall</td>
</tr>
<tr>
<td>Carry <strong>Oxygenated</strong> Blood</td>
<td>Carry <strong>De-oxygenated</strong> Blood</td>
</tr>
<tr>
<td>(except in the case of the Pulmonary Artery);</td>
<td>(except in the case of the Pulmonary Vein);</td>
</tr>
<tr>
<td>Have relatively <strong>narrow</strong> lumens (see diagram above);</td>
<td>Have relatively <strong>wide</strong> lumens (see diagram above);</td>
</tr>
<tr>
<td>Have relatively <strong>more</strong> muscle/elastic tissue;</td>
<td>Have relatively <strong>less</strong> muscle/elastic tissue;</td>
</tr>
<tr>
<td>Transports blood under <strong>higher</strong> pressure (than veins);</td>
<td>Transports blood under <strong>lower</strong> pressure (than arteries);</td>
</tr>
<tr>
<td>Do not have valves (except for the semi-lunar valves of the pulmonary artery and the aorta).</td>
<td>Have valves throughout the main veins of the body. These are to prevent blood flowing in the wrong direction, as this could (in theory) return waste materials to the tissues.</td>
</tr>
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</table>

**Hyper and Hypotension**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Causes of Condition</th>
<th>Effects / Symptoms</th>
</tr>
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</table>
| **High Blood Pressure**
Also called "Hyper-tension" | May be of unknown cause (essential hypertension, or hypertension) Or endocrine diseases (such as Cushing's disease or phaeochromocytoma) May result from kidney disease, including narrowing of the renal artery (renal hypertension) Or disease of the arteries (such as contraction of the aorta) - which is known as secondary, or symptomatic hypertension More general contributory factors are : Stress; Obesity; Age; Social Class; Smoking; Lack of exercise; Poor diet | Damage to arteries & veins. Holes get blocked up by cholesterol Hypertension is symptomless until the symptoms of its complications develop. These include : Atherosclerosis; Heart failure; Cerebral haemorrhage; Kidney failure |
| Defined as: Blood Pressure greater than: | 149 &nbsp;&nbsp;94 mm Hg | |
| for significant time period. | |
| **Low Blood Pressure**
Also called "Hypo-tension" | Can occur following: Excessive fluid loss (e.g. through diarrhoea, burns or vomiting) Severe blood loss (haemorrhage) from any cause Other causes may include: Myocardial infarction; Pulmonary embolism; Severe infections; Allergic reactions; Acute abdominal conditions (e.g. pancreatitis), Drugs (e.g. an overdose of the drugs used to treat hypertension). | Temporary Hypotension: Simple faint (syncope); Light-headed; Sweats; and Impaired consciousness Severe Hypotension : Peripheral circulatory failure (cardiogenic shock); Unrecordable blood pressure; Weak pulses; and Suppression of urine production |
| Defined as: Blood Pressure lower than: | 80 &nbsp;&nbsp;60 mm Hg | |
| for significant time period. | |

Blood pressure can be affected by gender, body size, age, time of the day, type of diet. For example blood pressure may not be the same at morning/mid day/evening or same age individuals, but different body size (different weight) may have different blood pressure or male and female the of the same age may have different blood pressure.

**Summary of capillaries**

<table>
<thead>
<tr>
<th>Continuous capillaries</th>
<th>Fenestrated capillaries</th>
<th>Sinusoid capillaries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have a complete lining</td>
<td>The endothelial plasma membranes contain pores</td>
<td>the endothelial plasma membranes contain larger pores</td>
</tr>
<tr>
<td>Found in most part of the body</td>
<td>Found in glands, kidney..</td>
<td>Found in liver</td>
</tr>
</tbody>
</table>

Materials can move across capillary walls by active transport and bulk transport, diffusion and osmosis. Blood flow through a capillary is regulated by the precapillary sphincter.