Name: Akinoso Ololade Precious

College: Medicine and Health Sciences

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1. In cardiac cycle, arterial blood pressure fluctuates between diastolic and systolic pressure. Human body behaves as if it regulated the mean arterial blood pressure. Mean arterial blood pressure is the average between diastolic and systolic pressures. Three parameters are involved in mean arterial blood pressure regulation, they are; Heart rate (HR), ventricular stroke volume (SV) and total peripheral vascular resistance (TPVR). The regulatory system includes stretch-sensitive sensors, central nervous integrators/evaluators and neuro-humoral effector mechanisms. Pons/ medulla region of the midbrain is where central nervous integration and evaluation of incoming signals occurs mostly. Long-term regulation mainly involves the regulation of extracellular fluid volume by widespread actions of angiotensin. The renin-angiotensin-aldosterone system is an essential regulator of arterial blood pressure; it relies on several hormones that act to increase blood volume and peripheral resistance. It begins with the production and release of renin from cells near the glomerulus of the kidney. They respond to decreased blood pressure, sympathetic nervous system activity, and reduced sodium levels within the distal convoluted tubules of the nephron. In response to these, renin is released from cells near the glomerulus and enters the blood where it comes in contact with angiotensinogen which is produced continuously by the liver. The angiotensinogen is converted into angiotensin I by renin. The angiotensin I makes its way to the pulmonary vessels where angiotensin-converting enzyme (ACE) is produced by the endothelium. Angiotensin I is then converted to angiotensin II by angiotensin-converting enzyme. Angiotensin II has many functions to increase arterial pressure, including: Potent vasoconstriction of arterioles throughout the body, vasoconstriction of the efferent arterioles within the glomerulus of the kidney resulting in the maintenance of glomerular filtration rate, increased sodium reabsorption within the kidney tubules - the increased sodium reabsorption from the kidney tubules results in passive reabsorption of water through osmosis; this causes an increase in blood volume and arterial pressure, the release of antidiuretic hormone (ADH) release from the posterior pituitary gland, the release of aldosterone from the zona glomerulosa of the adrenal cortex within the adrenal gland, aldosterone functions to increase the arterial pressure through the up regulation of Na+/K+ pumps of the distal convoluted tubule and collecting duct within the nephron, this activity is the distal convoluted tubule leads to increased reabsorption of sodium, as well as increased secretion of potassium, the increase in sodium reabsorption leads to passive reabsorption of water and an increase in blood pressure

2. a: <u>Pulmonary Circulation</u>: **Pulmonary circulation brings blood to lungs for oxygenation. The heart pumps oxygenated blood out of the left ventricle and into the aorta to begin systemic circulation. After blood has supplied cells throughout the body with oxygen and nutrients, it returns the deoxygenated blood to the right atrium. The deoxygenated blood flows down from the right atrium to the right ventricle, through the right AV valve and into the pulmonary arteries to begin *pulmonary circulation*. When the ventricles contract, the right AV valve closes off the opening between the ventricle and the atrium so blood doesn't flow back into the atrium. The right ventricle then contracts, forcing the deoxygenated blood through the pulmonary semi lunar valve and into the pulmonary artery. The pulmonary semi lunar valve keeps blood from flowing back into the right ventricle after it's in the pulmonary artery. The pulmonary artery carries the blood that's very low in oxygen to the lungs, where it becomes oxygenated. Freshly oxygenated blood returns from the lungs to the left atrium of the heart via the pulmonary veins. Pulmonary veins are the only veins in your body that contain oxygenated blood; likewise, pulmonary arteries are the only arteries in the body that contain deoxygenated blood. Pulmonary circulation moves blood between the heart and the lungs. It transports deoxygenated blood to the lungs to absorb oxygen and release carbon dioxide. The oxygenated blood then flows back to the heart.**

b. <u>Circle of Willis</u>: The Circle of Willis provides the blood supply to the brain by connecting two arterial sources together to form an arterial circle, which then supplies the brain with blood. The arteries which are the source of the Circle of Willis are two internal carotid arteries. Each carotid artery branches into an internal and external carotid artery, the internal carotid artery then branches into the cerebral arteries. Circle of Willis is located at the base of the brain, around the optic chiasm, and the hypothalamus. The circle of Willis is a junction of several important arteries at the bottom part of the brain. It helps blood flow from both the front and back sections of the brain. The structure encircles the middle area of the brain, including the stalk of the pituitary gland and other important structures. The arteries that stem off from the circle of Willis supply much of the blood to the brain. The circle of Willis also serves as a sort of safety mechanism when it comes to blood flow. If a blockage or narrowing slows or prevents the blood flow in a connected artery, the change in pressure can cause blood to flow forward or backward in the circle of Willis to compensate. This mechanism could also help blood flow from one side of the brain to the other in a situation in which the arteries on one side have reduced blood flow. In an emergency, such as a stroke, this may reduce the damage or aftereffects of the event. Importantly, the circle of Willis does not actively carry out the function. Instead, the natural shape of the circle and the way that pressure acts in the area simply allow for bidirectional blood flow when necessary.

c. <u>Splanchnic Circulation</u>: Circulation to the gastrointestinal tract, liver, spleen and pancreas is collectively called splanchnic circulation. The splanchnic circulation is also an important source of inflammatory mediators. In case of hemorrhage, the splanchnic circulation becomes markedly reduced to be able to supply more vital or essential organs such as the brain and heart. The splanchnic circulation can act as a site of regulation of distribution of cardiac output and also as a blood reservoir. Multiple regulatory pathways are involved in the

distribution of the splanchnic circulation. It consists of two large capillary beds partially in series. The small splanchnic arterial branches supply the capillary beds, and then the efferent venous blood flows into the portal vein (PV). The portal vein and hepatic artery supply blood flow to the liver. The splanchnic blood flow participates in the regulation of circulating blood volume as well as the systemic blood pressure.

d. <u>Coronary circulation</u>: Coronary circulation is the movement of blood throughout the vessels that supply the myocardium also known as the heart muscle. It is coronary vessels and flow through them (coronary blood flow) that are essential in managing the delicate supply and demand balance of oxygen and nutrients in the cardiac muscle. The coronary circulation system is mainly made up of arteries and veins. Two coronary arteries emerge from base of aorta; surround heart in coronary sulcus, delivering oxygenated blood to heart (myocardium). They are the left and right coronary artery, the arterial supply of the heart starts with the branching out of the left and right coronary arteries from the base of the aorta. The aorta carries oxygenated blood from the heart to the rest of the body. The left coronary artery supplies the left atrium, left ventricle and interventricular septum. The left coronary artery divides into circumflex artery: supplies left atrium, posterior wall of left ventricle and anterior interventricular artery: supplies interventricular septum, anterior walls of ventricles. The right coronary artery supplies the right atrium, right ventricle, part of left ventricle and electrical conduction system. It also divides into two branches; right marginal artery: supplies lateral right side of heart, superficial parts of ventricle and posterior interventricular artery: supplies interventricular septum, posterior walls of ventricles. The coronary circulation is also made up of veins, called cardiac veins.

They are responsible for returning deoxygenated blood and waste products like carbon dioxide, from the myocardium to the lungs. The blood moves from the capillary beds of the myocardium into the cardiac veins. The cardiac veins usually follow the same path as the coronary arteries. There is the great cardiac vein in the anterior interventricular sulcus, a middle cardiac vein in the posterior interventricular sulcus, and a small cardiac vein, running along the inferior margin of the right heart. All three cardiac veins empty into one big vessel behind the heart called the coronary sinus which empties into the right atrium. There are also the anterior cardiac veins which empty into the right atrium. The blood meets the rest of the deoxygenated venous blood delivered via the inferior and superior vena cava, then passes to the right ventricle, through the pulmonary trunk and finally the lungs where the red blood cells can pick up oxygen and dump off carbon dioxide. The blood in the coronary sinus has the lowest oxygen content in the body because the heart extracts the maximum amount of oxygen from the circulation at rest.

e. <u>Cutaneous circulation</u>: The cutaneous circulation is the circulation and blood supply of the skin. The blood supply of the skin is different to that of other tissues due to the fact that it is not a very metabolically active tissue and has relatively small energy requirements. The blood vessels in skin include; cutaneous arterioles, meta arterioles (resistance vessels), capillaries (which provide large surface area for heat exchange), venules and arteriovenous anastomoses (AVAs). Some of the circulating blood volume in the skin will flow through will flow through arteriovenous anastomoses (AVAs) instead of capillaries. Arteriovenous Anastomoses (AVAs) are low-resistance connections between the small arteries and small veins that supply and drain the skin. These

allow the shunt of blood directly into the venous plexus of the skin, without it passing through capillaries. Since AVAs contain no capillary section, they are not involved in transport of nutrients to/from the tissues, but instead play a major role in temperature regulation. The amount of blood flow to the skin determines the degree of heat loss and therefore the core body temperature. The blood flow through AVAs is heavily influenced by the sympathetic nervous system. At rest, the sympathetic nervous system dominates and acts to constrict AVAs. Any changes in core temperature are detected by the thermoregulatory centre in the hypothalamus. It regulates temperature by altering the level of sympathetic outflow to the cutaneous vessels, to return temperature to its normal range: In high core temperatures:

- **Sympathetic innervation is decreased, reducing the vasomotor tone in the AVAs.**
- **More blood flows through the AVAs and reaches the venous plexus (close to the surface of the skin), increasing heat loss to reduce core temperature.**

In low core temperatures:

- **Sympathetic innervation is increased, increasing the vasomotor tone in the AVAs.**
- **Less blood flows to the apical skin (of nose, lips, ears, hands and feet), reducing heat loss to increase the core temperature.**

3. **During exercise, there is an increase in impulse at the sino atrial node (S.A node). This is due to information moving from the cortex of the brain to the cardiac accelerator centre in the medulla which causes sympathetic discharge resulting in the stimulation of sino atrial node. Stimulation of the sino atrial node involves a reduction or withdrawal of the parasympathetic nerve activity to the heart. As parasympathetic nerve activity causes a lowering of heart rate, its withdrawal will actually result in an increase in heart rate. An increase in sympathetic nerve activity to the heart will directly cause an increase in heart rate and stroke volume. This increase in sympathetic nerve activity will be a function of the exercise intensity. As a result of increased heart rate and stroke volume, there is an increase in cardiac output (Q) which is the amount of blood pumped out in each ventricle in a minute. Chemobaroreceptors detect the change in the system. There is increase in cardiac conductivity, impulse from sino atrial node is transmitted /conducted to atrial muscle and arterioventricular node through internodal pathway and the increase in cardiac conductivity facilitates increase in cardiac contractility. The longer the tension in the ventricular wall, the stronger the subsequent ventricular contraction. Cardiac pressure increases with increased cardiac output which promotes blood flow. During exercise; more blood is sent to active skeletal muscles and as body temperature increases, more blood is sent to the skin. This is accomplished by an increase in cardiac output and redistribution of blood away from areas of low demand. Progressively more of the cardiac output will be redistributed to the skin to counter the increasing body temperature, limiting the amount going to skeletal muscle and the exercise endurance.**