NAME: ESITI MALLYNSON OGHENEVWEDE

MATRIC NO.: 18/MHS01/153

DEPT: MEDICINE AND SURGERY

LEVEL: 200

COLLEGE: MEDICINE AND HEALTH SCIENCES

COURSE: ICBS [INTEGRATED CORE BASIC SCIENCES- ANATOMY, BIOCHEMISTRY & PHYSIOLOGY

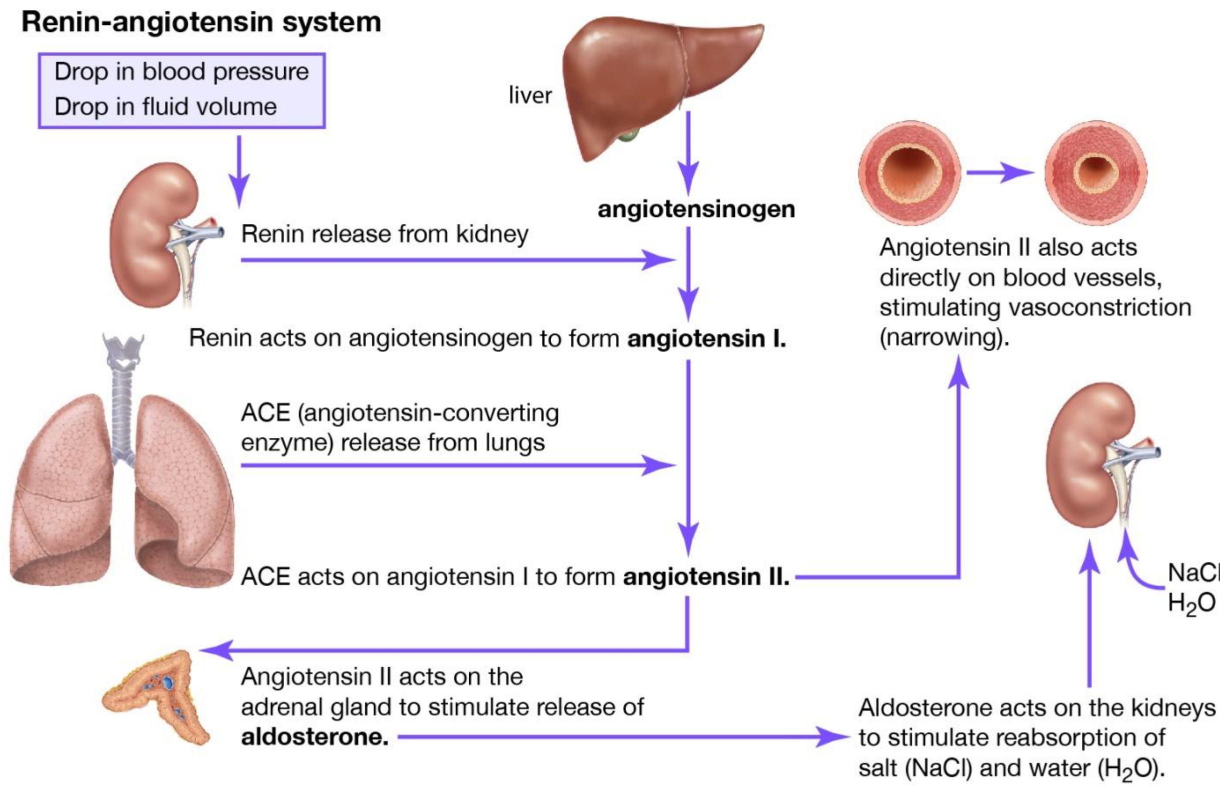
ASSIGNMENT TITLE: ASSIGNMENT ON CARDIOVASCULAR PHYSIOLOGY

QUESTION

1. Discuss the long-term regulation of mean arterial blood pressure

   Mean arterial pressure is the average arterial pressure throughout one cardiac cycle, systole and diastole. It is the average pressure existing in the arteries. It is influenced by cardiac output and systemic vascular resistance, each of which is under the influence of several variables.
   However, the long-term level of arterial pressure is dependent on the relationship between arterial pressure and the urinary output of salt and water which in turn is affected by a number of factors.
   There are several physiological mechanisms that regulate blood pressure in the long-term; first is the **renin-angiotensin-aldosterone system (RAAS).**
   Renin is a peptide hormone released by the granular cells of the juxtaglomerular apparatus in the kidney. It is released in response to sympathetic stimulation, reduced sodium-chloride delivery to the distal convoluted tubule and decreased blood flow to the kidney. *Renin* facilitates the conversion of angiotensinogen to angiotensin I which is then converted ton angiotensin II using angiotensin-converting enzyme (ACE).
   Angiotensin II *is* a potent vasoconstrictor; it causes constriction of arterioles in body so that the peripheral resistance is increased and blood pressure rises. It also acts directly on the kidneys and causes constriction of the afferent arterioles in the kidneys so that glomerular filtration reduces and sodium reabsorption in the proximal convoluted tubule. It also stimulates the adrenal

cortex to secrete aldosterone; this hormone increases reabsorption of sodium from the distal convoluted tubule thereby promoting salt and water retention. Angiotensin converting enzyme also breaks down a substance called bradykinin which is a potent vasodilator and its breakdown potentiates the overall constricting effect. More sodium collects in the kidney tissue and then water follows by osmosis; this results in decreased water excretion and therefore increased ECF volume and blood volume and thus increased blood pressure.
In the same vein, ***Angiotensin III and Angiotensin IV*** also increase the blood pressure and stimulate adrenal cortex to secrete aldosterone.



Kidneys also regulate arterial blood pressure **by regulating the extracellular fluid volume**; when blood pressure increases, kidneys excrete large amounts of water and sodium by means of pressure diuresis and natruiresis {excretion of large quantity of water and sodium in urine respectively}. As a result, there is decrease in ECF volume and blood volume which in turn brings the arterial blood pressure back to normal level. Conversely, when blood pressure decreases, the reabsorption of water from renal tubules is increases. This in turn increases ECF volume, blood volume and cardiac output resulting in restoration of blood pressure.

2. Write short notes on the following:
   a. Pulmonary circulation

      It is also called **lesser circulation**. It is the system of transportation that shunts de-oxygenated blood from the heart to the lungs to be re-saturated with oxygen before being dispersed into systemic circulation.

      In this circulation, deoxygenated blood is pumped from the right ventricles to lungs through the pulmonary valve and enters the pulmonary artery. In the lungs, the arteries divide further into very fine capillaries at the alveoli allowing gas exchange to take place; oxygen diffuses from the alveoli into the pulmonary capillaries while carbon dioxide diffuses from the capillaries into the alveoli. This newly oxygenated blood leaves the lungs through the pulmonary veins to the left atrium of the heart. The blood is then distributed around the body via the systemic circulation.

   b. Circle of Willis

      This is a ring of interconnecting arteries located at the base of the brain around the optic chiasm (partial crossing of the optic nerve –CNII), infundibulum of the pituitary stalk and the hypothalamus. It provides blood to the brain and neighbouring structures. This arterial circle is more accurately referred to as **the polygon of Willis** by the French but named after an English doctor called *Thomas Willis* as he completely described it in his book – *Cerebri Anatome* in 1664. It is a polygonal anastomosis formed by two groups of arteries – **the internal carotid arteries**, originating from the common carotid **and their branches** and **the vertebro-basilar system** {formed by two vertebral arteries and the basilar artery} **and their branches** which provide the anterior and posterior circulation of the brain respectively in an antero-posterior order. It's a polygonal anastomosis between *internal carotid artery*[branch of common carotid], *anterior cerebral artery*[branch of internal carotid], *anterior communicating artery*[branch of anterior carotid], *posterior cerebral artery*[branch of posterior cerebral] and *posterior communicating artery* [branch of posterior cerebral].

      The circle of Willis is a communicating pathway which allows for equalization of blood flow between left and right cerebral hemispheres and can allow anastomotic circulation; the polygonal anastomotic shape offers the possibility of alternate pathways for the blood flow which is essential for brain functioning since its most sensitive to hypoxia thereby serving as a backup system if there is an occlusion in the route of blood flow. Obstruction to blood flow to the brain tissues keads to oxygen and niutrients starvation and may ultimately result in conditions like stroke, paralysis, personality changes, aphasia, dulling of sensations, thrombosis, aneurysm

c. Splanchnic circulation
The splanchnic circulation comprises the *mesenteric {gastric, small intestinal, colonic, pancreatic}, hepatic and splenic circulation* supplying blood to the gastrointestinal tract6, liver and spleen respectively. It is composed of the blood flow originating from the celiac, superior and inferior mesenteric arteries and is distributed to all abdominal viscera. It has a unique feature in that the blood from mesenteric bed and spleen forms a major amount of blood flowing to liver; blood flows to liver from gastrointestinal tract and spleen through the portal system. The resistance arterioles are the primary determinant of vascular resistance in this circulation. The splanchnic venous capacitance reservoir contains about one-third of the body's total blood volume. Overall splanchnic blood flow requires about 25%-30% of cardiac output. Numerous extrinsic and intrinsic factors influence this circulation although neural control is almost entirely sympathetic; sympathetic stimulation cause arteriolar vasoconstriction and also contracts the smooth muscle of the capacitance veins in the splanchnic circulation and may expel pooled blood into the systemioc circulation. splanchnic circulation also powerfully influences systemic arterial pressure due to the arterial and venous constriction in response to neural and hormonal inputs. The liver is unique in that it has both an arterial and venous afferent blood supply; in a resting adult, the liver receives approximately 500ml/min of blood via the hepatic artery and a further 1300 ml/min from the portal circulation. The splanchnic circulation also responds to reduced perfusion pressure by redistribution of blood flow within individual organs.

d. Coronary circulation
This is a part of the systemic circulatory system which involves the circulation of blood in the blood vessels that supply the heart muscle (myocardium). Coronary arteries supply oxygenated blood to the heart muscle and cardiac veins drain blood away the blood once it has been deoxygenated and drains into the right atrium. In the human heart, two coronary arteries arise from the base of aorta just beyond the semilunar valves and surround the heart in coronary sulcus: the left and right coronary artery together with each of their branches which supply blood to the left side of the heart muscle (the left ventricle and left atrium) and the right side of the heart muscle (right ventricle, right atrium, the sino atrial

and atrioventricular nodes which regulate the heart rhythm) respectively. Together with the left anterior descending artery {a branch of the left coronary artery}, the right coronary artery helps to supply blood to the middle or septum of the heart. During diastole, the increased aortic pressure above the valves forces blood into the coronary arteries and into the musculature of the heart. Coronary circulation is managed primarily by local (intrinsic) control and secondarily by the sympathetic nervous system that is, increases in oxygen demand results in an increase in blood flow. The heart normally extracts 70-75% of the available oxygen from the blood in coronary circulation which is more than the amount extracted by other organs. Coronary arteries are very important because an obstruction of a coronary artery either due to atherosclerosis, build-up of a plaque in the inner lining of an artery causing it to narrow or become blocked (common cause) leads to death of part of the heart muscle{myocardial infarction} and in severe cases, total heart failure and a consequential death may ensue.

e. Cutaneous circulation

This is the circulation and blood supply of the skin. The skin is not a very metabolically active tissue and has a relatively small energy requirement so its blood supply is different to that of other tissues. Some of the circulating blood volume in the skin will flow through arteriovenous anastomoses (AVAs) instead of capillaries. AVAs are low resistance connections between the small arteries and small veins that supply and drain the skin; it includes the cutaneous arterioles, meta arterioles, cutaneous capillaries and venules which make up the extensive sub papillary venous plexus. These allow the shunt of blood directly into the venous plexus of the skin without it passing through the capillaries. Cutaneous blood flow performs two major functions: supply of nutrition to skin and regulation of body temperature by heat loss. Under normal conditions, the blood flow to the skin is about 250ml/square meter/min. When body temperature increases, it increases up to 2,800ml/square meter/min because of vasodilation; it also affects skin colour Cutaneous circulation is mainly regulated by body temperature and heavily influenced by the sympathetic nervous system; any changes are detected by the thermoregulatory centre in the hypothalamus and regulated by altering the level of sympathetic outflow to the cutaneous vessels to return temperature to its normal range; in high temperatures-sympathetic innervation is decreased reducing the vasomotor tone in the AVAs and more blood flows and reaches close to the surface of the skin increasing heat loss and the reverse is the case in low temperatures as sympathetic innervation is increased and less blood flows to the apical skin of nose, lips, ears hands and feet reducing heat loss. Baroreceptor mediated reflex and cortical control mechanism are other neural control mechanisms. The skin also develops reactions known as vascular responses when mechanical stimuli are applied over it- white reaction and Lewis triple reaction {red reaction, flare and weal}.

3. Discuss the cardiovascular adjustment that occurs during exercise
Exercise causes the heart to pump blood into the circulation more efficiently as a result of forceful and efficient myocardial contractions, increased perfusion of tissues and organs with blood and increased oxygen delivery to supply the working muscle to produce energy especially during aerobic exercises {activities with lower intensity involving oxygen usually done for a long duration. Aerobic conditioning exercises e.g. running, swimming, jogging train the heart and lungs to pump blood more efficiently and thus promote cardiovascular health.
The effects of exercise on the cardiovascular system can be determined by the effect on the

- **Heart rate-** the typical human resting heart rates from 60-100bpm. Before exercise begins, the heart rate increase in anticipation, this is known as the anticipatory response. It is mediated through the release of neurotransmitters epinephrine and norepinephrine. The speed of the heartbeat increases in direct proportion to exercise intensity until a maximum rate is reached. In elite endurance athletes, heart rates as low as 28 to 40bpm.
- **Stroke Volume-** it At rest, the amount of blood ejected from the left ventricle is approximately 80ml/beat; during exercise, it increases up to 130ml and increases proportionately with exercise intensity. In elite athletes, resting stroke volume averages 90-110ml/beat increasing up to 150-220ml/beat.
- **Cardiac output-** if either heart rate or stroke volume increase or both, the amount of blood pumped by the heart in 1 minute increases greatly owing tom the relatively high heart rates that are achieved during exercise
- **Heart size-** aerobic exercises usually enlarge the heart by increasing the left ventricle cavity size and thickening of its walls due to the increase in cardiac output and stroke volume. It is called eccentric hypertrophy.

- **Blood flow-** there is a large increase in muscle blood flow during exercise owing to improvement in maximal cardiac output; Redistribution of blood to those tissues with the greatest immediate demand for energy such as skeletal muscles and increase in muscle tissue capillarization. At rest, 15-20% of circulating blood supplies skeletal muscles; during vigorous exercise, this increases to 80-85% of cardiac output.
- **Blood pressure-**at rest, the systolic force exerted by blood on the walls of blood vessels in a healthy individual during contraction ranges from 110-140mmHg and 60-90mmHg for diastolic blood pressure. During exercise, systolic pressure during contraction of the heart{systole} can increase to over 200mmHg and levels as high as 250mmHg have been reported in highly trained, healthy athletes.
- **Oxygen extraction-** at resting conditions, the oxygen content of blood varies from about 20ml of oxygen per 100ml of arterial blood to 14ml of oxygen per 100ml of venous blood. The difference in oxygen content of arterial and venous blood is known as a-vO_2 difference. Ehen exercise intensity increases, the a-vO_2 difference increase also and at maximal exertion, the difference can be three times that at resting level. Aerobic training significantly increase the quantity of oxygen extracted from atrial blood during exercise.