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

Long term regulation occurs when the renal mechanism operates efficiently to regulate blood pressure. It happens when the nervous mechanism adapts to the altered pressure and loses sensitivity for the changes i.e. short term regulation is weakened. The kidney regulates blood pressure by regulating ECF Volume and through renin-angiotensin mechanism.

a) Regulation of ECF Volume.

When blood pressure increases, kidney excrete a large amount of water and salt, especially sodium through the means of pressure diuresis and natriuresis. Pressure diuresis is the excretion of large amount of water in urine. Even a little blood pressure increase doubles the water excretion by kidneys. Pressure natriuresis is the excretion of large amount of sodium in urine.

As pressure diuresis and natriuresis happens, the ECF Volume and blood volume increases resulting in the blood pressure reverting to normal. As blood pressure decreases, the ECF Volume, blood volume and cardiac output increases and as a result of increased reabsorption of water from renal tubules and as such restores blood pressure.

b) Through Renin-Angiotensin Mechanism

When blood pressure and ECF Volume decrease, renin secretion from ECF is increased. It converts angiotensin into angiotensin I. This is converted into angiotensin II by ACE (angiotensin-converting enzyme). Angiotensin II acts in two ways to restore the blood pressure.

i) It causes constriction of arterioles in the body so that the peripheral resistance is increased and blood pressure rises. In addition, angiotensin II causes constriction of afferent arterioles in kidneys, so that glomerular filtration decreases. This results in retention of water and salts, increases ECF Volume to normal level. This in turn increases the blood pressure to normal level.

ii) Simultaneously, angiotensin II stimulates the adrenal cortex to secrete aldosterone. This hormone increases reabsorption of sodium from renal tubules. Sodium reabsorption is followed by water reabsorption, resulting in increased ECF volume and blood volume. It increases the blood pressure to normal level.

Like angiotensin II, the angiotensin III and IV also increase the blood pressure and stimulate adrenal cortex to secrete aldosterone.

2. Write short notes on the following:

a. Pulmonary Circulation

This is the system of transportation that shunts deoxygenated blood from the heart to the lungs to be re-saturated with oxygen before being dispersed into systemic circulation. Deoxygenated blood from the body enters the heart from inferior vena cava while deoxygenated blood from upper body is delivered to the heart via the superior vena cava. Both the superior and inferior vena cava empty blood into the right atrium. Blood flows through the tricuspid vale into the right ventricle. It then flows through the pulmonic valve into pulmonic artery before being delivered to the lungs. While in the lungs, blood diverges into numerous pulmonary capillaries where it releases CO2 and it is replenished with oxygen. When fully saturated with oxygen, the blood is transported via pulmonary vein into the left atrium which pumps blood through the mitral valve and into the left ventricle. With a powerful contractor, the left ventricle expels oxygen-rich blood through the aortic valve and into the aorta.

b. Circle of Willis

It is the joining area of several arteries at the bottom(inferior) side of the brain. At the Circle of Willis, the internal carotid arteries braches into smaller arteries that supply oxygenated blood to 80% of cerebrum. The circle of Willis acts to provide collateral blood flow between the anterior and posterior circulations of the brain, protecting against ischemia in the event of vessel disease or damage in one or more areas. It also allows blood to flow across the midline of the brain if an artery on one side is occulated. The Circle of Willis thereby serves as a safety valve function for the brain, allowing collateral circulation for flow of blood through an alternate route to take place if the flow is reduced to one area.

c. Splanchnic Circulation

This circulation constitutes of mesenteric [supplying blood to Gastrointestinal Tract], splenic [blood to spleen], Hepatic [blood to liver] circulation. The blood from mesenteric bed and spleen forms a major amount of blood flowing to the liver which is through a portal system. For mesenteric circulation, its distribution has the stomach, intestine, pancreas 35, 50 and 80 mL/100g/ minute respectively. It is controlled by local autoregulation, contraction and relaxation of Gastrointestinal tract which reduces or increases blood flow respectively, sympathetic nerve fibers and functional hyperemia. For splenic circulation, the spleen is the main reservoir of blood due to dilation of blood vessels and it then releases blood into circulation because of dilation of blood vessels. The structures involved in the storage of blood at the spleen venous sinuses and splenic pulp which are lined with reticuloendothelial cells. Blood flow is regulated by sympathetic nerve fibers. For hepatic circulation, the liver receives blood from hepatic artery and portal vein. Blood flow to liver is 1500mL/minute forming 30% of cardiac output= 100 mL/100g of tissue/minute. Portal vein carries 25% of oxygen to liver while the remaining 75% of oxygen goes to the liver. Regulation of blood flow to the liver is done by the systemic blood pressure, splenic contraction, movements of intestine, chemical factors and sympathetic fibers.

d. Coronary Circulation

It is the circulation of blood in the blood vessels that supply the heart muscles. Coronary arteries supply oxygenated blood to heart muscle and cardiac veins drain away the blood once it has been deoxygenated. At rest, approximately 60-70% of oxygen is extracted from blood in coronary arteries. This degree of oxygen extraction is a testament to the high metabolic activity of myocardium. It also highlights the importance of increasing overall coronary flow during the times of increased myocardial oxygen demand.

e. Cutaneous Circulation

It has its architecture as thus: the arterioles arising from smaller arteries reach the base of papillae of dermis, then these arterioles turn horizontally and gives rise to meta-arterioles. From meta-arterioles, harpin shaped capillary loops arise, after reaching the base of the papillae, few venous limbs of neighboring papillae unite to form the collecting venule. Collecting venules anastomoses with one another to form the sub papillary venous plexus. Sub papillary plexus runs horizontally beneath basses of papillae and drains into deeper veins. It performs 2 functions (i) supply of nutrition to the skin and (ii) regulation of body temperature. The blood flow to skin under normal conditions is 250mL/square meter/minute but if temperature increases the blood flow follows up to 2800mL/square meter/minute. Blood flow is regulated by body temperature with hypothalamus being the chief in regulation. Vascular responses of skin are reactions developed in blood vessels of skin when mechanical stimulus is applied over it. They are of two types; the White Reaction and Lewis Triple Response. White reaction is due to constriction of cutaneous capillaries. Lewis Triple involves 3 consecutive reactions of blood vessels to skin to mechanical stimulus. They are the Red reaction, Flare and Wheal.

3. Discuss the cardiovascular adjustment that occurs during exercises?

Adjustments during exercises in the body are aimed at supply of various metabolic requisites like nutrients and oxygen to muscles and other tissues involved in exercise and prevention of increase in body temperature. Exercises are classified into types. For Muscular Contraction, it has static and dynamic exercises as types. In dynamic exercises, it involves the isotonic muscular contractions i.e. joints and muscles moving. It involves external work; here the cardiac output, heart rate, force of contraction and systolic blood pressure is increased while the diastolic blood pressure is unaltered. The static exercise meanwhile involves isometric contraction i.e. without movement of joints. It does not involve external work and the diastolic pressure increases, For the former, examples include swimming, walking, jogging, etc. while the latter is performed by pushing heavy load.

Another classification involves Aerobic and Anaerobic exercises which falls under types of Metabolism. Aerobic means “with air” while anaerobic states otherwise. The Aerobic exercises involves activities with lower intensity which is performed for longer periods e.g. soccer, jogging, running, etc. while anaerobic exercises involve exertion for short periods followed by periods of rest; it uses muscles at high intensity.

Both have metabolism involved. Exercises like jogging, the muscles start utilizing energy. For the body to have a quick energy during the first few minutes, the muscles burn stored glycogen. Note that the fat is not burnt. Only glycogen is burnt without oxygen and this is called Anaerobic metabolism. Lactic acid is produced during this period. Presence of lactic acid causes some form of burning sensation in muscles especially that of the leg and back. Muscles burn all the glycogen within 3-5 minutes. If the exercise continues, glycogen stored in liver is converted into glucose which is then transported to muscles through blood. Now this is called Aerobic metabolism. The glucose collected from the liver is burnt in the presence of oxygen. No more lactic acid is produced, So the burning sensation disappears. Proper breathing is required so that adequate oxygen is supplied to the muscles to extract energy from glucose. Supply of glucose from liver with the combination of adequate oxygen enables completion of exercise. Utilization of all glycogen stored in liver is completed by about 20 minutes. If exercise continues beyond this, the body starts utilizing fat. This fat called body fat is converted to carbohydrate and utilized by the muscles.

Based on severity, it is classified into (i) Mild exercises- simple form of exercise (ii) Moderate exercises- It does not involve strenuous activity and can be performed for longer periods, and (iii) Severe exercises- involves strenuous activities and for a short period. They are various effects of exercise on cardiovascular system, they can be on blood, venous return, blood volume, et al.