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<u>Assignment 1</u>

1. Discuss the long – term regulation of mean arterial blood pressure?
2. Write short notes on the following:
    a. Pulmonary circulation
    b. Circle of Willis
    c. Splanchnic Circulation
    d. Coronary Circulation
    e. Cutaneous Circulation
3. Discuss the cardiovascular adjustment that occurs during exercise?

<u>Answer</u>

1. Mean arterial blood pressure is the average pressure existing within the artery. The mean arterial blood pressure varies even under physiological condition hence there are organized mechanisms in the body that regulate the variance.
    They include;
    i. Nervous or Short – term Regulation Mechanism
    ii. Renal or Long – term Mechanism
    iii. Hormonal Mechanism and
    iv. Local Mechanism

    <u>Long – term Regulation of Mean Arterial Blood Pressure</u>
    For the long – term regulation of the mean arterial blood pressure the kidney plays a key role. When the blood pressure is altered at first it is regulated first by the with the help of the nervous system. The nervous system soon adapts over a long period of time and looses sensitivity to the changes. In such a condition the renal mechanism efficiently operates to ensure it is regulated. Therefore it is referred to as the long – term regulation.
    The kidney helps to regulate the mean arterial blood pressure either by

i) <u>Regulation of the extracellular fluid</u>: When the blood volume increases and vascular capacitance is not altered, arterial pressure will also increase. The rising pressure, in turn, causes the kidneys to excrete the excess volume, thus returning the pressure back toward normal. An increase in arterial pressure in the human of only a few mm Hg can double renal output of water, a phenomenon called pressure diuresis, as well as double the output of salt, which is called pressure natriuresis.
As a result of pressure diuresis and pressure natriuresis, there is a decrease in extracellular fluid volume and blood volume, which in turn brings the arterial blood pressure back to normal level. When blood pressure decreases, the reabsorption of water from renal tubules is increased. This in turn, increases extracellular fluid volume, blood volume and cardiac output, resulting in restoration of blood pressure.

ii) <u>Through renin – angiotensin system</u>: Renin is a protein enzyme released by the kidneys when the arterial pressure falls too low, helping to correct the initial fall in pressure. Renin is synthesized and stored in an inactive form called prorenin in the juxtaglomerular cells (JG cells) of the kidneys. When the arterial pressure falls, intrinsic reactions in the kidneys cause many of the prorenin molecules in the JG cells to split and release renin. Renin acts enzymatically on another plasma protein, a globulin called renin substrate (or angiotensinogen), to release angiotensin I.
Angiotensin I has mild vasoconstrictor properties but not enough to cause significant changes in circulatory function. The renin persists in the blood for some time and continues to cause formation of more angiotensin I. After formation of angiotensin I, two additional amino acids are split from the angiotensin I to form angiotensin II. Angiotensin II is an extremely powerful vasoconstrictor, and it affects circulatory function in other ways as well. It persists in the for a short time because it is rapidly inactivated by multiple blood and tissue enzymes collectively called angiotensinases.
Angiotensin II has two principal effects that can elevate arterial pressure. The first of these, vasoconstriction in many areas of the body, occurs rapidly. Vasoconstriction occurs intensely in the arterioles and much less so in the veins. Constriction of the arterioles increases the total peripheral resistance, thereby raising the arterial pressure. The second principal means by which angiotensin II increases the arterial pressure is to decrease excretion of both salt and water by the kidneys. This action slowly increases the extracellular fluid volume, which then increases the arterial pressure subsequently. This long-term effect, acting through the extracellular fluid volume mechanism, is even more powerful than the acute vasoconstrictor mechanism in eventually raising the arterial pressure.

2.

a. Pulmonary Circulation is the portion of the circulatory system which carries deoxygenated blood away from the right ventricle to the lungs and returns oxygenated blood to the left atrium and ventricle of the heart. The right atrium pumps blood though the tricuspid valve into the right ventricle. The blood is the pumped from the right ventricle through the pulmonary valve into the main pulmonary artery. The pulmonary arteries cary deoxygenated blood to the lungs where carbon dioxide leaves through the lungs through pulmonary veins which return it to the left part of the heart. The oxygenated blood enters the left atrium and passes the mitral valve into the left ventricle. From the left ventricle the blood passes the aortic valve to the aorta.

b. The circle of Willis refer to the blood flow of the brain supplied by four large arteries that merge at the base of the brain. This includes two carotid and two vertebral arteries that merge to form the circle of Willis. The arteries arising from the circle of Willis travel along the brain surface and give rise to pial arteries, which branch out into smaller vessels called penetrating arteries and arterioles The penetrating vessels are separated slightly from the brain tissue by an extension of the subarachnoid space called the Virchow-Robin space. The penetrating vessels dive down into the brain tissue, giving rise to intracerebral arterioles, which eventually branch into capillaries where exchange among the blood and the tissues of oxygen, nutrients, carbon dioxide, and metabolites occurs.

c. Splanchnic circulation describes the blood flow to the abdominal gastrointestinal organs including the stomach, liver, spleen, pancreas, small intestine and large intesitine. It is composed of the blood flow originating from the celiac, superior mesenteric and inferior mesenteric arteries and is distributed to all abdominal viscera. Under physiological conditions blood flow in the splanchnic circulation is controlled through intrinsic and extrinsic mechanisms.

d. Coronary Circulation is the circulation of blood in the blood vessels that supply the heart muscle. Coronary arteries supply oxygenated blood to the heart muscle and coronary veins drain away the blood once it has been deoxygenated. The rest of the body and most especially the brain needs a steady supply of oxygenated blood that is free of all but the slightest interruptions, the heart is required to function continuously therefore its circulation is of importance not only to its own tissue but the entire body.

e. Cutaneous circulation is the circulation and blood supply of the skin . The skin is not a very metabolically active tissue and has relatively small energy requirements, so its blood supply is different to that of other tissues. The cutaneous circulation helps in the supply of nutrition to skin and in the regulation of body temperature by heat loss.

3. The cardiovascular system consists of the heart and blood vessels. During exercise the cardiovascular system functions to pump oxygenated blood and essential nutrients to all parts of the body, deoxygenate blood, transport heat from the centre to the skin as well as transport hormones. When engaging in exercise there is an increased demand on the cardiovascular system to pump more oxygen to supply the working muscle to produce energy. As such the cardiovascular system adjusts to the demand brought about during exercise by

i) <u>Changes in cardiac function</u>: During exercise there will be a change in cardiac function as the cardiac output increases due to the increase of both the heart rate and stroke volume. These two parameter, heart rate and stroke volume, are influenced by and changes due to sympathetic nerve control, decrease in the parasympathetic nerve control as well as hormonal influence and as exercise progresses, increase in temperature. Venoconstriction, muscle pump, thoracic pump, mobilization of blood from the viscera and increased pressure transmitted through the dilated arterioles to the veins increase venous return to the heart. An increased venous return will raise cardiac output.

ii) Changes in arterial blood pressure: An important effect of increased sympathetic stimulation in exercise is to increase the arterial pressure. This increased arterial pressure results from multiple stimulatory effects, including vasoconstriction of the arterioles and small arteries in most tissues of the body except the brain and the active muscles, including the heart, increased pumping activity by the heart, and a great increase in mean systemic filling pressure caused mainly by venous contraction. These effects, working together, almost always increase the arterial pressure during exercise.

iii) Redistribution of cardiac output: There is marked increase in blood flow to the active muscles, while blood flow through most of the non-muscular areas of the body is temporarily reduced. This redistribution of blood diverts most of the cardiac output to the exercising muscles. However, blood flow to the brain and heart is not reduced during exercise. This is because both the coronary and the central circulations have poor vasoconstrictor innervation, so that the vessels in these two circulations are spared from the general vasoconstrictor effect that occurs in exercise.

iv) Increased oxygen delivery to the tissues: Oxygen delivered to the tissues is necessary as the rate and depth of breathing is increased and therefore there will be an increase in carbon dioxide production. Therefore for proper functioning of the tissue oxygen level is increased as more capillaries are open and the capillaries are dilated. These dilated vessels reduce the distance of diffusion between the capillary walls and the body cells. The muscle cells are very active, PO_2 inside would below therefore the diffusion gradient for O_2 is increased and this leads to a more rapid diffusion of O_2 to the tissues.

v) Temperature regulation: This is achieved through increased heat loss through the lungs due to increased pulmonary ventilation and the skin. Most of the heat produced in the body is generated in the deep organs, especially in the liver, brain, heart and skeletal muscles during exercise. This heat is transferred from the deeper organs and tissues to the skin, where heat is lost to the air and other objects in the surrounding of the body.