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COURSE CODE: PHY 201

COURSE TITLE: INTRODUCTION TO PHYSIOLOGY

ASSIGNMENT:

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

Answer

1.The long-term regulation of mean arterial blood pressure

The kidneys play an important role in the long-term regulation of arterial blood pressure. When blood pressure alters slowly in several days/months/years, the nervous mechanism adapts to the altered pressure and loses the sensitivity for the changes. It cannot regulate the pressure any more. In such conditions, the renal mechanism operates efficiently to regulate the blood pressure. Therefore, it is called long-term regulation.

Kidneys regulate arterial blood pressure by two ways;

- By regulation of ECF volume; when the blood pressure increases, kidneys excrete large amounts of water and salt, particularly sodium, by means of pressure diuresis and pressure natriuresis. Pressure diuresis is the excretion of large quantity of water in urine because of increased blood pressure, even a slight increase in blood pressure doubles the water excretion. Pressure natriuresis is the excretion of large quantity of sodium in urine. There is a decrease in ECF volume and blood volume, because of diuresis and natriuresis, 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 ECF volume, blood volume and cardiac output, resulting in restoration of blood pressure.
- Through renin-angiotensin mechanism; when renin is released into the blood, it acts on a specific plasma protein called angiotensinogen or renin substrate. It is the alpha2-globulin. By the activity of renin, the angiotensin is converted into a decapeptide called angiotensin I.

Angiotensin I is converted into Angiotensin II, which is an octapeptide by the activity of angiotensin-converting enzyme (ACE) secreted from lungs. Most of the conversion of angiotensin I into Angiotensin II takes place in the lungs. Angiotensin II has a short half-life of about 1 to 2 minutes. Then it is rapidly degraded into a heptapeptide called angiotensin III by angiotensinases, which are present in RBCs and vascular beds in many tissues. Angiotensin III is converted into angiotensin IV, which is a hexapeptide.

2.Short notes on the following:

a. Pulmonary circulation:

Pulmonary blood vessels

- Pulmonary artery
- Bronchial artery
- Physiological shunt

Pulmonary blood flow: Lungs receive the whole amount of blood that is pumped out from right ventricle. Output of blood per minute is same in both right and left ventricle. It is about 5litres. Thus, the lungs accommodate amount of blood, which is equal to amount of blood accommodated by all other parts of the body.

Pulmonary blood pressure: pulmonary blood vessels are more distensible than systemic blood vessels. So the blood pressure is less in pulmonary blood vessels. Thus, the entire pulmonary vascular system is a low pressure bed.

Pulmonary arterial pressure:

- Systolic pressure : 25mm/hg
- Diastolic pressure : 10mm/hg
- Mean arterial pressure : 15mm/hg

Pulmonary capillary pressure:

Pulmonary capillary pressure is about 7mm/hg. This pressure is sufficient for exchange of gases between alveoli and blood.

Regulation of pulmonary blood flow:

Pulmonary blood flow is regulated by the following factors:

1. Cardiac output
2. Vascular resistance
3. Nervous factors
4. Chemical factors
5. Gravity and hydrostatic pressure

b. Circle of Willis:

The Circle of Willis is the joining area of several arteries at the bottom (inferior) side of the brain. At the Circle of Willis, the internal carotid arteries branch into smaller arteries that supply oxygenated blood to over 80% of the cerebrum.

The Circle of Willis encircles the stalk of the pituitary gland and provides important communication between the blood supply of the forebrain and hindbrain (ie, between the internal carotid and vertebra-basilar systems following obliteration of primitive embryonic connections. Although a complete Circle of Willis is present in some individuals, it is rarely seen radiographically in its entirety; anatomically variations are very common and well developed communications between each of its parts is identified in less than half of its population.

The Circle of Willis begins to form when the left and right internal carotid artery (ICA) enters the cranial cavity and each one divides into two main branches;

- the anterior cerebral artery (ACA)
- the middle cerebral artery (MCA)

The anterior cerebral arteries are then united and blood can cross flow by the anterior communicating (ACOM) artery. The ACAs supply most midline portions of the frontal lobes and superior medial parietal lobes. The MCAs supply most of the lateral surface of the hemisphere, except the superior portion of the parietal lobe (via ACA) and the inferior portion of the temporal lobe and the occipital lobe. The ACAs, ACOM, and MCAs form the anterior half, better known as anterior cerebral circulation. Posteriorly, the basilar artery (BA), formed by the left and right vetebral arteries, branches into left and right posterior cerebral artery (PCA), forming the posterior circulation. The PCAs mostly supply blood to the occipital lobe and inferior portion of the temporal lobe.

The PCAs complete the Circle of Willis by joining the anterior circulation formed by the ICAs via the posterior communicating (PCOM) arteries.

c. Splanchnic circulation:

It is also called visceral circulation and it consist of three portions namely;

- Mesenteric circulation supplying blood to GI tract.
- Splenic circulation supplying blood to spleen.
- Hepatic circulation supplying blood to liver.

<u>Mesenteric circulation</u>

Distribution of blood flow

- Stomach: 35ml / 100g/min
- Intestine: 50ml / 100g/min
- Pancreas: 80ml / 100g/min

Regulation of mesenteric blood flow

Mesenteric blood flow is regulated by the following factors;

1. Local autoregulation
2. Activity of gastrointestinal tract
3. Nervous factiors
4. Chemical factors – functional hyperemia

<u>Splenic circulation</u>:

Spleen is the main reservoir for blood. Due to the dilatation of blood vessels, a large amount of blood is stored in spleen, and the constriction of blood vessels by sympathetic stimulation releases blood into circulation.

In spleen, two structures are involved in storage of blood, namely

- splenic venous sinuses
- splenic pulp.

The blood flow to spleen is regulated by sympathetic nerve fibres.

Hepatic circulation:

Liver receives blood from two sources

- Hepatic artery
- Portal vein

Liver receives maximum amount of blood as compared to any other organ in the body since, most of the metabolic activities are carried out in the liver. Blood flow to liver is 1,500 mL/min, which forms 30% of the cardiac output. It is about 100mL/ 100g of tissue per minute.

Normally, about 1,100 mL of blood flows through portal vein and remaining 400mL of blood flows through hepatic artery. However, portal vein carries only about 25% of oxygen to live. It is because it carries the blood, which has already passed through the blood vessels of GI tract, where oxygen might have been used. Hepatic artery transports 75% of oxygen to the liver.

Regulation of blood flow to liver

Blood flow to liver is regulated by the following factors;

1. Systemic blood pressure
2. Splenic contraction
3. Movements of intestine
4. Chemical factors
5. Nervous factors

d. Coronary circulation:

It is the circulation of blood through blood vessels of the heart muscles (myocardium). It is responsible for functional blood supply to heart muscle itself. Blood flowing through the chambers of heart does not nourish the myocardium. When functioning normally, blood in coronary blood vessels supply adequate oxygen to myocardium, like systemic circulation and pulmonary circulation, coronary circulation is also made up of arteries, arterials, capillaries, venules, and veins.

Distribution of coronary blood vessels:

- Coronary arteries
- Venous drainage
- Physiological shunt

Normal coronary blood flow

Normal blood flow through coronary circulation is about 200mL/min.

It forms 4% of cardiac output. It is about 65 to 70 mL/min / 100g of cardiac muscle.

Factors regulating coronary blood flow

1. Need for oxygen
2. Metabolic factors
3. Coronary perfusion pressure
4. Nervous factors

e. Cutaneous circulation:

Cutaneous blood flow performs two functions;

- Supply of nutrition to skin
- Regulation of body temperature by heat loss

Normal blood flow to skin

Under normal conditions, the blood flow to skin is about 250mL/sq. m/min. When the body temperature increases, cutaneous blood flow increases up to 2,800 mL/sq. m/min because of cutaneous vasodilatation.

Regulation of cutaneous blood flow

Cutaneous blood flow is regulated mainly by body temperature. Hypothalamus plays an important role in regulating cutaneous blood flow. When body temperature increases, the hypothalamus is activated. Hypothalamus in turn causes cutaneous vasodilatation by acting through medullary vasomotor centre. Now blood flow increases in skin. Increase in cutaneous blood flow causes the loss of heat from the body through sweat. When body temperature is low, vasoconstriction occurs in the skin. Therefore, the blood flow to skin decreases and prevents the heat loss from skin.

3. Discuss the cardiovascular adjustment that occurs during exercise

During exercise, there is an increase in metabolic needs of body tissues, particularly the muscles. Various adjustments in the body during exercise are aimed at

- Supply of various metabolic requisites, like nutrients and oxygen to muscles and other tissue involved in exercise
- Prevention of increase in body temperature

Exercise is generally classified into two types depending upon the type of muscular contaction

1. Dynamic exercise
2. Static exercise

Metabolism in aerobic and anaerobic exercises

When a person starts doing some exercise like jogging, bicycling or swimming, the muscles start utilizing energy in other to have quick energy during the first few minutes, the muscle burn glycogen stored in them. During this period, fat is not burnt. Only glycogen is burnt and it is burnt without using oxygen. This is called anaerobic metabolism. Lactic acid is produced during this period. Presence of lactic acid causes some sought of burning sensation in the muscle particularly the muscle of arms, legs and backs.

Muscles burn all the muscle glycogen within 3 to 5 minutes. If the person continues to exercise beyond this, glycogen stored in liver is converted into glucose, which is transported to muscles through blood. Now the body moves into aerobic metabolism. The glucose obtained from liver is burnt in presence of oxygen. No more lactic acid is produced. So the burning sensation in the muscles disappears. Proper breathing is essential during this period so that adequate oxygen is supplied to the muscles to extract the energy from glucose. The supply of glucose from liver in combination with adequate availability of oxygen allows the person to continue the exersice.

Utilization of all the glycogen stored in liver is completed by about 20 minutes. If the exercise is continued beyond this, the body starts utilizing the fat. The stored fat called body fat is converted into carbohydrate, which is utilized by the muscles. This allows the person to do the exercise for a longer period.

Cardiovascular and other changes in the body depend upon the severity of exercise. Based on severity, the exercise is classified into three types:

- Mild exercise
- Moderate exercise
- Severe exercise

Effects of exercise on cardiovascular system

1. On blood: Mild hypoxia developed during exercise stimulates the juxtaglomerular apparatus to secrete erythropoietin. It stimulates the bone marrow and causes release of red blood cells. Increased carbon dioxide content in blood decreases the pH of blood.

2. On blood volume: More heat is produced during exercise and the thermoregulation system is activated. This in turn, causes secretion of large amount of sweat leading to:

- Fluid loss
- Reduced blood volume
- Hemoconcentration
- Sometimes, severe exercise leads to even dehydration

3. On heart rate: Heart rate increases during exercise. Even the thought of exercise or preparation for exercise increases the heart rate. It is because of impulses from cerebral cortex to medullary centres, which reduces vagal tone. In moderate exercise, the heart rate increases to 180 beats per minute. In severe muscular exercise, it reaches 240 to 260 beats per minute. Increased heart rate during exercise is mainly because of vagal withdrawal. Increase in sympathetic tone also plays some role.

Increase heart rate during exercise is due to four factors;

1. Impulses from proprioceptors, which are present in the exercising muscles; these impulses act through higher centres and increase the heart rate
2. Increased carbon dioxide tension, which acts through medullary centres
3. Rise in body temperature, which acts on cardiac centres via hypothalamus, increased temperature also stimulates SA node directly
4. Circulating catecholamines, secreted in large quantities during exercise.

4. On cardiac output: Cardiac output increases up to 20L/min in moderate exercise and up to 35L/min during severe exercise. Increase in cardiac output is directly proportional to the increase in the amount of oxygen consumed during exercise.

During exercise, the cardiac output increases because of increase in heart rate and stroke volume. Heart rate increases because of vagal withdrawal. Stroke volume increases due to increased force of contraction. Because of vagal withdrawal, sympathetic activity increases leading to increase in rate and force of contraction.

5. On venous return: Venous return increases remarkably during exercise because of muscle pump, respiratory pump and splanchnic vasoconstriction.

6. On blood flow to skeletal muscles: There is a great increase in the amount of blood flowing to skeletal muscles during exercise. In resting condition, the blood supply to the skeletal muscles is 3 to 4 mL/100g of the muscle per minute. It increases up to 60 to 80 mL in moderate exercise and up to 90 to 120 mL in severe exercise.

During the muscular activity stoppage of blood flow occurs when the muscles contract. It is because of compression of blood vessels during contraction, and in between the contractions, the blood flow increases.

Sometimes the blood supply to muscles starts increasing even during the preparation for exercise. It is due to the sympathetic activity. Sympathetic nerves cause vasodilation in muscles. The sympathetic nerve fibres causing vasodilatation in skeletal muscle are called sympathetic cholinergic fibres since these fibres secrete acetylcholine instead of noradrenaline.

Several other factors also are responsible for the increase in blood flow to muscles during exercise. All such factors increase the amount of blood flow to muscles by means of dilatation of blood vessels of the muscles. Such factors are; hypercapnia, hypoxia, potassium ions, metabolites like lactic acid, rise in temperature, adrenaline secreted from adrenal medulla, increased sympathetic cholinergic activity.

7. On blood pressure: During moderate isotonic exercise, the systolic pressure is increased. It is due to increase in heart rate and stroke volume. Diastolic pressure is not altered because peripheral resistance is not affected during moderate isotonic exercise.