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18/MHS01/027
200 LVL

PHYSIOLOGY ASSIGNMENT

1. **Long Term Regulation of MAP**

The long term regulation of Mean Arterial blood pressure is done by the kidneys. It is called long term regulation because in contrast to the nervous regulation of blood pressure, it takes a relatively long period of time before its effects make a change in the blood pressure.

The kidney regulates blood pressure in two ways: By altering the blood volume and through the Renin Angiotensin Aldosterone System.

The kidney corrects blood pressure by causing appropriate changes in blood volume through excretion of water and sodium from the body.

- When blood pressure rises too high, the kidneys excrete more sodium and water because of pressure natriuresis and pressure diuresis, respectively. As a result of this increased salt and fluid excretion, the extracellular fluid volume and blood volume both decrease until blood pressure returns to normal and the kidneys excrete normal amounts of sodium and water.
- When the blood pressure falls too low, the kidneys reduce the rate of sodium and water excretion, and increase reabsorption of water in the renal tubules. However, it is by far the most potent of all long-term arterial pressure controllers.

The Renin Angiotensin Aldosterone System (RAAS) of the kidney makes use of hormones secreted by the kidneys to cause changes in blood pressure.

Renin is the enzyme released from the kidneys that initiates the system for causing change in blood pressure. Renin is synthesized and stored in an inactive form called prorenin in the juxtaglomerular cells (JG cells) of the kidneys. The JG cells are located mainly in the walls of the afferent arterioles. When the arterial pressure falls, prorenin molecules in the JG cells to split and form renin. Renin enters the renal blood and then passes out of the kidneys to circulate throughout the entire body.

Renin as an enzyme, catalyzes the conversion of angiotensinogen, a substrate present in the plasma to angiotensin I. Angiotensin I is converted into Angiotensin II by the action of angiotensin converting enzyme (ACE) present in the endothelium of blood vessels throughout the body, especially in the lungs and kidneys. Angiotensin II remains in the blood until it is .inactivated by enzymes called angiotensinases.

Angiotensin II has some effects by which it can elevate the arterial pressure:

I. Vasoconstriction: By producing vasoconstriction of arterioles and veins throughout the body it raises both systolic and diastolic pressure.
II. Decrease in salt and water excretion by kidney: This action slowly increases extracellular fluid volume, which increases arterial pressure over a period of hours and days. Mechanisms by which angiotensin II causes salt and water retention by the kidneys. Angiotensin II causes salt and water retention by the kidney.
    - By constricting the efferent arterioles which diminishes blood flow through the peritubular capillaries, allowing rapid osmotic reabsorption from the tubules.

- By directly stimulating the epithelial cells of renal tubules to increase reabsorption of sodium and water.
- By stimulating secretion of aldosterone. Angiotensin II stimulates the adrenal glands to secrete aldosterone which in turn increases salt and water reabsorption by the epithelial cells of the renal tubules.

2. Short notes on

   a. <u>Pulmonary Circulation</u>

The pulmonary circulation is one of the circulation that exists at the lungs. It begins with the pulmonary trunk. The pulmonary trunk arises from the right ventricle and divides into right and left pulmonary arteries which convey deoxygenated blood to the right and left lung, respectively. The blood circulates through a capillary plexus related to the walls of alveoli and receives oxygen from the alveolar air. This blood which is now oxygenated is returned to the heart (left atrium) through the pulmonary veins. There are four pulmonary veins, two each (superior and inferior) on the right and left sides.

The lungs also receive oxygenated blood like other tissues in the body. This is conveyed through bronchial arteries (two left and one right) which are branches of the descending thoracic aorta. The oxygenated blood in the bronchial arteries supplies the connective tissues, large and small bronchi of the lungs. The bronchial blood empties into the pulmonary veins and bypasses the right heart, the bronchial circulation so it is a physiological shunt, i.e. a channel that bypasses oxygenation in the lungs. This physiological shunts have two effects:

- They reduce the O2 saturation of arterial blood slightly and
- They make the left ventricular output slightly more than the right ventricular output.

  <u>Concerning Pulmonary Circulation</u>,
- The distensibility of pulmonary vessels makes the pulmonary circulation a low pressure, low-resistance and high-capacitance system.
- The thickness of the right ventricle and pulmonary artery is approximately one-third of the thickness of left ventricle and aorta, respectively.
- The pulmonary arterioles have very little smooth muscles in their walls. The pulmonary capillaries are larger in diameter than systemic capillaries and have multiple anastomoses.

   b. <u>Circle of Willis</u>

The Circle of Willis is part of the arterial circulation of the brain. The arteries which supply the brain are derived from two internal carotid arteries and the basilar artery (formed by union of the right and left vertebral arteries). Branches of the internal carotid arteries and of basilar artery anastomose on the inferior surface of the brain to form the circulus arteriosus (Circle of Willis). The Circle of Willis is thus basically a free anastomoses between the two internal carotid arteries and the two vertebral arteries, which equalize pressure on the arteries of the two sides. In this way, the circle of Willis allows blood that enters by either internal carotid or vertebral artery to be distributed to any part of both cerebral hemispheres.

Six large arteries, taking part in formation of Circle of Willis, supply blood by their central and cortical branches to the brain substance. They include:

1. Anterior cerebral artery (left and right)

2. Anterior communicating artery
3. Internal carotid artery (left and right)
4. Posterior cerebral artery (left and right)
5. Posterior communicating artery (left and right)
6. Middle cerebral arteries

c. <u>Splanchnic Circulation</u>

Splanchnic circulation includes the combined vascular beds of the intestines, pancreas, spleen and liver. The main vessels which constitute the splanchnic circulation are:

- Arteries: These include the coeliac trunk, the superior and inferior mesenteric artery
- Hepatic portal system
- Hepatic portal vein

The splanchnic circulation includes three parts:

1. Intestinal (mesenteric) circulation
2. Splenic circulation
3. Hepatic circulation

The Intestinal Circulation consists of the blood supplied to the intestines and pancreas about via the branches of superior and inferior mesenteric arteries. The intestinal circulation is regulated by:

- Neural mechanism: The vessels are richly innervated by noradrenergic sympathetic nerve fibers
- Autoregulation: The ability to adjust its vascular resistance and maintain constant blood flow over a wide range of arterial blood pressure
- Local control: Chemicals, which are secreted from mucosal glands during food ingestion, cause local vasodilation and augment the blood flow

The Splenic Circulation includes the splenic artery, which is a branch of coeliac trunk, supplies blood to the spleen. Due to the dilation of blood vessels, a large amount of blood is stored in spleen. The constriction of blood vessels by nervous stimulation releases blood into circulation. The spleen is regulated by nervous mechanisms through sympathetic stimulation.

The Hepatic Circulation is for the liver. The liver receives blood from two sources: the hepatic artery and the hepatic portal vein. The hepatic portal vein collects blood from the mesenteric and splenic vascular beds of the abdominal organs. So, the portal vein supplies about 70-80% of the blood to the liver, but because it passes through different tissues, it supplies about 25% of oxygen to the liver. The hepatic circulation is regulated by:

- Neural mechanism: through sympathetic fibers
- Chemical factors: which cause vasodilation
- Movement of the intestines: causes an increase in the blood flow to the liver

d. <u>Coronary Circulation</u>

The heart is supplied by the right and left coronary arteries. These arteries arise from the ascending aorta and supply blood to the heart musculature. Smaller branches are called epicardiac arteries and give rise to smaller branches known as end arteries or intramural vessels

The right coronary artery supplies blood to the right ventricle, right atrium, the posterior part of left ventricle, posterior part of interventricular septum and major portion of the conducting system of heart including SA node. The left coronary artery supplies blood mainly to the anterior part of left ventricle, left atrium, anterior part of the interventricular septum and a part of the left branch of bundle of His

The venous drainage of the heart is through

Coronary sinus: The tributaries include the great cardiac vein, the small cardiac vein, the posterior vein of left ventricle and the oblique vein of left ventricle

Anterior Cardiac vein: drains blood from the right ventricle opens directly into the right atrium.

Thebesian veins: drain deoxygenated blood from myocardium, directly into the concerned chamber of the heart, contributing to an anatomic shunt

Factors regulating coronary blood flow include:

1. Need for oxygen: Oxygen is very important to the heart. In low oxygen conditions, coronary vasodilation occurs to increase blood flow to the heart
2. Metabolic factors: These include vasodilators like adenosine
3. Nervous factors.
4. Autoregulation: Well developed but fails when blood pressure falls below 70mmHg

e. Cutaneous Circulation

The cutaneous blood vessels form a dense network just under the dermis of the skin. This includes:

- Arterioles which give rise to metarterioles
- The metarterioles subdivide into cutaneous capillary loops
- After reaching the base of papillae, few venous limbs of neighboring papillae unite to form the collecting venule
- Collecting venules anastomose with one another to form the subpapillary venous plexus
- Subpapillary arteriovenous anastomoses drain into deeper veins

The skin has little metabolic activity compared to the other organs in the body. So it has little oxygen consumption. Therefore, in contrast to most other tissues, the cutaneous blood flow is predominantly regulated by the nervous control instead of metabolic control.

The hypothalamus plays the role in regulating cutaneous blood flow. When body temperature increases, the hypothalamus is activated. It causes cutaneous vasodilatation to increase blood flow in skin. Sweat glands also get activated due to cholinergic sympathetic discharge. 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 due to increased sympathetic discharge. Therefore, the blood flow to skin decreases and prevents the heat loss from skin.

3. Cardiovascular Changes during exercises

Certain changes take place in the body to adjust to the increasing demands of the working muscles. These changes include:

1. Increased Heart Rate: Before exercise, heart rate increases due to impulses from the cerebral cortex to prepare the body for exercise. During exercise, heart rate increases due to increased sympathetic tone. Other factors include
    a. Rise in body temperature from working muscles. This acts on the cardiac centers in the brain and stimulates the SA node
    b. Catecholamines like noradrenaline are secreted in large quantities during exercises which help to increase heart rate
2. Increased Blood Pressure: During exercise, the systolic pressure is increased but diastolic pressure decreases or is not changed at all, depending on whether the peripheral resistance is affected or not. After exercises, large quantities of metabolic end products are produced. These substances accumulate in the tissues, especially the working skeletal muscle. These products cause vasodilatation. So, the blood pressure falls slightly below the resting level. With time, the pressure returns to resting level as the metabolic end products are removed from muscles.
3. Increased Cardiac Output: Depending on the severity of the exercise, cardiac output increases 5-6 times the resting value. During exercise, the cardiac output increases because of the increase in heart rate and stroke volume.
4. Reduced blood volume: Due to the heat produced during exercise, there is secretion of sweat from sweat glands in the skin leading to fluid loss and eventually, a reduced blood volume. In severe and prolonged exercised, it may cause dehydration.
5. Increased venous return: During exercise, the muscle pump is very effective. This caused venoconstriction and increases the venous return to the right side of the heart.