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COURSE: 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

SOLUTION

Long-term regulation of mean arterial blood pressure: there are mechanisms that help in the regulation of mean arterial blood pressure starting with RAAS (Renin-Angiotensin-Aldosterone System). In this mechanism, renin, a peptide hormone is released by cells from the kidney in response to sympathetic stimulation, reduced sodium chloride delivery to the kidney and also reduced blood flow. It facilitates the conversion from angiotensinogen to angiotensin I and later converts to angiotensin II by the use of angiotensin converting enzyme (ACE). Angiotensin increases reabsorption in the kidney and also promotes the release of aldosterone. Aldosterone promotes salt and water retention at the distal convoluted tubules. It also increases the activity of sodium-potassium ATPase, thus increasing the electrochemical gradient for movement of sodium ions. This results in decreased water excretion and therefore, increased blood volume thus blood pressure.

Blood pressure can also be regulated in the long term by the release of ADH (Anti-Diuretic Hormone) from the hypothalamus in response to thirst or am increased plasma osmolarity. It stimulates sodium reabsorption from the thick ascending limb of the loop of Henle increasing water reabsorption thus plasma volume and blood volume thus blood pressure.

Natriuretic peptides also regulate blood pressure it includes: atrial natriuretic peptide. These peptides are stored in cardiac myocytes and are often released when the atria are stretched indicating high blood pressure. It also promotes sodium excretion and dilates the afferent arterioles of the glomerulus increasing blood flow thus blood pressure. Atrial natriuretic peptide secretion is low when blood pressure is low.

Clinical importance: hypertension is a sustained increase in blood pressure. It may be primary (of an unknown cause) or secondary to another condition such as chronic renal disease or Cushing’s syndrome. It damaged the walls of the heart and the heart itself by increasing the after-load of the heart. The heart is pumping against greater resistance thus leading to left ventricular hypertrophy. Pharmacological therapies include; ACE inhibitors, angiotensin receptor blockers and diuretics. Also low saturated fat intake, exercise, low salt intake can also reduce high blood pressure.

2a. **Pulmonary circulation**: It is a 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 lower half of the body enters the heart from the inferior vena cava while deoxygenated blood from the upper body is delivered to the heart via the superior vena cava. Both the superior vena cava and inferior vena cava empty blood into the right atrium. Blood flows through the tricuspid valve into the right ventricle. It then flows through the pulmonic valve into the pulmonary artery before being delivered to the lungs. While in the lungs, blood diverges into the numerous pulmonary capillaries where it releases carbon dioxide and is replenished with oxygen. Once fully saturated with oxygen, the blood is transported via the pulmonary vein into the left atrium which pumps blood through the mitral valve and into the left ventricle. With a powerful contraction, the left ventricle expels oxygen-rich blood through the aortic valve and into the aorta: This is the beginning of systemic circulation.

b. **Circle of Willis**: The circle of Willis encircles the stalk of the pituitary gland and provides important communications between the blood supply of the forebrain and hindbrain (ie, between the internal carotid and vertebro-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; anatomical variations are very common and a well-developed communication between each of its parts is identified in less than half of the population. Circle of Willis is the joining area of several arteries at the bottom side of the brain. The internal carotid arteries branch into smaller arteries that supply oxygenated blood to over 80% of the cerebrum. Some of the arteries of the Circle of Willis include the anterior cerebral artery, anterior communicating artery, posterior cerebral artery, posterior communicating artery and internal carotid artery.

If one part of the circle becomes blocked or narrowed, blood flow from other vessels can preserve the cerebral perfusion enough to avoid symptoms of ischaemia.

c. **Splanchnic circulation**: it is composed of blood flow originating from the celiac, superior mesenteric and inferior mesenteric arteries that is distributed to all the abdominal viscera. It receives over 25% of the cardiac output and contains a similar percentage of the total blood volume under normal conditions. It acts as a site of regulation of the distribution of cardiac output and also acts as blood reservoir. The splanchnic circulation comprises the gastric, small intestinal, colonic, pancreatic, hepatic, and splenic circulations. They are arranged in parallel and fed by the celiac artery and the superior and inferior mesenteric arteries.

d. **Coronary circulation**: is the circulation of blood in the blood vessels that supply the heart muscles (myocardium). Coronary arteries supply oxygenated blood to the heart muscle, and cardiac veins drain away the blood once it has been deoxygenated. Because 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 major importance not only to its own tissues but to the entire body and even the level of consciousness of the brain from moment to moment. Interruptions of coronary circulation quickly cause heart attacks (myocardial infarctions), in which the heart muscle is damaged by oxygen starvation. Such interruptions are usually caused by ischemic heart disease (coronary heart diseases) and sometimes by embolism from other causes like obstruction in blood flow through vessels.

e. **Cutaneous circulation**: it has to do with the blood supply to the skin. Some circulating blood volume in the skin will go through arteriovenous anastomoses instead of capillaries. Arteriovenous anastomosis play a role in temperature regulation. They are low resistance connections between small arteries and veins that supply and drain the skin. These allows the shunt of blood directly into the venous plexus of the skin, without it passing through capillaries. The skin is the body's main heat dissipating surface: the amount of blood flow to the skin determines the degree of heat loss and therefore the core body temperature. The blood flow through arteriovenous anastomoses heavily influenced by the sympathetic nervous system. At rest, the sympathetic nervous system dominates and acts to constrict arteriovenous anastomoses.

Any changes in core temperature are detected by the thermoregulatory centre in the hypothalamus. It regulates temperature by altering the level of sympathetic outflow to the cutaneous vessels, to return temperature to its normal range.

3. **The cardiovascular adjustment that occurs during exercise**: during exercise, cardiac output increases to provide the flow needed to serve the contracting skeletal muscles. The integrated response to severe exercise involves fourfold to fivefold increases in cardiac output, which are due primarily to increases in cardiac rate and to a lesser extent to augmentation of stroke volume. The increase in stroke volume is partly due to an increase in end-diastolic cardiac size (Frank-Starling mechanism) and secondarily due to a reduction in end-systolic cardiac size. The full role of the Frank-Starling mechanism is masked by the concomitant tachycardia.
   The central nervous system (CNS), and especially neural feedback from contracting muscles, are important for the blood pressure response to exercise. Acceleration of the heart is governed by central command, whereas a blood-borne substance may contribute to the maintained elevation of heart rate (HR). Even in the absence of influence from CNS and neural feedback from working muscles, a tight coupling between cardiac output and whole body oxygen uptake ($\dot{V}O_2$) is maintained.