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DEPARTMENT: MEDICINE AND SURGERY

COURSE: PHYSIOLOGY (PHS 201)

ASSIGNMENT

1. Discuss the long term regulation of mean arterial blood pressure

Mean arterial blood pressure is regulated by changes in the heart, blood vessels and other vital organs.

Changes in the heart are determined through inotropic agents (Chemicals, ions and hormones which alter the force of muscular contractions), Cardiac output (Volume of blood being pumped out of the heart per unit time (stroke volume*heart rate) and the autonomic nervous system, usually through sympathetic and parasympathetic nerves. These changes determine the amount of blood being pumped out of the heart and its resultant pressure into the arteries.

Changes in the blood vessels which influence blood pressure majorly involves the diameter of the lumen of blood vessels, which when increased lowers blood pressure and vice versa. Systemic vascular resistance (Resistance of blood vessels except all pulmonary blood vessels to blood flow) increases when vasoconstriction (increase in the diameter of the lumen of blood vessels) occurs and decreases when vasodilation (decrease in the diameter of the lumen of blood vessels) occurs.

Other vital organs play a role in regulation of arterial blood pressure when oxygen supply is scarce, releasing chemicals to increase blood pressure and subsequently oxygen supply. The kidneys especially play a big role as the renin-angiotensin-aldosterone system which regulates blood pressure and systemic vascular resistance is activated along with production of more red blood cells when the kidneys receive poor oxygen supply.

These changes are overall affected by pulse pressure (systolic pressure-diastolic pressure), baroreceptors and chemoreceptors in blood vessels, and several chemicals either produced in the body or taken orally or intravenously. These overall changes could be caused by physical or pathological factors.

2. Write short notes on the following:

- a) Pulmonary circulation: This is the portion of the circulatory system that carries deoxygenated blood from the right ventricle to the lungs, and returns oxygenated blood to the left atrium and ventricle of the heart. The major blood vessels involved in pulmonary circulation are the pulmonary artery and pulmonary vein. Deoxygenated blood from the rest of the body enters the right atrium through the superior and inferior vena cava. From the right atrium, blood enters the right ventricle through the tricuspid valve and passes to the pulmonary artery through the pulmonary valve. From the pulmonary artery, deoxygenated blood is carried to the lungs, where carbon dioxide is released and oxygen is picked up through fine capillaries. The now oxygenated blood enters the pulmonary vein where it is returned to the left atrium and ventricle of the heart.

Clinical significance:

- Pulmonary embolus: This is a blood clot lodged in the pulmonary vasculature. It results from deep vein thrombosis in a pulmonary or systemic blood vessel and can cause chest pain or difficulty breathing. It is diagnosed through CT pulmonary angiography or a ventilation/perfusion scan and is treated with anticoagulants such as heparin.
 - Pulmonary hypertension: This occurs when there is increased blood pressure in the arteries of the lungs. It can be diagnosed through a CT scan, electrocardiography and can be treated with physical therapy and medication such as epoprostenol, sildenafil, etc.
- b) Circle of Willis: Also called the cerebral arterial circle, it is a circulatory anastomosis that supplies blood to the brain and surrounding structures. It is made up of the left and right internal carotid arteries, left and right anterior and posterior cerebral arteries, the left and right posterior communicating arteries and the anterior communicating artery.

The internal carotid arteries arise from the respective common carotid arteries. The internal carotid arteries then divide into the anterior cerebral artery which forms the anterolateral portion of the circle of willis and the middle cerebral artery which does not contribute to the circle. The anterior communicating artery connects the two anterior cerebral arteries and could arise from either side. The posterior cerebral arteries arise from the basilar artery, which is formed from the left and right vertebral arteries which

arise from the left and right subclavian arteries. The posterior communicating arteries connect the left and right internal carotid arteries to the left and right posterior cerebral arteries.

Clinical significance

- Aneurysm: This is an outward bulging in an artery wall which can increase in size and rupture, leading to uncontrolled bleeding. Aneurysms can also be the starting point for blood clot formation in blood vessels and embolism. Aneurysms in the circle of willis usually occur in the anterior communicating artery, the internal carotid arteries, the posterior communicating arteries and the junction where the basilar artery divides into the posterior cerebral arteries. Aneurysms are treated by surgery and physical therapy.
 - Subclavian steal syndrome: A condition that occurs due to reduced blood flow in the vertebral artery or the internal thoracic artery due to a proximal narrowing and/or blockage of the subclavian artery. This leads to blood flowing downwards from the vertebral artery to supply the upper limb at the expense of blood flow to the brain. It is caused by atherosclerosis, cervical rib and can be treated by endarterectomy (removal of fat blockage in an artery) or a surgical bypass involving the carotid and subclavian arteries. It can be diagnosed through a Doppler ultrasound or CT angiography.
- c) Splanchnic circulation: This is the portion of the circulatory system that supplies blood to the gastrointestinal tract and its related organs such as the liver, pancreas and spleen. It consists of the celiac, superior mesenteric, inferior mesenteric arteries and their branches. Splanchnic circulation is subdivided into:
- Gastric circulation which supplies the stomach.
 - Small intestinal circulation which supplies the duodenum and small intestine
 - Colonic circulation which supplies the large intestine.
 - Pancreatic circulation which supplies the pancreas
 - Hepatic circulation which supplies the liver and gallbladder
 - Splenic circulation which supplies the spleen

The overall splanchnic blood flow receives about 25% of cardiac output

Clinical significance

- Ischemia: A medical condition that occurs when there is reduced blood flow to a tissue or organ. Ischemia in a major blood vessel can lead to localized inflammation in the blood vessel and surrounding structures, leading to porous blood vessel walls. This leads to microorganisms entering nearby tissue, causing damage. This is particularly dangerous in the splanchnic circulation as the liver and stomach are usually affected first.
- Liver disease: The liver receives more than half of the total blood in the splanchnic circulation. Diseases such as cirrhosis, cancer, liver abscess would increase the blood pressure in the liver in order to shunt blood into other systemic arteries through the liver anastomosis, which can cause a number of complications. Liver diseases are treated by surgery.

d) Coronary circulation: This is the circulation of blood in the blood vessels that supply the heart muscle (myocardium). The blood vessels which supply the myocardium are the coronary arteries contain oxygenated blood and the cardiac veins which carry the deoxygenated blood to the heart.

The coronary arteries are two in number, originating from the left side of the heart at the beginning of the aorta, specifically in two dilations/sinuses in the wall of the aorta just superior to the aortic valve. The two dilations; left posterior aortic sinus and anterior aortic sinus, give rise to the left and right coronary arteries respectively. The left coronary artery supplies the left atrium, ventricle and the interventricular septum while the right coronary artery supplies the right atrium, portions of both ventricles and the impulse conducting system in the heart. The coronary arteries give off many branches with anastomose with each other.

The cardiac veins, apart from the anterior cardiac veins and thebesian veins, unite to form the coronary sinus, which is a large vessel that empties into the right atrium. The anterior cardiac veins and thebesian veins empty directly into the right atrium.

Clinical significance

- Atherosclerosis: This occurs when fat deposits accumulate in the wall of an artery, reducing or completely blocking blood flow. Atherosclerosis in the coronary arteries can cause an heart attack or chest pain due to ischemia.
- Embolism: This occurs when a blood clot which forms in a blood vessel breaks off

and completely blocks blood flow in a smaller blood vessel. It can occur due to injury, atherosclerosis, heredity, etc. Embolism in a smaller coronary artery can lead to ischemia in the heart. This condition is treated with anticoagulants and in more serious cases, surgery.

- e) Cutaneous circulation: This is the overall blood supply to the skin. It consists of cutaneous arterioles, venules and capillaries. The arterioles carry oxygenated blood from the larger arteries to the skin and the venules carry deoxygenated blood to the larger veins. The capillaries are the point of material and gaseous exchange between the blood and skin tissue. Sometimes the arterioles anastomose directly with the venules to form arteriovenous anastomosis which are usually found in the skin of the hands, feet, nose, lips and ear lobules.

The blood flow to the skin is greatly influenced by temperature because the skin is exposed to the external environment. During heat, blood flow to the skin increases and decreases during cold. The nervous system also maintains blood flow to the skin by controlling the rate and frequency of dilation and constriction of blood vessels. The skin is not a metabolically active tissue, so it has little energy requirements and different blood flow.

Clinical significance

- **Diabetes mellitus**: A digestive condition which is caused by reduced production/lack of insulin in the body. Insulin is an hormone which reduces the level of glucose in the blood. Excess glucose in the body damages tissues and nerves. A damaged nervous system disrupts the rate of blood flow to the skin, deviating blood flow from the skin and reducing sensitivity of the skin.

3. Discuss the cardiovascular adjustment that occurs during exercise

During exercise, cardiac output (CO) increases to provide the blood flow needed to supply the contracting skeletal muscles. As this occurs, the blood vessels undergo controlled vasodilatation in order to increase and stabilize blood pressure. This entire process is governed by the autonomic nervous system, vasodilatory substances and the active skeletal muscles.

The autonomic nervous system controls the heart rate and initiates changes in systemic vascular resistance. Neural feedback from contracting muscles, coupled with motor

control and sympathetic activity, contribute to maintain blood pressure during exercise. Vasodilatory substances are released from the active skeletal muscles and surrounding tissues which bind to chemoreceptors in the blood vessels, coupled with nervous control, cause vasodilatation in blood vessels.

The main objective of the blood pressure increase is to enable a tight coupling between cardiac output and whole body oxygen uptake (Vo_2) which keeps the working state of the muscles intact throughout exercise. This cycle is maintained even in the absence of nervous control.