NAME: AWE ONAJEVWE ANNE

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COURSE TITLE: PHYSIOLOGY

ASSIGNMENT ON CARDIOVASCULAR PHYSIOLOGY FOR MBBS 200L.

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

The mean arterial pressure (MAP) is an average blood pressure in an individual during a single cardiac cycle. It is the arithmetic product of the cardiac output and the total peripheral resistance (P=COxR). Mean arterial pressure is regulated by changes in cardiac output and systemic vascular resistance .Cardiac output is determined by the product of stroke volume and heart rate. Stroke volume is determined by ventricular preload. Ventricular preload is altered by changes in venous compliance and blood volume. Total blood volume is regulated by renal function, particularly renal handling of sodium and water. Blood volume shifts within the body as occurs when changing body posture, also change central venous pressure and preload. Heart rate, inotropy, venous compliance, and renal function are all strongly influenced by neurohumoral mechanisms. Tissue factors (e.g., adenosine, potassium ion, hydrogen ion, histamine) are chemicals released by parenchymal cells surrounding blood vessels and can significantly alter vessel diameter. In general, tissue factors are more concerned with regulating organ blood flow than systemic arterial pressure; however, any change in vessel tone will affect both organ blood flow and systemic arterial pressure. Finally, neurohumoral mechanisms play a very important role in regulating systemic vascular resistance and arterial pressure, particularly in certain forms of secondary hypertension. Neurohumoral mechanisms are regulated principally by arterial baroreceptors and to a lesser extent by chemoreceptors. Many of the therapies used for reducing arterial pressure involve inhibiting the action of neurohumoral mechanisms.

2. Write short notes on the following

a) Pulmonary circulation

The 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 vessels of the pulmonary circulation are the pulmonary arteries and the pulmonary veins. Deoxygenated blood leaves the heart through the right ventricle through the pulmonary artery, goes to the lungs, and then re-enters the heart. From the right atrium, the blood is pumped through the tricuspid valve into the right ventricle. Blood is then pumped from the right ventricle through the pulmonary valve and into the main pulmonary artery. The pulmonary arteries carry deoxygenated blood to the lungs, where carbon dioxide is released and oxygen is picked up during respiration. The pulmonary vein returns oxygenated blood to the left atrium of the heart. The oxygenated blood then leaves the lungs through pulmonary veins, which return it to the left part of the heart, completing the pulmonary cycle. This blood then enters the left atrium, which pumps it through the mitral valve into the left ventricle. From the left ventricle, the blood passes through the aortic valve to the aorta. The blood is then distributed to the body through the systemic circulation before returning again to the pulmonary circulation. From the right ventricle, blood is pumped through the semilunar pulmonary valve into the left and right main pulmonary arteries (one for each lung), which branch into smaller pulmonary arteries that spread throughout the lungs.

b) Circle of Willis

The Circle of Willis is the joining area of several arteries at the inferior part 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. It helps blood flow from both the front and back sections of the brain. The circle of Willis is an important junction of arteries at the base of the brain. The structure encircles the middle area of the brain, including the stalk of the pituitary gland and other important structures. Two arteries, called the carotid arteries, supply blood to the brain. They run along either side of the neck and lead directly to the circle of Willis.Each carotid artery branches into an internal and external carotid artery. The internal carotid artery then branches into the cerebral arteries. This structure allows all of the blood from the two internal carotid arteries to pass through the circle of Willis. The circle of Willis is critical, as it is the meeting point of many important arteries supplying blood to the brain. The circle of Willis plays an important role, as it allows for proper blood flow from the arteries to both the front and back hemispheres of the brain. The arteries that stem off from the circle of Willis supply much of the blood to the brain. The circle of Willis also serves as a sort of safety mechanism when it comes to blood flow. If a blockage or narrowing slows or prevents the blood flow in a connected artery, the change in pressure can cause blood to flow forward or backward in the circle of Willis to compensate. This mechanism could also help blood flow from one side of the brain to the other in a situation in which the arteries on one side have reduced blood flow. In an emergency, such as a stroke, this may reduce the damage or aftereffects of the event.

c) Sphlanchnic circulation

The splanchnic circulation is composed of gastric, small intestinal, colonic, pancreatic, hepatic, and splenic circulations, arranged in parallel with one another. The three major arteries that supply the splanchnic organs, cellac and superior and inferior mesenteric, give rise to smaller arteries that anastomose extensively. The circulation of some splanchnic organs is complicated by the existence of an intramural circulation. Redistribution of total blood flow between intramural vascular circuits may be as important as total blood flow. Numerous extrinsic and intrinsic factors influence the splanchnic circulation. Extrinsic factors include general hemodynamic conditions of the cardiovascular system, autonomic nervous system, and circulating neurohumoral agents. Intrinsic mechanisms include special properties of the vasculature, local metabolites, intrinsic nerves, paracrine substances, and local hormones. The existence of a multiplicity of regulatory mechanisms provides overlapping controls and restricts radical changes in tissue perfusion,

d) Coronary circulation

Coronary circulation is the circulation of blood in the blood vessels that supply the heart muscle (myocardium). Coronary arteries supply oxygenated blood to the heart muscle, and cardiac veins drain away the blood once it has been deoxygenated. Coronary arteries supply blood to the myocardium and other components of the heart. Two coronary arteries originate from the left side of the heart at the root of the aorta, just after the aorta exits the left ventricle. There are three aortic sinuses (dilations) in the wall of the aorta just superior to the aortic semilunar valve. Two of these, the left posterior aortic sinus and anterior aortic sinus, give rise to the left and right coronary arteries, respectively. The third sinus, the right posterior aortic sinus, typically does not give rise to a vessel. Coronary vessel branches that remain on the surface of the heart and follow the sulci of the heart are called epicardial coronary arteries. The left coronary artery distributes blood to the left side of the heart, the left atrium and ventricle, and the interventricular septum. The circumflex artery arises from the left coronary artery and follows the coronary sulcus to the left. Eventually, it will fuse with the small branches of the right coronary artery. The larger anterior interventricular artery, also known as the left anterior descending artery (LAD), is the second major branch arising from the left coronary artery. It follows the anterior interventricular sulcus around the pulmonary trunk. Along the way it gives rise to numerous smaller branches that interconnect with the branches of the posterior interventricular artery, forming anastomoses. An anastomosis is an area where vessels unite to form interconnections that normally allow blood to circulate to a region even if there may be partial blockage in another branch. The anastomoses in the heart are very small. Therefore, this ability is somewhat restricted in the heart so a coronary artery blockage often results in myocardial infarction causing death of the cells supplied by the particular vessel. The right coronary artery proceeds along the coronary sulcus and distributes blood to the right atrium, portions of both ventricles, and the heart conduction system. Normally, one or more marginal arteries arise from the right coronary artery inferior to the right atrium. The marginal arteries supply blood to the superficial portions of the right ventricle. On the posterior surface of the heart, the right coronary artery gives rise to the posterior interventricular artery, also known as the posterior descending artery. It runs along the posterior portion of the interventricular sulcus toward the apex of the heart, giving rise to branches that supply the interventricular septum and portions of both ventricles.

e) Cutaneous circulation

The 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. Some of the circulating blood volume in the skin will flow through arteriovenous anastomoses (AVAs) instead of capillaries. AVAs serve a role in temperature regulation. AVAs are low-resistance connections between the small arteries and small veins that supply and drain the skin. These allow the shunt of blood directly into the venous plexus of the skin, without it passing through capillaries. Since AVAs contain no capillary section, they are not involved in transport of nutrients to/from the tissues, but instead play a major role in temperature regulation.

3. Discuss the cardiovascular adjustment that occurs during exercise

Exercise causes the heart to pump blood into the circulation more efficiently as a result of more forceful and efficient myocardial contractions, increased perfusion of tissues and organs with blood, and increased oxygen delivery. The mean arterial pressure is the arithmetic product of the cardiac output and the total peripheral resistance (P=COxR). During exercise, the cardiac output increases more than the total resistance decreases, so the mean arterial pressure usually increases by a small amount. Pulse pressure, in contrast, markedly increases because of an increase in both stroke volume and the speed at which the stroke volume is ejected.

The cardiac output increase is due to a large increase in heart rate and a small increase in stroke volume. The heart rate increases because of a decrease in parasympathetic activity of SA node combined with increased sympathetic activity. The stroke volume increases because of increased ventricular contractility, manifested by an increased ejection fraction and mediated by sympathetic nerves to the ventricular myocardium. End-diastolic volume increase slightly. Because of this increased filling, the Frank-Starling mechanism also contributes to the increased stroke volume (stroke volume increases when end-diastolic volume increases).Cardiac output can be increased to high levels only if the peripheral processes favoring venous return to the heart are simultaneously activated to the same degree. Factor promoting venous return:

- Increased activity of the skeletal-muscle pump.
- Increased depth and frequency of respiration; respiratory pump.
- Sympathetically mediated increase in venous tone
- Greater ease of blood flow from arteries to veins.

One or more discrete control centers in the brain are activated by output from the cerebral cortex. Descending pathways from these centers transmit these centers' activity to the appropriate autonomic preganglionic neurons eliciting the firing patterns typical for exercise. These centers become activated before the exercise started. Once exercise is started, local chemical changes in the muscle can develop, particularly during high levels of exercise, because of imperfect matching between blood flow and metabolic demands. These changes activate chemoreceptors in the muscle. Afferent input from these receptors goes to the medullary cardiovascular centers. The result is a further increase in heart rate, myocardial contractility, and vasoconstriction in the non-activated organs. Mechanoreceptors of the exercising muscle are also stimulated and provide an excitatory input to the medullary cardiovascular center. As mean and pulsatile pressure increase, baroreceptors should respond to increase parasympathetic and decrease sympathetic outflows, a pattern designed to counter the rise in arterial pressure. During exercise the exact opposite occurs: the arterial baroreceptors increase the arterial pressure during exercise. The reason is that one of neuronal component of the central command output goes to the arterial baroreceptors and 'resets' them upwards as exercise begins. The resetting causes a decrease firing frequency in the baroreceptors, signaling for decreased parasympathetic and increase in sympathetic outflow.