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DEPARTMENT: MEDICINE AND SURGERY

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ASSIGNMENT

1. DISCUSS THE LONG TERM REGULATION OF MEAN ARTERIAL BLOOD PRESSURE

Arterial blood pressure can be defined as the pressure measured within large arteries in the systemic circulation. Arterial blood pressure is measured in millimeter of mercury and this number splits into systolic blood pressure and diastolic blood pressure. Systolic pressure refers to the maximum pressure within the large arteries when the heart muscle contracts to propel blood through the body. Diastolic pressure describes the lowest pressure within the large arteries during heart muscle relaxation between beating. Arterial pressure directly corresponds to cardiac output, arterial elasticity, and peripheral vascular resistance. Maintaining blood pressure within normal limits is essential.

Mean Arterial Blood Pressure (MAP) is the average arterial pressure throughout one cardiac cycle, systole, and diastole. MAP is influenced by cardiac output and systemic vascular resistance, each of which is under the influence of several variables. The MAP is usually estimated the MAP using the following formula: MAP = DP + 1/3(SP – DP) or MAP = DP + 1/3(PP).

Arterial pressure is continuously monitored by various sensors located within the body. Whenever arterial pressure varies from normal, multiple reflex responses are initiated, which cause the adjustments in cardiac output, and total peripheral resistance needed to return arterial pressure to its normal value. In the short term (seconds), these adjustments are brought about by changes in the activity of the autonomic nerves leading to the heart and peripheral vessels. In the long term (minutes to days), other mechanisms such as changes in cardiac output brought about by changes in blood volume play an increasingly important role in the control of arterial pressure.

There are several physiological mechanisms that regulate blood pressure in the long-term, they include:

1. Renin-Angiotensin-Aldosterone System (RAAS): Renin is a peptide hormone released by the granular cells of the juxtaglomerular apparatus in the kidney. It is released in response to:
* Sympathetic stimulation
* Reduced sodium-chloride delivery to the distal convoluted tubule
* Decreased blood flow to the kidney

Renin facilitates the conversion of angiotensinogen to angiotensin I which is then converted to angiotensin II using angiotensin-converting enzyme (ACE). Angiotensin II is a potent vasoconstrictor. It acts directly on the kidney to increase sodium reabsorption in the proximal convoluted tubule. Sodium is reabsorbed via the sodium-hydrogen exchanger. Angiotensin II also promotes release of aldosterone. ACE also breaks down a substance called bradykinin which is a potent vasodilator. Therefore, the breakdown of bradykinin potentiates the overall constricting effect. Aldosterone promotes salt and water retention by acting at the distal convoluted tubule to increase expression of epithelial sodium channels. Furthermore, aldosterone increases the activity of the basolateral sodium-potassium ATP-ase, thus increasing the electrochemical gradient for movement of sodium ions. More sodium collects in the kidney tissue and water then follows by osmosis. This results in decreased water excretion and therefore increased blood volume and thus blood pressure.

1. Anti-Diuretic Hormone (ADH)

The second mechanism by which blood pressure is regulated is release of Anti Diuretic Hormone (ADH) from the OVLT of the hypothalamus in response to thirst or an increased plasma osmolarity. ADH acts to increase the permeability of the collecting duct to water by inserting aquaporin channels (AQP2) into the apical membrane. It also stimulates sodium reabsorption from the thick ascending limb of the loop of Henle. This increases water reabsorption thus increasing plasma volume and decreasing osmolarity.

Other factors that can affect long-term regulation of blood pressure are natriuretic peptides. These include:

Atrial natriuretic peptide (ANP) is synthesized and stored in cardiac myocytes. It is released when the atria are stretched, indicating of high blood pressure.ANP acts to promote sodium excretion. It dilates the afferent arteriole of the glomerulus, increasing blood flow (GFR). Moreover, ANP inhibits sodium reabsorption along the nephron. Conversely, ANP secretion is low when blood pressure is low.

Prostaglandins act as local vasodilators to increase GFR and reduce sodium reabsorption. They also act to prevent excessive vasoconstriction triggered by the sympathetic nervous and renin-angiotensin-aldosterone systems.

1. WRITE SHORT NOTES ON THE FOLLOWING:
2. Pulmonary Circulation: Pulmonary circulation moves blood between the heart and the lungs. It transports deoxygenated blood to the lungs to absorb oxygen and release carbon dioxide. The oxygenated blood then flows back to the heart. 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.
3. Circle of Willis: The Circle of Willis is the joining area of several arteries at the bottom (inferior) side of the brain. It encircles the stalk of the pituitary gland and provides important communications between the blood supply of the forebrain and hindbrain (i.e., between the internal carotid and vertebro-basilar systems following obliteration of primitive embryonic connections). At the Circle of Willis, the internal carotid arteries branch into smaller arteries that supply oxygenated blood to over 80% of the cerebrum.
4. Splanchnic 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, celiac and superior and inferior mesenteric, give rise to smaller arteries that anastomose extensively. The splanchnic circulation is composed of the blood flow originating from the celiac, superior mesenteric, and inferior mesenteric arteries and is distributed to all abdominal viscera. The splanchnic circulation receives over 25% of the cardiac output and contains a similar percentage of the total blood volume under normal conditions. Thus, the splanchnic circulation can act as a site of regulation of distribution of cardiac output and also as a blood reservoir.
5. 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. The 2 main coronary arteries are the left main and right coronary arteries. Since coronary arteries deliver blood to the heart muscle, any coronary artery disorder or disease can have serious implications by reducing the flow of oxygen and nutrients to the heart muscle. This can lead to a heart attack and possibly death. Atherosclerosis (a buildup of plaque in the inner lining of an artery causing it to narrow or become blocked) is the most common cause of heart disease.
6. Cutaneous Circulation: 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 will flow through arteriovenous anastomoses (AVAs) instead of capillaries. 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.
7. DISCUSS THE CARDIOVASCULAR ADJUSTMENT THAT OCCURS DURING EXERCISE

The severity of exercise determines the cardiovascular effect the exercise will have on the body. The categorization of exercises based on severity is as follows;

a. Mild Exercise: Mild exercise is the very simple form of exercise like slow walking. Little or no change occurs in cardiovascular system during mild exercise.

b. Moderate Exercise: Moderate exercise does not involve strenuous muscular activity. So, this type of exercise can be performed for a longer period. Exhaustion does not occur at the end of moderate exercise. The examples of this type of exercise are fast walking and slow running.

c. Severe Exercise: Severe exercise involves strenuous muscular activity. The severity can be maintained only for short duration. Fast running for a distance of 100 or 400 meters is the best example of this type of exercise. Complete exhaustion occurs at the end of severe exercise.

 EFFECTS OF EXERCISE ON CARDIOVASCULAR SYSTEM

Exercise has varying effects on the different aspects of the cardiovascular system. It includes;

 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 thermoregulatory system is activated. This in turn, causes secretion of large amount of sweat leading to:

i. Fluid loss

ii. Reduced blood volume

iii. Hemoconcentration

iv. Sometimes, severe exercise leads to dehydration.

 3. ON HEART RATE: Heart rate increases during exercise. Even the thought of exercise or preparation for exercise increases the heart rate. This is because of impulses from cerebral cortex to medullary centers, which reduces vagal tone. In moderate exercise, the heart rate increases to 180 beats/minute. In severe muscular exercise, it reaches 240 to 260 beats/minute. Increased heart rate during exercise is mainly because of vagal withdrawal. Increase in sympathetic tone also plays some role. Increased heart rate during exercise is due to four factors:

i. Impulses from proprioceptors, which are present in the exercising muscles; these impulses act through higher centers and increase the heart rate

ii. Increased carbon dioxide tension, which acts through medullary centers

iii. Rise in body temperature, which acts on cardiac centers via hypothalamus, increased temperature also stimulates SA node directly

iv. Circulating catecholamines, which are secreted in large quantities during exercise.

 4. ON CARDIAC OUTPUT: Cardiac output increases up to 20 L/minute in moderate exercise and up to 35 L/minute 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 is3 to 4 mL/100 g of the muscle/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 vasodilatation in muscles. The sympathetic nerve fibers causing vasodilatation in skeletal muscle are called sympathetic cholinergic fibers since fibers secrete acetylcholine instead of noradrenalin. 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:

i. Hyper apnea

ii. Hypoxia

iii. Potassium ions

iv. Metabolites like lactic acid

v. Rise in temperature

vi. Adrenaline secreted from adrenal medulla

vii. 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. In severe exercise involving isotonic muscular contraction, the systolic pressure enormously increases but the diastolic pressure decreases. Decrease in diastolic pressure is because of the decrease in peripheral resistance. Decrease in peripheral resistance is due to vasodilatation caused by metabolites. During exercise involving isometric contraction, the peripheral resistance increases. So, the diastolic pressure also increases along with systolic pressure.

Blood Pressure after Exercise

Large quantities of metabolic end products are produced during exercise. These substances accumulate in the tissues, particularly the skeletal muscle. Metabolic end products cause vasodilatation. So, the blood pressure falls slightly below the resting level after the exercise. However, the pressure returns to resting level quickly as soon as the metabolic end products are removed from muscles.