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

ANSWER

LONG TERM REGULATION OF MEAN ARTERIAL BLOOD PRESSURE;

When blood pressure alters slowly in several days/months/years, the nervous mechanism adapts to the altered pressure and loses the sensitivity for the changes. It cannot regulate the pressure anymore. In such conditions, the renal mechanism operates efficiently to regulate the blood pressure. Therefore, it is called long term regulation.

Kidneys regulate arterial blood pressure by two ways:

1. By regulation of ECF volume: when blood pressure increases, kidneys excrete large amounts of water and salt, particularly sodium, by means of PRESSURE DIURESIS and pressure natriuresis. Pressure natriuresis is the excretion of large quantity of sodium in urine. Because of diuresis and natriuresis, there is a decrease in ECF volume and blood volume, which in turn brings the arterial blood pressure back to normal level.
   When blood pressure decreases, the reabsorption of water from renal tubules is increased. This in turn, increases ECF volume, blood volume and cardiac output, resulting in restoration of blood pressure.

2. Through renin-angiotensin mechanism: *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 **i**ncreasing the electrochemical gradien**t** 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.

QUESTION 2; Write short notes on the following:

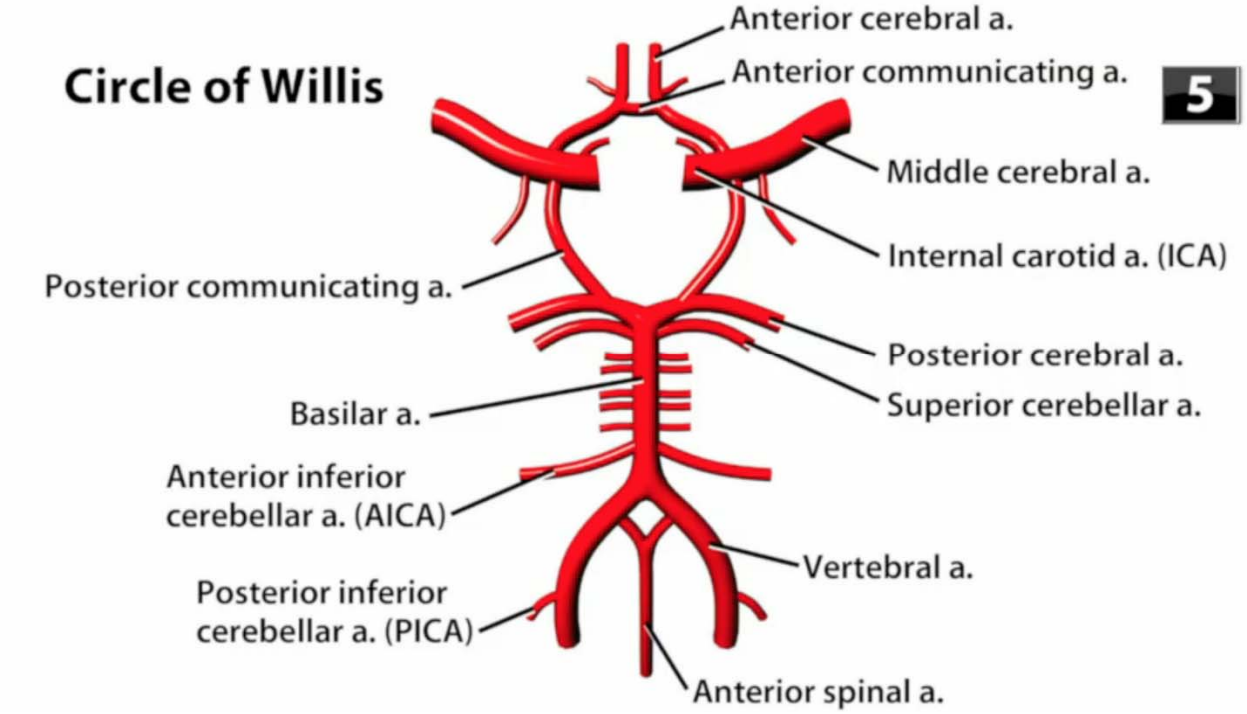
a. Pulmonary circulation- this is also known as lesser circulation. The **pulmonary circulation** is the portion of the circulatory system which carries deoxygenated blood away from the right ventricle, to the lungs, and returns oxygenated blood to the left atrium and ventricle of the heart.[1] The term pulmonary circulation is readily paired and contrasted with the systemic circulation. The vessels of the pulmonary circulation are the pulmonary arteries and the pulmonary veins.

*A separate system known as the bronchial circulation supplies oxygenated blood to the tissue of the larger airways of the lungs.

MECHANISM- Deoxygenated blood leaves the heart, goes to the lungs, and then re-enters the heart; Deoxygenated blood leaves through the right ventricle through the pulmonary artery. From the right atrium, the blood is pumped through the tricuspid valve (or right atrioventricular 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. Arteries are further divided into very fine capillaries which are extremely thin-walled. 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 a ring-like arterial structure located at the base of the brain that supplies blood to the brain and surrounding structures. It is a component of the

cerebral circulation and is comprised of five arteries.



The circle of Willis 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 vertebra-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. The circle of Willis begins to form when the right and left internal carotid artery (ICA) enters the cranial cavity and each one divides into two main branches: the anterior cerebral artery (ACA) and middle cerebral artery (MCA).The anterior cerebral arteries are then united and blood can cross flow by the anterior communicating (ACOM) artery.

FUNCTION-Several of the arteries of the circle of Willis branch into smaller vessels that directly provide blood to the brain.

Arteries are blood vessels that deliver oxygen and nutrient-rich blood to the cells of the body. Veins take blood from cells and back to the heart and then to the lungs to be replenished with oxygen. All of the blood vessels that make up the circle of Willis are arteries, and none of them are veins.

The ACAs provide blood to the anterior (front) region of the brain. This area of the brain is involved with decision-making, self-control, thinking, planning, emotions, and physical movements of the body.

The PCAs provide blood to areas in the back of the brain, including the occipital lobe (which integrates vision), the brainstem (which controls eye and face movement and breathing) and the cerebellum (which controls coordination).

c. Splanchnic circulation: The term 'splanchnic circulation' describes the blood flow to the abdominal gastrointestinal organs including the stomach, liver, spleen, pancreas, small intestine, and large intestine. 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.

It constitutes three portions;

- Mesenteric circulation supplying blood to the gastro intestinal tract.
- Splenic circulation supplying blood to the spleen.
- Hepatic circulation supplying blood to the liver.

d . Coronary circulation: this is the circulation of blood through blood vessels of the heart muscle (myocardium). It is responsible for functional blood supply to the heart muscle itself. Blood flowing through the chambers of the heart does not nourish the myocardium. When functioning normally, blood in coronary blood vessels supply adequate oxygen to the myocardium. Like systemic circulation and pulmonary circulation, coronary circulation is also made of arteries, arterioles, capillaries, venules and veins.

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 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.

Regulation of cutaneous blood flow-this is mainly regulated by body temperature. Hypothalamus plays an important role in regulating cutaneous blood flow. When body temperature increases, the hypothalamus in turn causes cutaneous vasodilation by acting through medullary vasomotor center. Now, blood flow increases in skin. 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. Therefore, the blood flow to the skin decreases and prevents the heat loss from skin.

Functions of cutaneous circulation

Cutaneous circulation performs two functions;

- Supply of nutrition to skin.
- Regulation of body temperature by heat loss.

QUESTION 3; Discuss the cardiovascular adjustment that occurs during exercise?

ANSWER

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 reduction in end-systolic dimensions can be related to increased contractility, mediated by beta adrenergic stimulation. Beta adrenergic blockade prevents the inotropic response, the decrease in end-systolic dimensions, and approximately 50% of the tachycardia of exercise. The enhanced cardiac output is distributed preferentially to the exercising muscles including the heart. Blood flow to the heart increases fourfold to fivefold as well, mainly reflecting the augmented metabolic requirements of the myocardium due to near maximal increases in cardiac rate and contractility. Blood flow to the inactive viscera (e.g., kidney and gastrointestinal tract) is maintained during severe exercise in the normal dog. It is suggested that local auto regulatory mechanisms are responsible for maintained visceral flow in the face of neural and hormonal autonomic drive, which acts to constrict renal and mesenteric vessels and to reduce blood flow. However, in the presence of circulatory impairment, where oxygen delivery to the exercising muscles is impaired as occurs to complete heart block where normal heart rate increases during exercise are prevented, or in congestive right heart failure, where normal stroke volume increases during exercise are impaired, or in the presence of severe anemia, where oxygen-carrying capacity of the blood is limited, visceral blood flows are reduced drastically and blood is diverted to the exercising musculature. Thus, visceral flow is normally maintained during severe exercise as long as all other compensatory mechanisms remain intact. However, when any other compensatory mechanism is disrupted (even the elimination of splenic reserve in the dog), reduction and diversion of visceral flow occur.

IN SUMMARY- the cardiovascular adjustment during exercise simply results in an increased cardiac output. This long process can be broken down into 5 simple steps.

- BARORECEPTORS DETECT THE IMPULSE.
- THIS STIMULATES THE CARDIAC COORDINATING CENTER.
- THE SYMPATHETIC NERVOUS SYSTEM IS STIMULATED VIA ACCELERATOR.
- THIS CAUSES AN INCREASED IMPULSE AT THE SINOATRIAL NODE.
- INCREASED HEART RATE/ STROKE VOLUME THEREBY INCREASING CARDIAC OUTPUT.