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18/MHS01/046

PHS 201

MEDICINE AND SURGERY/MHS

200 LEVEL

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

Kidneys play an important role in the long term regulation of arterial blood pressure. When blood pressure alters slowly in several days or months or years, the nervous mechanism adapts to the altered pressure and loses the sensitivity for the changes. It cannot regulate the pressure any more. In such conditions the renal mechanism (long term mechanism) works efficiently to regulate the blood pressure for a longer period of time, maintaining its homeostatic function. Kidney regulates blood pressure in two ways;

- By regulation of ECF volume
- Through renin-angiotensin aldosterone system

BY REGULATION OF ECF VOLUME

When the blood pressure increases, kidneys excrete large amounts of water and salt, particularly sodium, by means of pressure diuresis (excretion of large amounts of water in urine) and pressure natriuresis (excretion of large quantity of sodium in urine). Because of these two, 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.

THROUGH RENIN-ANGIOTENSIN ALDOSTERONE SYSTEM

If any factor, for example, dehydration for hours or reduction in blood volume occurs, plasma volume also drops which causes a decrease in blood pressure. This drop in blood pressure causes reduced renal blood supply and decreased perfusion to kidney as well. When kidney senses less perfusion, it secretes renin into bloodstream from its juxtaglomerular cells which converts angiotensinogen to angiotensin I. Liver produces and secretes angiotensinogen. Angiotensin I is converted to angiotensin II by ACE (Angiotensin converting enzyme). ACE is located on the surface of the lungs and on renal endothelium. Angiotensin II interacts with receptors and target organs.

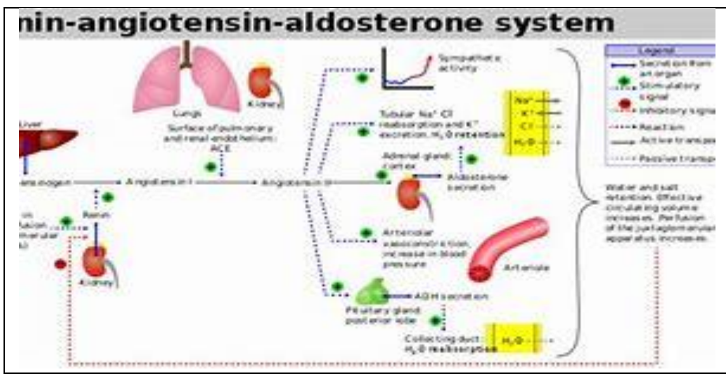
The main functions of angiotensin II are;

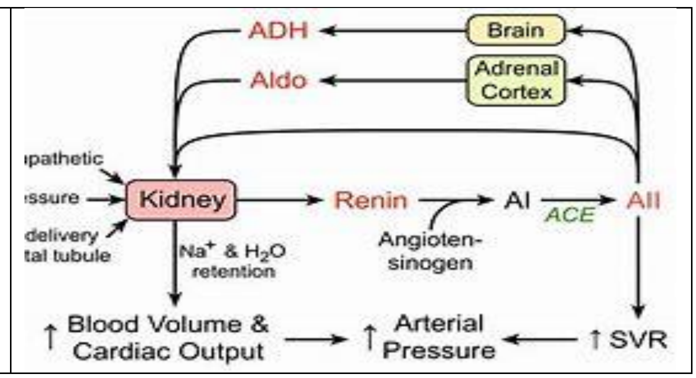
- It promotes sympathetic activity by acting directly on sympathetic nervous system by increasing release of epinephrine and norepinephrine from adrenal medulla which leads to an increase in heart rate, leading to an increase in cardiac output, in turn, increasing blood pressure.

- Angiotensin II causes tubular reabsorption and secretion. It increases the reabsorption of sodium alongside water into the blood at the same time excreting potassium to maintain neutrality.
- The major role of angiotensin II is to secrete aldosterone from adrenal cortex which directly promotes tubular reabsorption of sodium and water retention at the expense of potassium. This helps to increase blood volume which in turn increases cardiac output, finally increasing blood pressure.
- It causes arterial vasoconstriction I.e. constriction of arterioles, which increases blood pressure and peripheral resistance.
- Additionally, it works on pituitary gland and promotes the release of ADH which helps retention of water as well.

APPLIED PHYSIOLOGY

- ➢ Beta blockers cause liver to release less angiotensinogen so as to reduce blood pressure and its amount in blood.
- ➢ Renin inhibitor blocks the effect of renin.
- ➢ ACE inhibitors causes hyperkalemia, vasodilation
- ➢ ACE inhibitors can be useful in dealing with hypertension.





2. Write short note on;
   a. **<u>Pulmonary Circulation</u>**

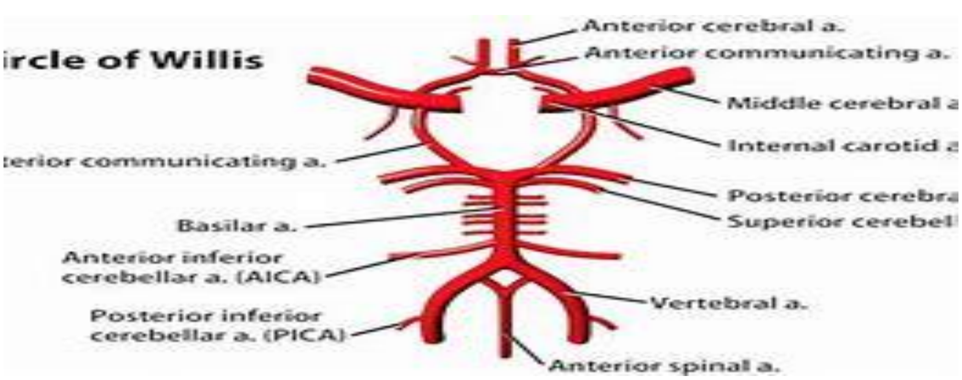
This is a portion of circulatory system which carries deoxygenated blood away from the right ventricle, to the lungs, and returns oxygenated blood to the left atrium and ventricle of the heart. This circulation works at a low resistance, low pressure of 25/10mmHg and at a high capacitance. Pulmonary trunk arises from the right ventricle and divides into right and left pulmonary arteries which convey the deoxygenated blood to the right and left lung, respectively. The blood circulates through a capillary plexus intimately related to the walls of alveoli and receives oxygen from the alveolar air. The blood which is now oxygenated is returned to the heart through the pulmonary vein. The vessels of pulmonary circulation are the pulmonary arteries and pulmonary veins. Pulmonary vessels contain about 600ml of blood at rest. Since pulmonary vessels act as capacitance vessels their blood content can vary from 200-900ml. pulmonary blood volume decreases in the physiological conditions like standing and is shifted to systemic circulation to compensate for the blood pooled in the leg veins due to gravity. Pulmonary vessels act as a reservoir of blood. Pulmonary blood flow is nearly equal to cardiac output since the right ventricle also pushes the same amount of blood simultaneously into the pulmonary circulation as the left ventricle pushes in the systemic. Blood flow through the lungs depends upon pulmonary arterial pressure, pulmonary venous pressure and alveolar pressure.

Respiratory gas exchange is the major function of pulmonary circulation. Other functions include acts as a reservoir for the left ventricle, filters for removal of emboli and other particles from blood, removes fluid from alveoli, absorption of drugs, synthesis of angiotensinogen converting enzyme. Efferent sympathetic vasoconstrictor nerves richly innervate the pulmonary blood vessels. This nerves have no resting discharge and tone, which means they can only show an increase in activity when stimulated and these participate in vasomotor reflexes. Clinical significances include: pulmonary hypertension, pulmonary embolus, cardiac shunt, pulmonary shunt, vascular pressure.

b. **Circle of Willis**

This is a part of cerebral circulation. It is a free anastomosis between the two internal carotid arteries, the two cerebral arteries, the anterior and two posterior communicating arteries (from vertebral arteries) which equalize pressure on the arteries of the two sides. In this way, the circulus arteriosus allows blood that enters by either internal carotid or vertebral artery to be distributed to any part of both cerebral hemispheres. Six large arteries taking part in the formation of circle of Willis supply by their central and cortical branches to the brain substance. Here, the internal carotid arteries branch into smaller arteries that supply oxygenated blood to over 80% of the cerebrum. The arrangement of the brains arteries into the circle of Willis creates redundancy for collateral circulation in the cerebral circulation. If one part of the circle becomes blocked or narrowed or one of the arteries supplying the circle is blocked or narrowed, blood flow from the other blood vessels can often preserve the cerebral perfusion well enough to avoid the symptoms of ischemia.

Redundancy of circle of Willis can lead to reduced cerebral perfusion. In subclavian steal syndrome, blood is stolen from the circle of Willis to preserve blood flow to the upper limb and this results into proximal stenosis of subclavian artery, which eventually feeds the circle of Willis via internal carotid arteries and vertebral arteries.



c. Splanchnic circulation

This is also known as visceral circulation and it consists of three portions:

- Mesenteric circulation supplying blood to GI tract with different mesenteric vessels such as; coeliac trunk, which divides into left gastric artery, hepatic artery and splenic artery, superior and inferior mesenteric artery
- Splenic circulation supplying blood to spleen
- Hepatic circulation supplying blood to liver

A unique feature about splanchnic circulation is that the blood from mesenteric bed and spleen forms a major amount of blood flowing to liver. Blood flows to liver from GI tract and spleen through hepatic portal system. Another unique feature is that the venous blood from GIT viscera is not directly carried to the heart through systemic veins, but is carried to the liver forming hepatic portal system.

<u>Mesenteric circulation</u> can be regulated locally, by contraction and relaxation of GI tract, by nervous factor (sympathetic and parasympathetic nerves) or by functional hyperemia-chemical factors. This circulation is constituted by the blood supplied to intestine and pancreas, about 100ml /min, by series of parallel circulations via the braches of superior and inferior mesenteric arteries.

<u>Splenic circulation</u> is regulated by sympathetic nerve fibers. The spleen is the main reservoir for blood in the splenic venous sinuses and splenic pulp. Splenic artery is a branch of coeliac trunk which supplies about 200ml of blood/min to the spleen during rest via its splenic branches which enter the hilum of the spleen.

<u>Hepatic circulation</u> can be regulated by systemic blood pressure, splenic contraction, movements of intestine, chemical factors which cause vasodilation, sympathetic and parasympathetic nerve fibers. The liver receives blood from hepatic artery and portal vein. Liver receives maximum amount of blood as compared to any other organ. Liver receives about 1500ml of blood/min from hepatic artery, supplying 300-400ml of blood which caters for metabolic requirements of the liver tissue, and portal vein which collects blood from the mesenteric and splenic vascular bed supplies about 1100-1200ml/min of the total blood. The hepatic and portal blood streams meet in the sinusoids. The functional liver is acinus. Blood supplied by hepatic arteries to the liver does not take part in portal circulation.

d. Coronary circulation

This is the circulation of blood in blood vessels that supply the heart muscle (myocardium). Heart muscle is supplied by two coronary arteries- left and right coronary arteries- which are the first branches of aorta. The arteries supply oxygenated blood to the heart muscle and cardiac veins drain away the blood once it has been deoxygenated. Interruption to the supply of blood to heart cold lead to myocardial infarction. Normal blood flow through coronary circulation is about 250mL/minute. It forms 5% of cardiac output. Its blood flow can be measured using an electromagnetic flowmeter or Doppler flowmeter, kety method, coronary angiographic technique or using ficks principle. Blood flow through coronary arteries isn't constant. It decreases during systole due to compression of intramural vessels and increases during diastole due to relaxation of intramural vessels. It is regulated by autoregulation and by local vascular response to needs of cardiac muscle like need for oxygen, metabolic factors etc.

A continuous flow of blood to the heart is essential to maintain an adequate supply of oxygen and nutrients. The coronary blood flow shows changes during the phases of the cardiac cycle. The blood flow is determined by the balance between aortic pressure and the resistance offered to the blood flow during various phases of cardiac cycle. Factors affecting coronary blood flow include; mean aortic pressure, muscular exercise, emotional excitement, hypotension, hormones, heart rate, effects of ions, metabolic factors, temperature.

Coronary artery disease is the heart disease caused by inadequate blood supply to cardiac muscle due to occlusion of coronary artery and cam lead to myocardial infarction.

e. **<u>Cutaneous circulation</u>**

The main function of cutaneous circulation is to aid in the regulation of boy temperature. Resting cutaneous blood when a person is at thermal equilibrium with the environment is about 10-15ml/min/100g of skin tissue. During exposure to cold, cutaneous blood flow falls to about $1/10^{th}$ of resting blood flow (1ml/min/100g tissue). During exposure to heat, blood flow may increase ten times of resting blood flow (150ml/min/100g of tissue). During heat stress, blood flow to the area with rich A-V anastomosis increases more (75ml/min/100g) as compared to the rest of the skin (about 25ml/min/100g). Amount of blood and degree of oxygenation affect the skin color tinge which may be reddish, bluish or some shade in between. Cutaneous arterioles form a dense network under the dermis layer of skin. Other blood vessels include meta-arterioles, cutaneous capillaries, venules, (form an extensive sub papillary venous plexus which holds large quantity of blood), arteriovenous anastomoses (located in the distal parts of the extremities, nose, lips and ear lobules. Cutaneous blood flow is regulated by the nervous control instead of metabolic control and these include hypothalamic control mechanism, baroreceptor mediated reflex, cortical control mechanism. It is supplied sympathetic vasoconstrictor nerves and parasympathetic vasodilation nerves.

Certain peculiar cutaneous vascular responses are: white reaction, triple response, dermatographia, axon reflex, reactive hyperemia, cold vasodilation, cold vasoconstrictor.

3. <u>CARDIOVASCULAR ADJUSTMENT DURING EXERCISE</u>

Severe muscular exercise is the most stressful physiological condition that the cardiovascular homeostasis mechanisms face in everyday life. To meet the increased demand of energy during exercise, the primary cardiovascular response is in the form of:

- Increase in the cardiac output
- Blood pressure changes
- Changes in blood volume

Effect on blood volume

During exercise, more heat is produced during exercise and the thermoregulatory system is activated. This in turn causes secretion of large amount of sweat leading to fluid loss, reduced blood volume, hemoconcentration, and sometimes dehydration.

Effect on heart rate

Heart rate increases during exercise. Even the thought or anticipation of exercise increases the heart rate. This occurs because of the stimulation of cardiac excitatory center in medulla from cerebral cortex, which sends impulses that stimulate the sympathetic nerve and inhibit the parasympathetic nerve, thereby reducing vagal tone. In moderate exercise, heart rate increases to 180beats/min. In severe muscular exercise, it reaches 240-260beats/min. Increased heart rate during exercise is mainly because of vagal withdrawal. Increased heart rate also occurs as a result of:

-secretion of catecholamine in large quantities during exercise,

- rise in body temperature, which acts on cardiac center via hypothalamus, increased temperature stimulates SA node also.

- impulses from proprioceptors, which are present in exercising muscles, they act through higher centers and increase the heart rate.

Effect on cardiac output

Cardiac output increases up to 20L/min in moderate exercise and up to 35L/min 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. 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.

Effect on venous return

Venous return increases remarkably during exercise because of muscle pump, respiratory pump and splanchnic vasoconstriction. An increase in venous output increases cardiac output.

Effect on blood pressure

During moderate isotonic exercise such as swimming, bicycling, walking etc., the systolic pressure is increased 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 decrease in peripheral resistance. Decrease in peripheral resistance is due to vasodilation caused by metabolites. During exercise involving isometric contraction like pushing heavy object, the peripheral resistance increases. So the diastolic pressure also increases along with systolic pressure. Mean arterial pressure may rise slightly during exercise.