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**LONG-TERM REGULATION OF MEAN ARTERIAL BLOOD PRESSURE(RENAL MECHANISM FOR BLOOD PRESSURE REGULATION)**

Renal mechanism is responsible for the long-term regulation of blood pressure. The kidneys play an important role in long-term regulation of blood pressure. When blood pressure alters slowly in several days/months/years, the nervous mechanism adapts to the altered pressure and loses sensitivity for the changes. It cannot regulate the pressure any more. In such conditions , the renal mechanism operates efficiently to regulate the blood pressure, Therefore, it is called long-term regulation.

The kidneys regulate arterial blood pressure by;

1.Regulation of ECF volume

2.Through Renin-Angiotensin mechanism.

1. By Regulation of Extracellular Fluid Volume

When the blood pressure increases, kidneys excrete large amount of water and salt, particularly sodium, by means of pressure diuresis and pressure natriuresis. Pressure diuresis is the excretion of large quantity of water in urine because of increased blood pressure. Even a slight increase in blood pressure doubles the water excretion. Pressure natriuresis is the excretion of large quantity of sodium in urine. Because of natriuresis and diuresis, there is a decrease in ECF volume and blood volume, which in turn brings the arterial blood pressure back to normal.

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

The Juxtaglomerular apparatus is responsible for the secretion of Renin. Renin is a peptide with 340 amino acids. Along with Angiotensin, renin forms the Renin-Angiotensin System, which is a hormone system that plays an important role in blood pressure regulation.

Renin is stimulated by;

* Fall in arterial blood pressure
* Reduction in the ECF volume
* Increased Sympathetic activity
* Decreased load of sodium and chloride in macula densa.

The Renin-Angiotensin system.

When Renin is released into the blood, it acts on a specific plasma protein called angiotensinogen or renin substrate. It is the a2-globulin. By the activity of renin, the angiotensinogen is converted into a decapeptide called angiotensin I. Angiotensin I is converted into angiotensin II which is an octapeptide by the activity of angiotensin-converting enzyme(ACE) secreted from lungs. Most of the conversion of angiotensin I into angiotensin II t in the lungs.

Angiotensin II has a short half-life of about 1 to 2 minutes. Then it is rapidly degraded into a heptapeptide called angiotensin III by angiotensinases, which are present in RBCs and vascular beds in many tissues. Angiotensin III is converted into angiotensin IV, which is a hexapeptide.

Action of Angiotensin II

When blood pressure and ECF volume decreases, renin secretion from kidneys is increased. It converts angiotensin into angiotensin I. This is converted into angiotensin II by ACE (angiotensin-Converting enzyme). Angiotensin II acts in two ways to restore blood pressure:

1. It causes constriction of arterioles in the body so that the peripheral resistance is increased and blood pressure rises. In addition, angiotensin II causes constriction of afferent arterioles in kidneys, so that glomerular filtration reduces. This results in retention of water an salts, increases ECF volume to normal level. This in turn increases the blood pressure to normal level.
2. Simultaneously, angiotensin II stimulates the adrenal cortex to secure aldosterone. This hormone increases reabsorption of sodium from renal tubules. Sodium reabsorption is followed by water reabsorption, resulting in increased ECF volume and blood volume. It increases blood pressure to normal.

Action of Angiotensin III & IV

Like angiotensin II, the angiotensins III & IV also increase blood pressure and stimulate the adrenal cortex to secrete aldosterone.

**PULMONARY CIRCULATION.**

Pulmonary circulation is also known as lesser circulation. This is the process whereby deoxygenated blood(venous blood) is pumped from the right ventricle of the heart, through the pulmonary artery to the lungs where exchange of gases occur between the blood and the alveoli of the lungs at pulmonary capillaries, and oxygenated blood(arterial blood) is returned from the lungs to the left atrium of the heart through the pulmonary veins.

Thus the left side of the heart contains oxygenated or arterial blood and the right side of the heart contains deoxygenated or venous blood.

**CIRCLE OF WILLIS**

The circle of Willis is an anastomosis of several important arteries at the bottom(inferior) side of the brain. It helps blood flow to both the posterior and anterior sections of the brain. The circle of Willis gets its name from the physician Thomas Willis who described this part of the anatomy in 1664. The branches of the basilar artery and internal carotid artery from the circle of Willis. Venous drainage is by sinuses which open into internal jugular vein.

**SPLANCHNIC CIRCULATION**

The term “Splanchnic circulation’ describes the blood flow to the abdominal gastrointestinal organs including the stomach, the liver, spleen, small intestine, large intestine and pancreas. Splanchnic or Visceral circulation constitutes three portions, which are;

1. Mesenteric circulation
2. Splenic circulation
3. Hepatic circulation

1. Mesenteric circulation:

This deals with the supply of blood flow to the Gastro Intestinal tract(the stomach, the pancreas and the intestine.

2. Splenic circulation:

Supplies blood to the spleen. The spleen is the major reservoir of blood. It is also known as the grave yard of Red blood cells(RBCs) because that is the site of destruction of senile Red blood cells.

3. Hepatic circulation:

Describes blood flow through an to the liver. The liver receives maximum amount of blood as compared to any other organ in the body since most of the metabolic activities occur in the liver. Blood flow to liver is 1,500ml/min, which forms about 30% of cardiac output. The liver receives blood from two sources;

* Hepatic artery: which normally carries about 400ml of blood to the liver, but is the source of 75% of the oxygen being transported to the liver.
* Portal vein: which normally carries about 1,100ml of blood to the liver. Although this is the major source of blood to the liver, it is responsible for only 25% of the oxygen transported to the blood. This is because the vessel carries blood which has already passed through the vessels of the GI tract where oxygen might have been used.

A unique feature of 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 portal system.

**CORONARY CIRCULATION**

Coronary circulation is one of the regional circulations. Circulation of blood through a particular organ or region of the body is called regional circulation. Splanchnic, pulmonary, cerebral, Renal, Capillary and Cutaneous circulations along with circulation through skeletal muscle are all regional circulations.

Coronary circulation 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 myocardium. Like systemic circulation and pulmonary circulation, coronary circulation is also made up of arteries, arterioles, capillaries, venules and veins.

Normal blood flow through coronary circulation is about 200ml/min. It forms 4% of cardiac output. It is about 70ml/min/100g of cardiac muscle.

**CUTANEOUS CIRCULATION**

Cutaneous circulation describes the circulation of blood though the skin. The importance of this circulation is for the supply of nutrients to the skin and also for regulation of body temperature by heat loss( vasodilation of blood vessels) and heat gain(vasoconstriction of blood vessels). Under normal conditions, the blood flow to skin is about 250ml/sq. m/min. When the body temperature increases, cutaneous blood flow increases up to 2,800ml/sq. m/min because of cutaneous vasodilation.

**CARDIOVASCULAR ADJUSTMENT THAT OCCURS DURING EXERCISE**

1. ON BLOOD:

Mild hypoxia developed during exercise stimulates the juxtaglomerular apparatus to secrete nd 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:

* Fluid loss
* Reduced blood volume
* Hemoconcentration
* Sometimes, severe exercise leads to even dehydration.

3. ON HEART RATE:

Heart rate increased during exercise. In moderate exercise, the heart rate increases to 180 beats per minute. In severe muscular exercise, it reaches 240 to 260 beats per minute. Increased heart rate during exercise is mainly because of vagal withdrawal. Increases in sympathetic tone also plays some role. Increase heart rate during exercise is due to four factors;

* Impulses from proprioceptor which are present in the exercising muscle; These impulses act through high centers and increase heart rate.
* Increased carbon dioxide tension, which acts through medullary centers.
* Rise in body temperature which acts on cardiac centers via hypothalamus, increased temperature also stimulates SA node directly
* Circulating catecholamines, secreted in large quantities during exercise.

4. ON CARDIAC OUTPUT

Cardiac output increases up to 20L/min during moderate exercise and up to 35L/min during severe exercise. Increase in cardiac output is directly proportional to the amount of oxygen consumed during exercise. During exercise, the cardiac output increases because of increase in heart rate and stroke volume. Hear rate increases due to increased force of contraction. Because of vagal withdrawal, sympathetic increases leading to increase on 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 great increase in the amount of blood flowing to skeletal muscles during exercise. In resting condition, the blood supply of blood to the skeletal muscle is 3-4ml/100 g of the muscle per minute. It increases up to 60 – 80 ml in moderate exercise and 90 – 120ml in severe exercise.

During the muscular activity stoppage of blood flow occurs when the muscle contracts. 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 preparation for exercise. It is due to the sympathetic activity. Sympathetic nerves cause vasodilation in muscles. The sympathetic nerve fibers causing vasodilation in skeletal muscles are called sympathetic cholinergic fibers since these fibers secrete acetylcholine instead of noradrenaline. 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 dilation of blood vessels of the muscles. Such factors are;

* Hypercapnia
* Hypoxia
* Potassium ions
* Metabolites like Lactic acid
* Rise in temperature
* Adrenaline secreted from adrenal medulla.
* 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 diastolic pressure decreases because of decreases in peripheral resistance. Decrease in peripheral resistance is due to vasodilation caused by metabolites.

During exercise involving isometric contraction, the peripheral resistance increases. So, the diastolic pressure also increases along with systolic pressure.