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MBBS/MHS

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PHYSIOLOGY

ASSIGNMENT

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

Answer

There are several physiological mechanisms that regulate blood pressure in the long term, the first of which is the renin-angiotensin aldosterone system. Others include the stress relaxation of the vasculature and shift of fluid through the capillary wall.

Renin-Angiotensin Aldosterone System (RAAS)

Many factors can affect the pressure-regulating level of the renal body fluid mechanism, one of these is aldosterone. Aldosterone promotes salt and water retention by acting on the distal convoluted tubule to increase expression of epithelial sodium channels. It increases the activity of the basolateral sodium-potassium ATP-ase, thus increasing the electrochemical gradient for movement of sodium ion. A decrease in arterial pressure leads within minutes to an increase in aldosterone secretion and over the next few hours or days, this effect plays an important role in modifying the pressure control characteristics of the renal body fluid mechanism.

Furthermore, the interaction of renin-angiotensin aldosterone with aldosterone and renal fluid mechanism is important. For instance, a person’s salt intake varies tremendously from one day to another, it can increase 10 to 15 times normal or decrease to one-tenth of the normal value and yet the regulated level of the mean arterial blood pressure will only change a few mmHg if the RAAS is fully operative. If not the blood pressure becomes very sensitive to change in salt intake. Thus, arterial pressure control begins with the life-saving measures of the nervous pressure control, then continues with the sustaining characteristics of the intermediate pressure controls and finally is stabilized at the long term pressure level by the RAAS.

One of the most important function of the RAAS is that it allows one to eat small or large amounts of salt without causing great changes in either ECF volume or arterial blood pressure. The initial effect of increased salt intake elevated the ECF volume and the arterial pressure. The increased arterial pressure causes blood flow through the kidney as well as other effects, which reduce the rate of secretion of renin to a much lower level and leads subsequently to decreased renal retention of salt and water, return of the ECF volume almost to normal and finally return of the arterial pressure almost to normal as well. Thus, RAAS is an automatic feedback mechanism that helps maintain the arterial pressure at or near normal level even when salt intake is increased. When salt is decreased below normal the opposite effects take place.

Increased salt intake

Increased ECF volume

Increased Arterial pressure

Decreased renin and angiotensin

Decreased renal retention of salt and water

Return of ECF volume near or at normal

Return of Arterial pressure to almost normal

1. Write short notes on the following:
2. Pulmonary Circulation

The circulation is divided into two: the systemic and pulmonary circulation. The pulmonary circulation is the system of transportation that shunts deoxygenated blood from the heart to the lungs to be re-saturated with oxygen before being dispersed into the systemic circulation. The lungs has two circulations, a high pressure, low flow circulation and a low pressure, high flow circulation. The high pressure, low flow circulation supplies systemic arterial blood to the trachea, the bronchial tree (including terminal bronchioles), the supporting tissues of the lings and the outer coats (adventitia) of the pulmonary arteries and veins. The bronchial arteries, which are branches of the thoracic aorta, supply most of the systemic arterial blood at a pressure that is only slightly lower than the aortic pressure. The low pressure, high flow circulation supplies venous blood from all parts of the body to the alveolar capillaries where oxygen is added and carbon (IV) oxide is removed. The pulmonary artery which receives blood from the right ventricle and its arterial branches carry blood to the alveolar capillaries for gas exchange. The pulmonary veins then return the blood to the left atrium to be pumped by the left ventricle through systemic circulation.

Deoxygenated blood from the lower half of the body enters the heart from the inferior vena cava, while deoxygenated blood from the upper half enters the heart via the superior vena cava. Both the superior 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 CO2 and is replenished with oxygen. Once full saturated with oxygen the blood is transported via the pulmonary vein into the left atrium which pumps blood through the mitrial valve and into the left ventricle. With a powerful contraction, the left ventricle expels oxygen-rich blood through the aortic valve then systemic circulation begins.

1. Circle of Willis

The circle of Willis is the joining area of several arteries at the inferior side of the brain. The circle of Willis gives rise to the four large arteries responsible for blood flow to the brain, namely; two carotid and two vertebral arteries. The arteries travel along the brain surface to give rise to pial arteries, which branch out into smaller arteries called the penetrating arteries and arterioles. The penetrating vessels are separated slightly from the brain tissue by an extension of the subarachnoid space called Virchow-Robin space. The penetrating vessels dive down into brain tissue, giving rise to intracerebral arterioles, which eventually branch into capillaries where exchange among the blood and the oxygen, nutrients, CO2, and metabolites occurs.

1. Splanchnic Circulation

The splanchnic circulation comprises the gastric, small intestine, colonic, pancreatic, hepatic and splenic circulations. They are arranged in parallel and fed by the celiac artery and the superior and inferior mesenteric arteries. The design of the system is such that all the blood that courses through the gut, spleen and pancreas then flows immediately into the liver by way of the portal vein. In the liver, the blood through millions of minute liver sinusoids and finally leaves the liver by way of hepatic veins that empties into the vena cava of the general circulation. This flow of blood through the liver, before it empties into the vena cava, allows the reticuloendothelial cells that line the liver sinusoids to remove bacteria and other particulate matter that might enter the blood from the gastrointestinal tract, thus preventing direct transport of potentially harmful agents into the remainder of the body.

1. Coronary Circulation

Coronary circulation, part of the systemic circulatory system that supplies blood to and provides drainage from the tissues of the heart. In the human heart, two coronary arteries arise from the aorta just beyond the semilunar valves; during diastole, the increased aortic pressure above the valves forces blood into the coronary arteries and thence into the musculature of the heart. Deoxygenated blood is returned to the chambers of the heart via coronary veins; most of these converge to form the coronary venous sinus, which drains into the right atrium. The heart normally extracts 70 to 75 percent of the available oxygen from the blood in coronary circulation, which is much more than the amount extracted by the other organs from their circulations.

1. Cutaneous Circulation

In skin, blood flow control is closely linked to regulation of body temperature. Skin blood flow is controlled largely by the central nervous system through the sympathetic nerves. Although, skin blood flow is only about 3ml/minute/100g of tissue in cool weather, large changes from that valve can occur as needed. When humans are exposed to body heating, skin blood flow may increase many fold, to as high as 7 to 8 L/min for the entire body.

Some of the circulating blood volume in the skin will flow through Arterovenous Anastomoses (AVAs) instead of capillaries. AVAs serve a role in temperature regulation. They 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.

1. Cardiovascular Adjustment During Exercise:

Three major effects occur during exercise that are essential for the cardiovascular and circulatory system to supply tremendous amounts of blood required by the muscles. They include:

1. An increase in cardiac output or pumping capacity of the heart, designed to enhance the delivery of oxygen and fuel the working muscles.
2. An increase in local blood flow to the working muscles.
3. Decrease in blood flow to other organs such as, the kidney, liver and stomach, thereby redirecting blood flow to the working muscles.

Cardiac output is the amount of blood pumped from the heart in one minute, it is simply calculated by heart rate in beats per minute times stroke volume, or the amount of blood ejected by the heart each beat. Thus in order to increase cardiac output we can increase heart rate, stroke volume or as it is during exercise the both are increased. The heart is stimulated to a greatly increased heart rate and increased pumping strength as a result of the sympathetic drive to the heart plus release of the heart from normal parasympathetic inhibition.

Most of the arterioles of the peripheral circulation are strongly contracted, except for the arterioles in the active muscles, which are strongly vasodilated by the local vasodilator effects in the muscles, as noted earlier. Thus the heart is stimulated to supply the increased blood flow required by the muscles, while at the same time blood flow through the most non muscular areas of the body is temporarily reduced thereby “lending blood supply to the muscles”. This process accounts for as much as 2 L/min of extra blood flow to the muscles which is exceedingly important when even a fractional increase in running speed may make the difference between life and death. Two of the peripheral circulation, the coronary and cerebral system, are spared this vasoconstrictor innervation.

An important effect of increased sympathetic stimulation during exercise is to increase the arterial pressure. This increased arterial pressure results from multiple stimulatory effects including; (1) vasoconstriction of the arterioles and small arteries in most tissue of the body except the brain and active muscles, including the heart (2) increased pumping activity by the heart and (3) a great increased in mean systemic filling pressure caused mainly by venous contraction. The effects working together almost always increase the arterial pressure during exercise.