Name: Njoku Michael Chidiebere

Matriculation number: 18/MHS01/227

Physiology

Assignment on Cardiovascular Physiology

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

Ans. Long term regulation involves mainly the regulation of extracellular fluid volume by natriuresis mechanisms residing in the kidney and by widespread actions of angiotensin 2.

Long term regulation of blood pressure:- There are several physiological mechanisms that regulate blood pressure in the long term.

¡) Renin- Angiotensin- Aldosterone system (RAAS)

Renin is a peptide hormone released by the granular cells of the juxtaglomerular apparatus in the kidney and 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.

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 synthesised 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 vasoconstriction triggered by the Sympathetic nervous and renin- angiotensin- aldosterone systems.

2. Short note on pulmonary circulation

A. Pulmonary circulation is the system of transportation that shunts de-oxygenated blood from the heart to the lungs to be re- saturated with oxygen before being dispersed into systemic 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. 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.

The pulmonary circulation loop is virtually bypassed in fetal circulation. The fetal lungs are collapsed, and blood passes from the right atrium directly into the left atrium through the foramen ovale: an open conduit between the paired atria, or through the ductus arteriosus: a shunt between the pulmonary artery and the aorta. When the lungs expand at birth, the pulmonary pressure drops and blood is drawn from the right atrium into the right ventricle and through the pulmonary circuit. Over the course of several months,

the foramen ovale closes, leaving a shallow depression known as the fossa ovalis.

A number of medical conditions can affect the pulmonary circulation.

- Pulmonary hypertension escribes an increase in resistance in the pulmonary arteries
- Pulmonary embolus is a blood clot, usually from a deep vein thrombosis that has lodged in the pulmonary vasculature. It can cause difficulty breathing or chest pain, is usually diagnosed through a CT pulmonary angiography or V/Q scan, and is often treated with anticoagulant such as heparin and warfarin.
- Cardiac shunt is an unnatural connection between parts of the heart that leads to blood flow that bypasses the lungs.
- Vascular resistance
- Pulmonary shunt

B. Circle of willis :- The circle of Willis (CoW) is an anatomical structure that provides an anastomotic connection between the anterior and posterior circulations, providing collateral flow to affected brain regions in the event of arterial incompetency.

The circle of Willis (also called Willis' circle, loop of Willis, cerebral arterial circle, and Willis polygon) is a circulatory anastomosis that supplies blood to the brain and surrounding structures. It is named after Thomas Willis (1621–1675), an English physician.

The arrangement of the brain's arteries into the circle of Willis creates redundancy (analogous to engineered redundancy) for collateral circulation in the cerebral circulation. If one part of the circle becomes blocked or narrowed (stenosed) 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.

C. Splanchnic circulation:- Mesenteric Circulation. The splanchnic circulation consists of the blood supply to the gastrointestinal tract, liver, spleen, and pancreas. It consists of two large capillary beds partially in series. The small splanchnic arterial branches supply the capillary beds, and then the efferent venous blood flows into the PV.

Splanchnic circulation – the circulation of the gastrointestinal tract originating at the celiac trunk, the superior mesenteric artery and the inferior mesenteric artery.

Splanchnic is usually used to describe organs in the abdominal cavity

D. 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.

Because the rest of the body, and most especially the brain, needs a steady supply of oxygenated blood that is free of all but the slightest interruptions, the heart is required to function continuously. Therefore its circulation is of major importance not only to its own tissues but to the entire body and even the level of consciousness of the brain from moment to moment. Interruptions of coronary circulation quickly cause heart attacks (myocardial infarctions), in which the heart muscle is damaged by oxygen starvation. Such interruptions are usually caused by ischemic heart disease (coronary artery disease) and sometimes by embolism from other causes like obstruction in blood flow through vessels.

The papillary muscles attach the mitral valve (the valve between the left atrium and the left ventricle) and the tricuspid valve (the valve between the right atrium and the right ventricle) to the wall of the heart. If the papillary muscles are not functioning properly, the mitral valve may leak during contraction of the left ventricle. This causes some of the blood to travel "in reverse", from the left ventricle to the left atrium, instead of forward to the aorta and the rest of the body. This leaking of blood to the left atrium is known as mitral regurgitation. Similarly, the leaking of blood from the right ventricle through the tricuspid valve and into the right atrium can also occur, and this is described as tricuspid insufficiency or tricuspid regurgitation.
The anterolateral papillary muscle more frequently receives two blood supplies: left anterior descending (LAD) artery and the left circumflex artery (LCX). It is therefore more frequently resistant to coronary ischemia (insufficiency of oxygen- rich blood). On the other hand, the posteromedial papillary muscle is usually supplied only by the PDA. This makes the posteromedial papillary muscle significantly more susceptible to ischemia. The clinical significance of this is that a myocardial infarction involving the PDA is more likely to cause mitral regurgitation.

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.

3. Discuss the cardiovascular adjustment that occurs during exercise

Ans. 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 autoregulatory 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.