Homeostasis and cardiovascular system

Science, Anatomy

The American physiologist Walter Cannon used the term Homeostasis to describe the body’s ability to maintain a constant stable internalenvironmentdespite the changes to the external surrounding1, 2. The body has a range of receptors these are used to constantly monitor the body’s internal conditions to keep them in physiological limits.

To achieve this, every organ works together and thus the body works together as a whole. This requires body to communicate with the organs, this is established through two very highly specialized systems; nervous system and endocrine system, they use electrical impulses and hormones to communicate respectively1. It is vital for our body to maintain homeostasis for our survival, this ability of the body allows us to adapt to our environment which is why we can live in a variety of different settings3. The mechanism of every homeostatic control has three interdependent components; the receptor, which is a sensor that responds to a change (stimuli) in the environment, by sending information through the afferent pathway to the control center1. The second component, which is the control center, is where the information received is assessed and it is determined whether the conditions are in limits1. The final component is the effector; it uses the information provided by the control center to respond to the change1. The information travels along the efferent pathway from control center to the effector this result in a response to the stimuli1.

There are two different homeostatic mechanisms; a negative feedback and a positive feedback. Which mechanism is in action depends on the stimuli. During negative feedback the mechanism reacts by producing a response to the variable in opposite directions, this is achieved through reducing the

intensity or cutting off the output completely2. For example, you have your central heating on but you open your window this would result in losing heat hence, reducing the temperature of the room. This change would be detected by the thermostat thus signals will be sent to the boiler to increase the activity. This increase in activity would lead to restoring of the temperature. Now if you close the window and the temperature is established the thermostat would detect this and so will again send signals to the boiler to reduce the activity.

For the positive feedback mechanism the body tends to produce a response that increases the activity of the variable so it supports the change1, 2. This moves the stimulus further away from its physiological range. This type of control is not as common as the negative control; it has no limits and is more focused on continuous change1. It occurs during the events where frequent adjustment is not required. A very good example for this control is blood clotting. If a blood vessel is damaged, the platelets tend to stick to the site and release chemicals which attract more platelets1. This leads to a rapid accumulation of platelets which eventually forms a clot.

The cardiovascular system consists of the heart and the blood vessels. Its job is to pump the blood to all parts of the body. The system contributes to maintain homeostasis in the body at all times whether it’s to do with providing brain cells with oxygen and glucose so that the control center in the brain carry’s on working to its best potential or working with kidneys to control the blood volume. The system itself is very complex and specialized. The blood flow in the body must be kept constant and steady. This requires

the body to work as a whole with the heart being the center of the homeostatic control. The components that control blood pressure in the heart play a significant role in homeostasis.

Cardiac output (CO), Stroke volume, peripheral resistance, blood volume and heart rate all of these contribute towards regulating blood pressure in the body4. The cardiac output “ is the volume of blood pumped put by each ventricle in 1 minute” 5 . It can be measured by CO= Heart rate x Stroke volume, as the equation shows the CO depends on the heart rate and stroke volume (“ the volume of blood pumped out by one ventricle with each beat”), therefore any changes in one of these would bring a change to the amount of blood pumped out of the ventricles1, 6. The heart rate in controlled by the cardioinhibitory center located in medulla which sends signals through the parasympathetic nerves to the heart7. When the heart is at its resting state the stroke volume is controlled by the end diastolic volume1. When the body is understressthe activity on the sympathetic nervous system is increased by the cardioacceleratory center1. This results in increase in the heart rate and stroke volume by increasing the cardiac muscle activity.

The peripheral resistance is adjusted or altered every now and then in order to maintain the fluctuation in blood pressure. The cardiovascular system and nervous system work together to maintain the mean arterial pressure (MAP) by changing the size of the blood vessels diameter, therefore if the blood pressure is low; blood vessels constrict apart from those supplying blood to the heart and the brain1, 7. This result in an increase in peripheral resistance

hence maintains the blood pressure to its normal range. These type of controls are operated through baroreceptors and vasomotor center located in the medulla. The increase in arterial pressure leads to stretching of baroreceptors; these are located in the aortic arch, carotid arteries and other large arteries8. The stretching of these baroreceptors sends signals to the vasomotor center8. This is responsible for altering the size of blood vessels.

If the blood pressure is higher than this would be detected by the baroreceptors which in return would cause vasodilation of not only arteries but also veins, this dilation of the vessels reduces peripheral resistance1. The dilation of veins declines in the volume of blood returned to the heart therefore the cardiac output is also decreased, baroreceptors sends out impulses that stimulate activity of parasympathetic activity and reduce activity of the cardioacceleratory center therefore reducing the heart rate1, 4, 8. Similarly, if the blood pressure was low the vessels would constrict causing vasoconstriction; this increases peripheral resistance hence increase in the blood pressure. In addition to this, the body’s temperature has to be maintained for all the metabolic reactions taking place. These reactions are vital for survival and growth therefore the cardiovascular system and skin together maintain the optimum temperature. For example, if the surrounding temperature is low the blood vessels near the skin go under vasoconstriction by the sympathetic vasoconstrictor9. This results in blood not reaching to the skin and restricted to the areas away from the skin.

Therefore heat loss is reduced significantly maintaining the body temperature to physiological range. Whereas if the temperature of the

surrounding is high, the body must lose heat in order to keep its optimum temperature. It achieves this by dilating the blood vessels this allows blood to travel even more closely to the skin thus radiating the heat out9. On the other hand, if there is a homeostatic imbalance of the cardiovascular system (CVS) this can be life threatening. An imbalance could be caused by anything it can be a genetic disorder, unhealthy diet or a disease. An example of such a condition of CVS that can cause homeostatic imbalance is atherosclerosis. This condition blocks the artery and therefore leads to hypertension (homeostatic imbalance)10.

The blockage of the artery is caused by damage to the tunica intima, this allows lumps of fatty substances such as lipids, cholesterol and LDLs to accumulate at the ruptured site1. Overtime reactions take place; these oxidize the LDLs which then act as chemotactic agents that attract macrophages8. These take up oxidized LDLs and ingest them, but they become so engorged that they turn into foam cells1, 8. The foam cells build up overtime to form atheroma (plaque). Macrophages release chemicals, these make the smooth muscle cells move to the surface of the plaque and forming a covering8. Due to this obstruction the blood pressure and supply is affected, as a result the heart increases the contraction strength to meet the needs of the body causing hypertension. Consequently, the person is at a high risk of other diseases such as congestive heartfailure, coronary heart disease, stroke, damage to kidneys and many others10.

It is still not sure what causes atherosclerosis however there are certain risk factors that increase an individual’s chance of having this condition. Some of

these factors are diet rich in cholesterol, smoking, hypertension andfamilyhistory 10, 11. Overall, it is very clear how difficult it is to maintain homeostasis; the cardiovascular system plays a very important role and is involved in homeostasis directly and indirectly. However, every organ must carry out its job to maintain a constant internal environment; one small condition can lead to a complete collapse of the system.