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COURSE: PHYSIOLOGY

1) RENAL MECHANISM FOR REGULATION OF BLOOD PRESSURE – LONG-TERM REGULATION Kidneys play an important role in the long­term regulation of arterial blood pressure. When blood pressure alters slowly in several days/months/years, the nervous mechanism adapts to the altered pressure and looses the 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 long­term regulation. Kidneys regulate arterial blood pressure by two ways: 1. By regulation of ECF volume

 2. Through renin­angiotensin mechanism: by regulation of extracellular fluid volume, When the blood pressure increases, kidneys excrete large amounts 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 diuresis and natriuresis, 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.

2) PULMONARY CIRCULATION: Pulmonary circulation is otherwise called lesser circulation. Blood is pumped from right ventricle to lungs through pulmonary artery. Exchange of gases occurs between blood and alveoli of the lungs at pulmonary capillaries. Oxygenated blood returns to left atrium through the pulmonary veins. Thus, 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 a ring of interconnecting arteries located at the base of the brain around the optic chiasm or chiasma (partial crossing of the [optic nerve](https://www.kenhub.com/en/library/anatomy/the-optic-nerve) – CNII; this crossing is important for binocular vision), infundibulum of the pituitary stalk and the [hypothalamus](https://www.kenhub.com/en/library/anatomy/hypothalamus). This arterial ring provides blood to the brain and neighboring structures. Polygonal anastomotic shape offers the possibility of alternate pathways for the blood flow, which is essential for the brain functioning, since it is the structure that is mostly sensitive to hypoxia. Hypoxia of the brain tissue that lasts longer than 6 minutes results with the irreversible changes in the brain parenchyma, and depending on the location of the lesion, the functional damages vary widely.

SPLANCHNIC CIRCULATION **:** splanchnic circulation comprises the gastric, small intestinal, 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 resistance arterioles are the primary determinant of vascular resistance in the splanchnic circulation. Neuronal control of the mesenteric circulation is almost entirely sympathetic in origin. The parasympathetic fibers from the vagi have little effect on blood flow. Overall splanchnic blood flow requires about 25% of cardiac output. The splanchnic venous capacitance reservoir contains about one-third of the body's total blood volume. The sympathetic postganglionic fibers cause arteriolar vasoconstriction and decrease splanchnic perfusion. Sympathetic stimulation also contracts the smooth muscle of the capacitance veins in the splanchnic circulation, and may expel a large volume of pooled blood from the splanchnic into the systemic circulation. Autoregulation in the splanchnic circulation is less marked than in the cerebral, cardiac, or renal circulations. The response is present, however, and serves to restore blood follow to areas suffering hypoperfusion because of an acute reduction in perfusion pressure. The splanchnic circulation also responds to reduced perfusion pressure by the redistribution of blood flow within individual organs. For example, in hypovolemic shock perfusion usually favors the mucosa of the gut at the expense of the muscularis mucosa. The liver is unique in that it has both an arterial and a venous afferent blood supply. In the resting adult the liver receives approximately 500 mL min of blood via the hepatic artery and a further 1300 mL min from the portal 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 other organs from their circulations—e.g., 40 percent by resting skeletal muscle and 20 percent by the liver. Obstruction of a coronary artery, depriving the heart tissue of oxygen-rich blood, leads to death of part of the heart muscle (myocardial infarction) in severe cases, and total heart failure and death may ensue.

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. Some of the circulating blood volume in the skin will flow through will flow through **arteriovenous anastomoses (AVAs)** instead of capillaries. AVAs serve a role in temperature regulation. In this article we shall consider the different adaptations of the cutaneous circulation, and its role in body temperature control.

## Arteriovenous Anastomoses

AVAs 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.

## Temperature Regulation

The skin is the body’s main heat dissipating surface: the amount of blood flow to the skin determines the degree of heat loss and therefore the core body temperature. The blood flow through AVAs is heavily influenced by the **sympathetic nervous system.**  At rest, the sympathetic nervous system dominates and acts to constrict AVAs.

Any changes in core temperature are detected by the thermoregulatory center in the **hypothalamus**. It regulates temperature by altering the level of sympathetic outflow to the cutaneous vessels, to return temperature to its normal range:

In high core temperatures:

* Sympathetic innervation is decreased, reducing the vasomotor tone in the AVAs.
* More blood flows through the AVAs and reaches the venous plexus (close to the surface of the skin), increasing heat loss to reduce core temperature.

In low core temperatures:

* Sympathetic innervation is increased, increasing the vasomotor tone in the AVAs.
* Less blood flows to the apical skin (of nose, lips, ears, hands and feet), reducing heat loss to increase the core temperature.

3) Exercise places an increased demand on the cardiovascular system to pump more oxygen to supply the working muscle to produce energy (aerobic oxidation). Oxygen demand by the muscle increases, more nutrients are needed and more waste is created.

Response and adaptation of the cardiovascular system to exercise

* Heart rate
* Stroke volume
* Cardiac output
* Blood flow
* Blood pressure
* Blood
1. Heart Rate: Resting heart rate averages 60 to 80 beats/min in healthy adults. In sedentary, middle aged individuals it may be as high as 100 beats/min. In elite endurance athletes heart rates as low as 28 to 40 beats/min.

Anticipatory response

* Anticipatory response ( increased heart rate before exercise) Caused by the release of epinephrine.
* Before exercise even begins heart rate increases in anticipation. This is known as anticipatory response
* It is mediated through the releases of neurotransmitters epinephrine and norepinephrine also known as adrenaline and noradrenaline.
1. Stroke volume
* Stroke volume is the amount of blood ejected per beat from left ventricle and measured in ml/beat.
* Stroke volume increases proportionally with exercise intensity.
* In untrained individuals stroke volume at rest it averages 50-70ml/beat.
* During intense, physical activity stroke volume increasing up to 110-130ml/beat
* In elite athletes resting stroke volume averages 90-110ml/beat increasing to as much as 150-220ml/beat.
1. Cardiac output:
* Cardiac output is the amount of blood pumped by the heart in 1 minute measured in L/min.
* It is a product of; stroke volume and heart rate.
* If either heart rate or stroke volume increases, or both, cardiac output increases also.
* Cardiac Output remains relatively unchanged or decreases only slightly following endurance training.
* During maximal exercise on the other hand, cardiac output increases significantly. This is a result of an increase in maximal stroke volume as maximal heart rate remains unchanged with training.
1. Blood flow : The vascular system can redistribute blood to those tissues with the greatest immediate demand for energy such as muscles (skeletal muscle receives a greater blood supply)
* At rest 15-20% of circulating blood supplies skeletal muscle.
* During vigorous exercise this increases to 80-85% of cardiac output.
1. Blood Pressure:
* At rest, a typical systolic blood pressure in a healthy individual ranges from 110-140mmHg and 60-90mmHg for diastolic blood pressure.
* During exercise systolic pressure, the pressure during contraction of the heart (Known as systole) can increase to over 200mmHg and in highly trained, healthy athletes.