UNIT 6- CARDIO-VASCULAR SYSTEM

UNIT STRUCTURE

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6.1 LEARNING OBJECTIVES:

By the end of this chapter, you will be able to-

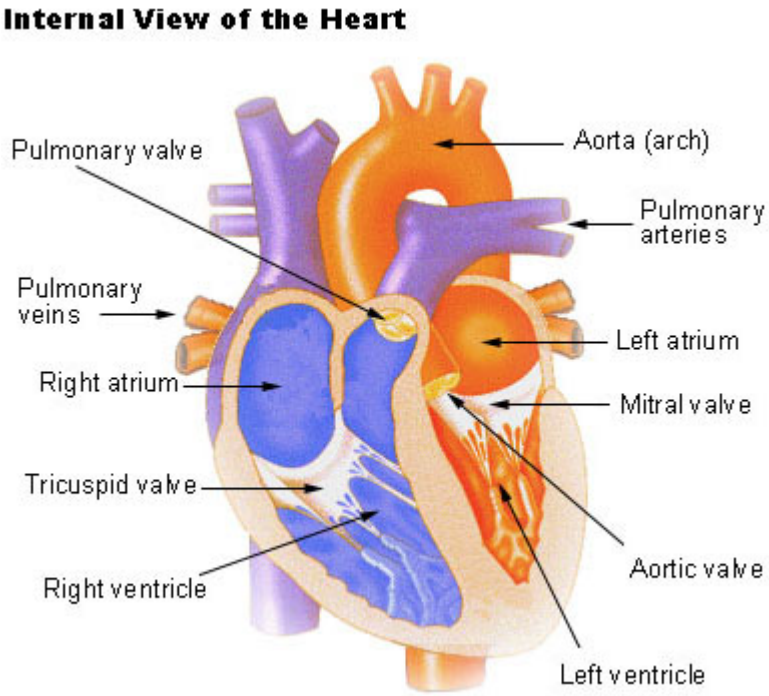
- Know the structure and function of heart
- learn the types of blood vessels and their functions
- understand the effect of yoga on circulatory system

6.2 INTRODUCTION:

The circulatory system is a system of organs that includes the heart, blood vessels, and blood which is circulated throughout the body. It includes the cardiovascular system, that consists of the heart and blood vessels.The circulatory system has two divisions, a systemic circulation, and a pulmonary circulation.The circulatory system is made up of blood vessels that carry blood away from and towards the heart. **Arteries** carry blood away from the heart and **veins** carry blood back to the heart. The circulatory system carries oxygen, nutrients, and hormones to cells, and removes waste products, like carbon dioxide. These roadways travel in one direction only, to keep things going where they should. The heart is a pump, usually beating about 60 to

100 times per minute. With each heartbeat, the heart sends blood throughout our bodies, carrying oxygen to every cell. After delivering the oxygen, the blood returns to the heart.

6.3 STRUCTURE AND FUNCTION OF HEART, ARTERIES, VEINS AND CAPILLARIES



The human heart is a four-chambered muscular organ, If you clench your hand into a fist, this is approximately the same size as your heart. It is located in the middle of the chest and slightly towards the left, called the mediastinum. The heart is a roughly cone-shaped hollow muscular organ. It is about 10 cm long and is about the size of the owner's fist. It weighs about 225 g in women and is heavier in men (about 310 g).

The heart pumps blood through the blood vessels.Heart and blood vessels together make the circulatory system. The pumped blood carries oxygen and nutrients to the tissue, while carrying metabolic waste such as carbon dioxide to the lungs.

The heart is divided into four chambers: upper left and right atria and lower left and right ventricles. Commonly, the right atrium and ventricle are referred together as the right heart and their left counterparts as the left heart. In a healthy heart, blood flows one way through the heart due to heart valves, which prevent backflow. The heart is enclosed in a protective sac, the pericardium, which also contains a small amount of fluid.

The heart pumps blood with a rhythm determined by a group of pacemaker cells in the sinoatrial node. These generate an electric current that causes the heart to contract, traveling through the atrioventricular node and along the conduction system of the heart.

The adult heart beats at a resting rate close to 72 beats per minute. Exercise temporarily increases the rate, but lowers it in the long term, and is good for heart health.

6.3.1 Layers of the Heart Wall

Three layers of tissue form the heart wall. The outer layer of the heart wall is the epicardium, the middle layer is the myocardium, and the inner layer is the endocardium.

6.3.2 Chambers of the Heart

The internal cavity of the heart is divided into four chambers:

- Right atrium
- Right ventricle
- Left atrium
- Left ventricle

The two atria are thin-walled chambers that receive blood from the veins. The two ventricles are thick-walled chambers that forcefully pump blood out of the heart. Differences in thickness of the heart chamber walls are due to variations

in the amount of myocardium present, which reflects the amount of force each chamber is required to generate.

The right atrium receives deoxygenated blood from systemic veins; the left atrium receives oxygenated blood from the pulmonary veins.

6.3.3 Valves of the Heart

Pumps need a set of valves to keep the fluid flowing in one direction and the heart is no exception. The heart has two types of valves that keep the blood flowing in the correct direction. The valves between the atria and ventricles are called atrioventricular valves (also called cuspid valves), while those at the bases of the large vessels leaving the ventricles are called semilunar valves.

The right atrioventricular valve is the tricuspid valve. The left atrioventricular valve is the bicuspid, or mitral, valve. The valve between the right ventricle and pulmonary trunk is the pulmonary semilunar valve. The valve between the left ventricle and the aorta is the aortic semilunar valve.

When the ventricles contract, atrioventricular valves close to prevent blood from flowing back into the atria. When the ventricles relax, semilunar valves close to prevent blood from flowing back into the ventricles.

6.3.4 Pathway of Blood through the Heart

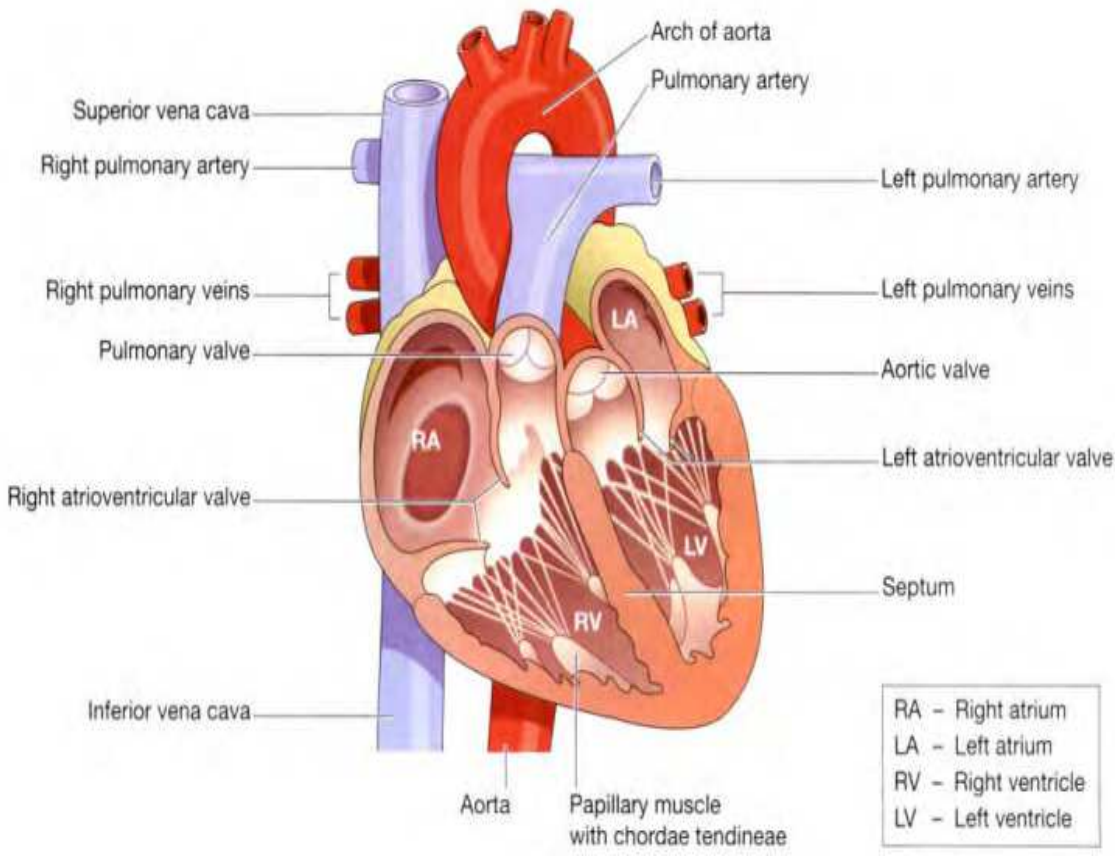
While it is convenient to describe the flow of blood through the right side of the heart and then through the left side, it is important to realize that both atria and ventricles contract at the same time. The heart works as two pumps, one on the right and one on the left, working simultaneously. Blood flows from the right atrium to the right ventricle, and then is pumped to the lungs to receive oxygen. From the lungs, the blood flows to the left atrium, then to the left ventricle. From there it is pumped to the systemic circulation.

6.3.5 Blood Supply to the Myocardium

The myocardium of the heart wall is a working muscle that needs a continuous supply of oxygen and nutrients to function efficiently. For this reason, cardiac muscle has an extensive network of blood vessels to bring oxygen to the contracting cells and to remove waste products.

The right and left coronary arteries, branches of the ascending aorta, supply blood to the walls of the myocardium. After blood passes through the capillaries in the myocardium, it enters a system of cardiac (coronary) veins. Most of the cardiac veins drain into the coronary sinus, which opens into the right atrium.

6.3.6 Function of heart:



The heart's two upper chambers are called the atria, with the atrial septum dividing the right and left atria. The superior and inferior vena cava are major veins that supply the right atrium with deoxygenated blood from the rest of the body.

The superior vena cava brings deoxygenated blood into the right atrium from the upper limbs and head, whereas deoxygenated blood from the lower abdomen and limbs is brought into the heart through the inferior vena cava.

The pulmonary veins supply oxygenated blood from the lungs into the left

atrium and are the only veins in the body to carry oxygenated blood. However, during pregnancy, the umbilical vein carries oxygenated and nutrient-rich blood from the placenta to the fetus.

Both atria contract and release blood into the ventricles when full, a process controlled by the atrioventricular valves. The flow of deoxygenated blood from the right atrium into the right ventricle is regulated by the tricuspid valve, while the mitral valve controls the flow of oxygenated blood from the left atrium to the left ventricle.

The two lower chambers of the heart are called the ventricles. The right ventricle receives deoxygenated blood that collects in the right atrium. This process occurs by systematically opening and closing the atrioventricular and semilunar valves.

The semilunar valve connecting the right ventricle to the lungs is the pulmonary valve. This valve remains closed while the tricuspid valve opens and releases blood into the right ventricle from the right atrium.

ARTERIES

Arteries are muscular blood vessels that carry oxygen-rich blood from the heart to the body's cells.They vary considerably in size and their walls consist of three layers of tissue. They are a key part of the cardiovascular system.

Function:

- **Transport blood**: Arteries transport oxygen, nutrients, and hormones throughout the body.
- **Maintain blood pressure**: Arteries help keep blood pressure steady by constricting or dilating in response to stimuli.

- **Control blood flow**: Arteries control blood flow to different parts of the body.

Types of arteries:

- **Elastic arteries**

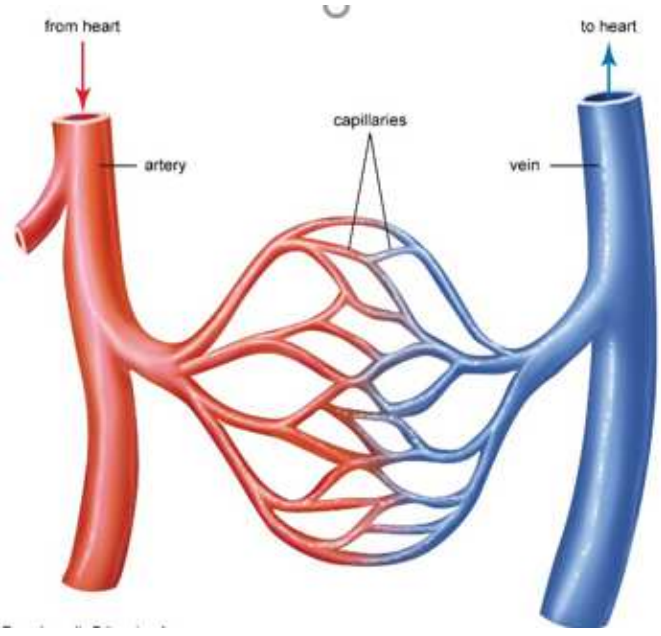
These arteries are located close to the heart and have more elastic tissue than muscular arteries. The aorta and pulmonary artery are examples of elastic arteries.

- **Muscular arteries**

  These arteries are located further away from the heart and have more smooth muscle thanelastic arteries.

Structure:

- Arteries have three layers, or coats: tunica intima, tunica media, and tunica adventitia.
- The tunica intima is the innermost layer, made of a lining, connective tissue, and elastic fibers.
- The tunica media is the middle layer, made of smooth muscle cells and elastic fibers.
- The tunica adventitia is the outermost layer, made of collagen fibers.



Veins and capillaries are both blood vessels that carries blood throughout the body. Blood vessels are small tube-like structures.Veins carry deoxygenated blood back to the heart, while capillaries exchange oxygen and nutrients with body tissues. Veins have thicker walls than capillaries. Veins use valves to transport blood towards the heart, but capillaries don't have valves. Capillaries diffuse blood and nutrients between veins and arteries through their thin walls.

VEINS:

Veins carry deoxygenated blood towards your heart and are often located close to your skin. Veins don't have a muscular layer like arteries do, so they rely on valves to keep your blood moving. Veins start as tiny blood vessels called venules, which become full-size veins as they come closer to your heart.

Characteristics of veins:

- Carry deoxygenated blood from the body to the heart
- Are located closer to the surface of your body
- Have one-way valves to prevent blood from flowing backwards
- Have thin, less elastic walls to handle large volumes of blood at low pressure
- Veins in the legs work against gravity to push blood back to the heart

CAPILLARIES

Capillaries connect your arteries to your veins. Capillaries are the smallest type of blood vessel. They can be as tiny as 5 micrometres, which is less than a third of a hair's width.

A capillary wall is only one cell in thickness. The capillary wall is made of endothelial cells and allows oxygen, nutrients, and waste to pass to and from tissue cells.

Characteristics of Capillaries

- Are located inside all tissues
- Carry blood between veins and arteries
- Carry both oxygenated and deoxygenated blood
- They are tiny blood vessels that connect arteries and veins

- Have thin walls that allow blood to come into close contact with body tissues
- Allow oxygen and nutrients to pass from the blood to the cells

- Allow waste products to pass from the cells to the blood
- Capillaries in the lungs remove carbon dioxide and pick up oxygen
- Capillaries in the intestines pick up nutrients like glucose, vitamins, and minerals

6.4 BLOOD COMPOSITION AND FUNCTIONS:

Blood:

Blood is a connective tissue. It provides one of the means of communication between the cells of different parts of the body and the external environment, e.g. it carries:

• oxygen from the lungs to the tissues and carbon dioxide from the tissues to the lungs for excretion

• nutrients from the alimentary tract to the tissues and cell wastes to the excretory organs, principally the kidneys

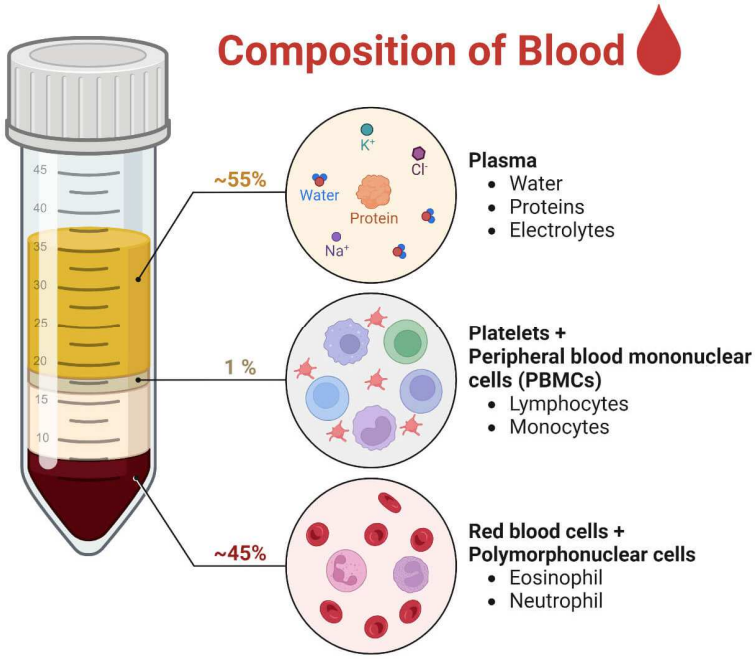
• hormones secreted by endocrine glands to their target glands and tissues

• heat produced in active tissues to other less active tissues

• protective substances, e.g. antibodies, to areas of infection

• clotting factors that coagulate blood, minimising its loss from ruptured blood vessels.

Blood makes up about 7% of body weight (about 5.6 litres in a 70 kg man). This proportion is less in women and considerably greater in children, gradually decreasing until the adult level is reached. Blood in the blood vessels is always in motion. The continual flow maintains a fairly constant environment for the body cells. Blood volume and the concentration of its many constituents are kept within narrow limits by homeostatic mechanisms.



Blood is a fluid that flows through your body's circulatory system. It's made up of plasma, red blood cells, white blood cells, and platelets.

Blood composition:

Blood is composed of a straw-coloured transparent fluid, plasma, in which different types of cells are suspended. Plasma constitutes about 55% and cells about 45% of blood volume.

Plasma:

- The constituents of plasma are water (90 to 92%) and dissolved substances, including:
  • plasma proteins: albumins, globulins (including antibodies), fibrinogen, clotting factors
  • inorganic salts (mineral salts): sodium chloride, sodium bicarbonate, potassium, magnesium, phosphate, iron, calcium, copper, iodine, cobalt
  • nutrients, principally from digested foods, e.g. monosaccharides (mainly glucose), amino acids, fatty acids, glycerol and vitamins
  • organic waste materials, e.g. urea, uric acid, creatinine
  • hormones
  • enzymes, e.g. certain clotting factors

• gases, e.g. oxygen, carbon dioxide, nitrogen.

- **Plasma**: The liquid portion of blood that's mostly water, but also contains proteins, nutrients, ions, and waste products
- **Red blood cells/erythrocytes**: Carry oxygen from the lungs to the body's cells
- **White blood cells/ Leukocyte**: Part of the immune system and fight infection
- **Platelets/ Thrombocyte**: Cell fragments that help blood clot

Functions:

- Transport oxygen and nutrients: Blood carries oxygen from the lungs to the body's cells, and nutrients like glucose, vitamins, and minerals from the small intestine to the body's tissues
- Fight infection: White blood cells fight infection by pathogens, and lymphocytes produce antibodies to specifically defend against pathogenic germs
- Form blood clots: Platelets help blood clot to prevent excess blood loss
- Regulate body temperature: Blood helps regulate body temperature
- Transport waste products: Blood carries waste products like urea, uric acid, and creatinine to the kidneys and liver, which filter and clean the blood

BLOOD PRESSURE

Blood pressure is the force of blood pushing against artery walls as the heart pumps blood. It's usually measured as two numbers, systolic and diastolic, which indicate the pressure when the heart beats and when it's at rest.

The systemic arterial blood pressure, usually called simply arterial blood pressure, is the result of the discharge of blood from the left ventricle into the already full aorta.

When the left ventricle contracts and pushes blood into the aorta the pressure produced within the arterial system is called the systolic blood pressure. In adults it is about 120 mmHg (millimetres of mercury).

When complete cardiac diastole occurs and the heart is resting following the ejection of blood, the pressure within the arteries is called diastolic blood pressure. In an adult this is about 80 mmHg or 11 kPa. The difference between systolic and diastolic blood pressures is the pulse pressure.

These figures vary according to the time of day, the posture, gender and age of the individual. During bedrest at night the blood pressure tends to be lower. It increases with age and is usually higher in women than in men.

Arterial blood pressure is measured with a sphygmomanometer and is usually expressed in the following manner:

BP = 120/80mmHg

The elasticity of the artery walls. There is a considerable amount of elastic tissue in the arterial walls, especially in large arteries. Therefore, when the left ventricle ejects blood into the already full aorta, it distends, then the elastic recoil pushes the blood onwards. This distension and recoil occur throughout the arterial system. During cardiac diastole the elastic recoil of the arteries maintains the diastolic pressure.

Systemic arterial blood pressure maintains the essential flow of substances into and out of the organs of the body. Control of blood pressure especially to the vital organs is essential to maintain homeostasis.

Range of blood pressure:

- A normal blood pressure reading for most adults is 120/80 or lower
- A reading of 130–139/80–89 is considered stage 1 high blood pressure
- A reading of 140/90 or higher is considered stage 2 high blood pressure

6.5 EFFECT OF YOGIC PRACTICES ON CARDIOVASCULAR SYSTEM:

Yogic practices, including asanas (physical postures), pranayama (breathing exercises), and meditation, have been shown to positively impact the cardiovascular system by lowering blood pressure, improving heart rate variability, reducing stress hormones, and potentially lowering cholesterol levels, thereby contributing to better overall cardiovascular health and reducing the risk of cardiovascular diseases; making it a beneficial lifestyle intervention for heart health.

Key benefits of yoga on the cardiovascular system:

- **Blood pressure reduction:**
  Studies consistently demonstrate that regular yoga practice can significantly lower both systolic and diastolic blood pressure, particularly in individuals with hypertension.

- **Improved heart rate variability (HRV):**
  Yoga practice, especially deep breathing techniques, can enhance the variability in heart rate, indicating a more balanced autonomic nervous system and better stress resilience.

- **Lower stress hormone levels:**
  Yoga helps reduce the production of stress hormones like cortisol, which can positively impact blood pressure and heart health.

- **Lipid profile improvement:**
  Some research suggests that yoga may contribute to favourable changes in lipid profiles, potentially lowering LDL ("bad") cholesterol and raising HDL ("good") cholesterol levels.

- **Enhanced blood circulation:**
  Certain yoga poses, like inversions (e.g., headstand), can improve blood flow throughout the body, potentially benefiting circulation.

How yoga can improve cardiovascular health

- **Stress relief**

  Yoga's deep breathing and mental focus can help reduce stress hormones that can strain the heart.
- **Exercise capacity**

  Yoga can improve exercise capacity and quality of life for people with heart failure.
- **Atherosclerosis**

  Yoga can help regress atherosclerosis when combined with dietary and other lifestyle changes.

1.8 How yoga can help with cardiovascular disease

- Yoga can help manage risk factors for cardiovascular disease (CVD) like diabetes, obesity, hypertension, and psychological stress.
- Yoga can be a useful tool for cardiac rehabilitation.

6.6 LET US SUM UP

The circulatory system is essential for transporting oxygen, nutrients, hormones, and waste products throughout the body. It consists of the heart, blood, and blood vessels, working together to maintain homeostasis and support cellular function. The system plays a crucial role in immunity, temperature regulation, and overall health. Proper circulation ensures that tissues receive adequate oxygen and nutrients while removing carbon dioxide and metabolic waste. Maintaining a healthy circulatory system through a balanced diet, exercise, and lifestyle choices is vital for overall well-being and longevity.

6.7 FURTHER READING

1. Waugh, A. & Grant, A. (2014). *Ross & Wilson Anatomy and physiology in health and illness,* Elsevier Health Sciences
2. Pearce, E. (1993). *Anatomy and physiology for Nurses*, Jaypee Brothers Medical Publishers

3. Tortora, G.J. & Derrickson, B. *Principles of Anatomy and Physiology,* John Wiley & Sons Inc
4. Gray, H. *Anatomy of the Human Body*, Lea &Febiger, Philadelphia
5. Guyton, Arthur C. *Textbook of Medical Physiology*, W.B.Saunders Co. Philadelphia

✓ 6.8 ANSWERS TO CHECK YOUR PROGRESS

Ans to Q No.1 What makes circulatory system?

Answer: The circulatory system is made up of the heart, blood, and blood vessels.

Ans to Q No.2 How many chambers are there in heart and what are they?

Answer: There are four chambers in heart.

Right atrium
Right ventricle
Left atrium
Left ventricle

Ans to Q No.3 How many divisions does a circulatory system has?

Answer: There are two divisions in circulatory system.

1. Systemic circulation
2. Pulmonary circulation

Ans to Q No.4 What is the composition of blood?

Answer: The composition of blood is-

1. Plasma
2. Red blood cells
3. White blood cells
4. Platelets

Ans to Q No. 5 what is the normal range of blood pressure?

Answer: The normal range of blood pressure is 120/80 mm Hg.

Ans to Q No.6 Explain stage1 and stage 2 high blood pressure?

Answer: When the blood pressure falls between 130–139/80–89 is considered as stage 1 high blood pressure and when it goes above 140/90 or higher is considered as stage 2 high blood pressure.

Ans to Q No.7 Explain the working of the heart.

Answer: The heart's electrical system controls the rate and rhythm of your heartbeat. The heart has four chambers, with valves that direct blood flow. The heart's upper chambers, the atria, receive blood. The heart's lower chambers, the ventricles, pump blood out of the heart. The heart's valves prevent blood from flowing in the wrong direction.

⑦ 6.9 MODEL QUESTIONS:

Short questions:

Q.1 What is the main organ of the circulatory system?
Q.2 Which chamber of the heart pumps oxygenated blood to the body?
Q.3 What is the main function of the circulatory system?
Q.4 What is the normal blood pressure of an adult?
Q.5 What are the main functions of the circulatory system?
Q.6 How does the heart pump blood throughout the body?
Q.7 What are the differences between arteries, veins and capillaries?

C) Long questions:

Q.1 Describe the structure and function of the human circulatory system.
Q.2 Explain the difference between systemic and pulmonary circulation.
Q.3 Discuss the structure and function of the human heart.

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