



# ROHINI

COLLEGE OF ENGINEERING AND TECHNOLOGY

Approved by AICTE and affiliated to Anna University Chennai (An ISO Certified Institution)

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## DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

### CBM352 Human Assist Devices

#### UNIT-I HEART LUNG MACHINE AND ARTIFICIAL HEART

##### **1.1 Cardiovascular system:**

The cardiovascular system, also known as the circulatory system, consists of the heart, blood vessels, and blood, and it plays a vital role in maintaining the body's overall function. The working of the cardiovascular system involves a coordinated series of events to ensure the circulation of blood throughout the body. Here's an overview of how the cardiovascular system works:

**Heart Pumping:** The process begins with the heart, a muscular organ divided into four chambers: two atria (upper chambers) and two ventricles (lower chambers).

The right atrium receives deoxygenated blood from the body through the superior and inferior vena cava. The right atrium contracts, pumping the blood into the right ventricle. The right ventricle then contracts, sending the deoxygenated blood to the lungs through the pulmonary arteries.

**Pulmonary Circulation:** In the lungs, carbon dioxide is exchanged for oxygen in the alveoli through the process of respiration. Oxygenated blood returns to the heart via the pulmonary veins, entering the left atrium.

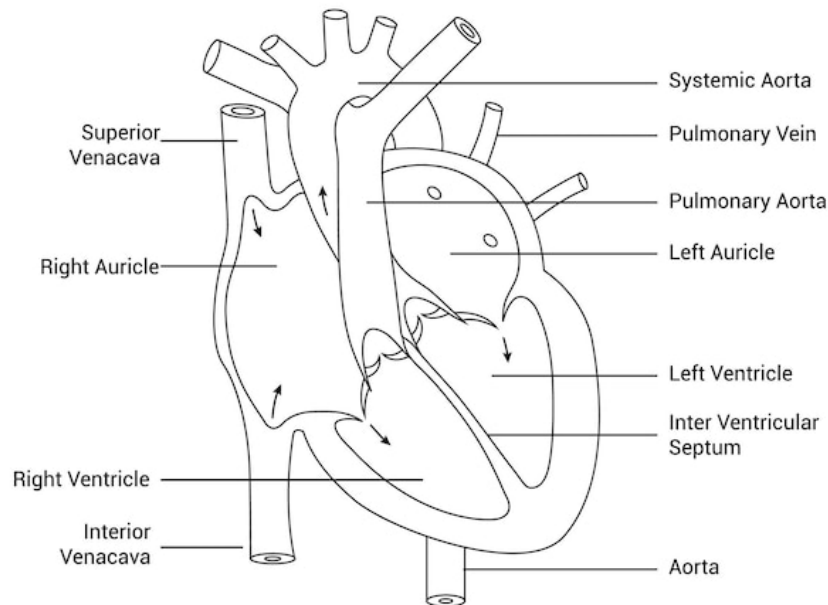
**Systemic Circulation:** The left atrium contracts, pumping oxygenated blood into the left ventricle. The left ventricle contracts, sending oxygenated blood into the aorta—the main artery that carries blood away from the heart.

**Distribution through Arteries:** The aorta branches into smaller arteries, carrying oxygenated blood throughout the body. Arteries have thick, muscular walls to withstand the pressure generated by the heart's contractions.

## Capillary Exchange:

Arteries branch into smaller vessels called arterioles, which, in turn, lead to microscopic capillaries in the tissues.

Capillaries facilitate the exchange of oxygen, nutrients, and waste products between the blood and surrounding tissues.



**Human Heart**

**Venous Return:** Deoxygenated blood, along with waste products, returns to the heart through veins. Veins from different parts of the body converge into larger veins, eventually leading to the superior and inferior vena cava, which return blood to the right atrium.

**Heartbeat and Cardiac Cycle:** The cardiac cycle includes the events of one complete heartbeat, consisting of systole (contraction) and diastole (relaxation) of the atria and ventricles. The heart's electrical system, driven by the sinoatrial (SA) node and atrioventricular (AV) node, coordinates the rhythmic contraction and relaxation of the heart chambers.

**Blood Pressure Regulation:** Blood pressure is the force exerted by blood against the walls of blood vessels. It is regulated by the contraction and relaxation of the heart, the elasticity of blood vessels, and blood volume.

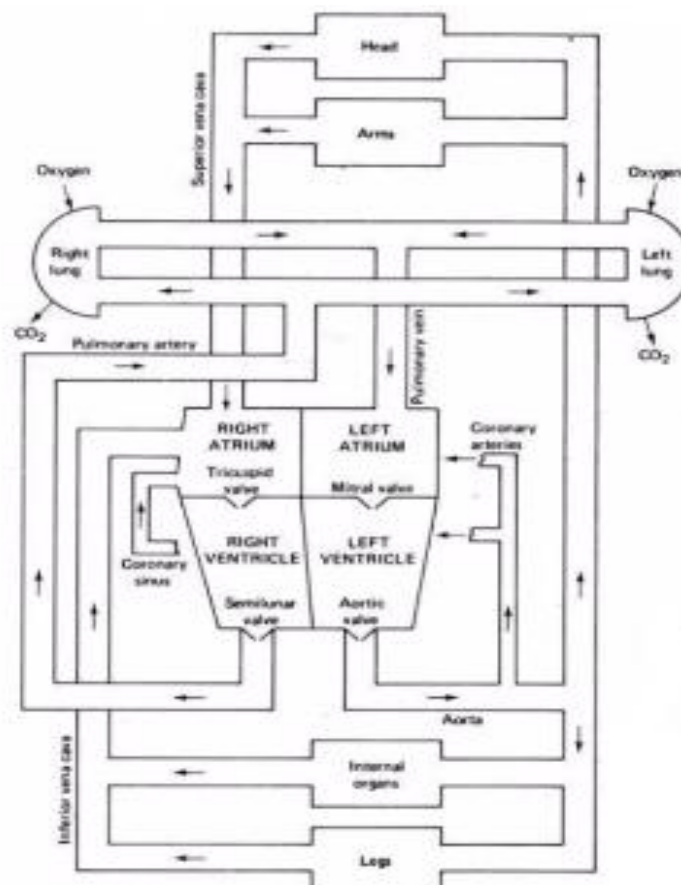
The autonomic nervous system and hormones, such as adrenaline, play a role in adjusting blood pressure to meet the body's demands.

**Lymphatic System:** The lymphatic system, a complementary system to the cardiovascular system, returns excess interstitial fluid to the bloodstream and aids in immune responses.

### Homeostasis and Regulation:

The cardiovascular system works to maintain homeostasis by regulating blood pressure, heart rate, and blood composition to ensure optimal conditions for the body's cells and organs.

The working of the cardiovascular system is a continuous and dynamic process that ensures the delivery of oxygen and nutrients to cells, the removal of waste products, and the support of various physiological functions essential for the body's survival. Coordination between the heart, blood vessels, and blood is crucial for maintaining overall health and well-being.



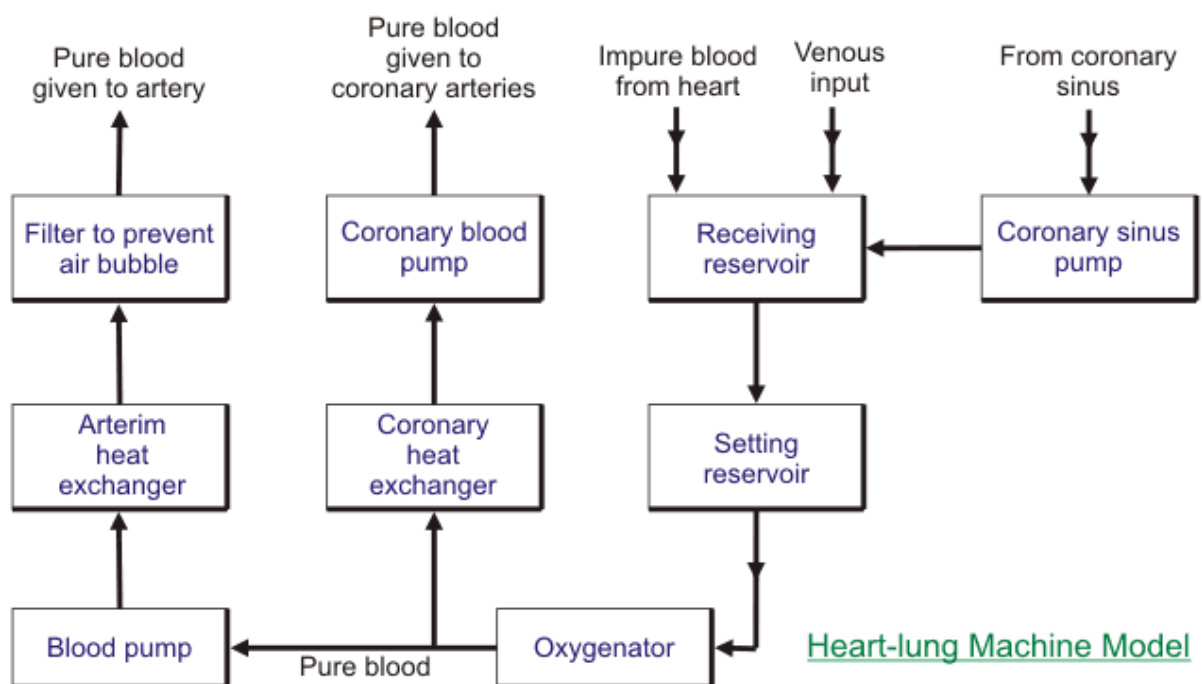
## 1.2. Heart Lung Machine :

A heart-lung machine is an apparatus that does the work both of the heart (i.e., pumps blood) and the lungs (i.e., oxygenates the blood) during, for example, open-heart surgery. The basic function of the machine is to oxygenate the body's venous supply of blood and then to pump it back into the arterial system. Blood returning to the heart is diverted through the machine before returning it to the arterial circulation.

### 1.2.1 Working of Heart-Lung Machine:

The main components of a heart-lung machine are, pumps, oxygenators, temperature regulators, and filters

- Heart lung machine is used to partially or completely replace the functions of heart and the lungs.
- This machine is used to provide the oxygenated blood to the whole body



and also, to the heart.

- Heart lung machine works on the same principle of supplying the blood to the body and heart as in systemic and pulmonary circulation takes place.
- It is mainly used in case of the open-heart surgery where the heart is exposed.
- It is used in bypass surgery where we need to replace the function of the heart while it is being operated.

- During open heart surgery for installation of a valve prosthesis or correction of a congenital mal formation the heart can not maintain the circulation. It is then necessary to provide extra- corporeal circulation with a special machine called heart lung machine.
- Usually two cannulas are inserted in to the right side of the heart to collect the returning venous blood as shown in figure.
- Using heart lung machine extracorporeal circulation can be possible and in which the lungs and heart are replaced by the OXIGENERATOR and BLOOD PUMP respectively.
- The collected venous blood is directed in to a receiving reservoir of heart lung machine by gravity drainage. The accumulated blood in the operating field is also collected and passed in to the receiving reservoir by suction devices.
- From here the blood is passed in to the setting reservoir or dabbling chamber and then it is passed in to oxygenator.
- In the oxygenator, the blood is exposed to an atmosphere rich in oxygen. From oxygenator a pump raises the pressure of the blood to the mean arterial pressure from which it flows in to an arterial heat exchanger.
- arterial heat exchanger is necessary during hypothermic or low temperature operation which is followed for two reasons the first is to reduce body metabolism and therefore to reduce oxygen consumption during the operation.
- And secondly the brain damage due to oxygen starvation is reduced.
- In the heat exchanger the blood is maintained at the human body temperature. From the heat exchanger the blood passes through a filter to prevent the possibility of partials or bubbles returning to the body.
- Systematic circulation is maintained by returning this arterial oxygenated blood to a major artery.

### **1.1.1 Condition to be satisfied by the H/L System:**

The heart-lung system, also known as the cardiovascular-respiratory system, is a critical component of the human body responsible for pumping blood and facilitating the exchange of oxygen and carbon dioxide. Several conditions must be satisfied for the heart-lung system to function effectively:

1. **Functional Heart:** The heart must be in good working condition to pump blood efficiently throughout the body. It should have a normal rhythm, and its valves should open and close properly to maintain unidirectional blood flow.
2. **Adequate Blood Volume:** There must be a sufficient volume of blood in the circulatory system to ensure proper perfusion of organs and tissues. Adequate blood volume is crucial for maintaining blood pressure and delivering oxygen and nutrients.
3. **Clear Blood Vessels:** Blood vessels, including arteries, veins, and capillaries, should be clear of any obstructions such as plaques, clots, or other blockages. Clear vessels facilitate smooth blood flow and prevent complications like heart attacks or strokes.
4. **Functional Lungs:** The respiratory system, including the lungs, must be in good condition to facilitate the exchange of oxygen and carbon dioxide. The lungs should have healthy air sacs (alveoli) and a clear airway for proper ventilation.
5. **Oxygen-Rich Blood:** The blood should carry a sufficient amount of oxygen, which is essential for cellular function and energy production. This requires effective oxygen uptake in the lungs and its transport through the bloodstream.
6. **Carbon Dioxide Removal:** The heart-lung system must effectively remove carbon dioxide, a waste product of cellular metabolism, from the blood. This occurs primarily through the respiratory system during exhalation.
7. **Balanced Blood Pressure:** The cardiovascular system should maintain a balanced blood pressure to ensure proper perfusion of organs without causing damage to blood vessels. This involves a coordinated effort between the heart, blood vessels, and kidneys.
8. **Regulatory Mechanisms:** The body's regulatory mechanisms, such as the autonomic nervous system and hormonal control, should function properly to adjust heart rate, blood pressure, and respiratory rate based on the body's needs.
9. **Healthy Blood Components:** The blood must contain the right mix of red blood cells, white blood cells, and platelets. Proper blood composition is crucial for immune function, oxygen transport, and clotting.
10. **Temperature Regulation:** The cardiovascular system plays a role in regulating body temperature through blood circulation. Proper temperature regulation is essential for enzymatic activity and overall cellular function.

Overall, the heart-lung system's effective functioning is crucial for ***maintaining homeostasis*** in the body, supporting metabolism, and ensuring the delivery of oxygen and nutrients to tissues while removing waste products. Various factors, including lifestyle choices, genetics, and overall health, can influence the condition of the heart-lung system. Regular exercise, a balanced diet, and avoidance of smoking and excessive alcohol consumption contribute to maintaining a healthy cardiovascular-respiratory system.

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