Cardiovascular system

Subject: **Human anatomy and physiology-I**

Unit-V

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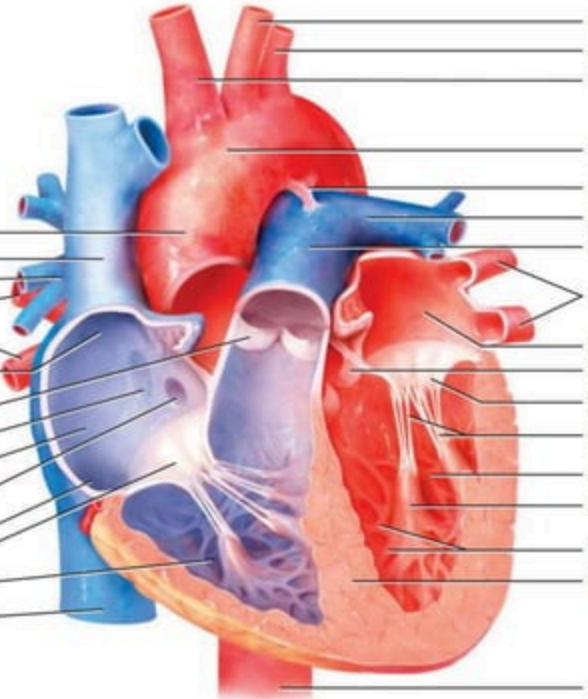
Introduction

- The scientific study of the normal **heart** and the **diseases** associated with it is known as **cardiology**
- The heart is relatively small, roughly about **12cm** (5 inches) long , **9cm** (3.5 inches) wide at its broadest point , and 6cm (2.5 inches) thick, with an average mass of **250g** in adult females and **300g** in adult males.
- The heart lies in the **mediastinum** an anatomical region that extends from the sternum to the vertebral column, from the first rib to the diaphragm, and between the lungs
- The pointed apex is formed by the tip of the left ventricle (a lower chamber of the heart) and rests on the diaphragm. It is directed anteriorly, inferiorly, and to the left.
- The base of the heart is opposite the apex and is its posterior aspect. It is formed by the atria (upper chambers) of the heart, mostly the **left** atrium

❑ Anatomy of the Heart

Frontal plane

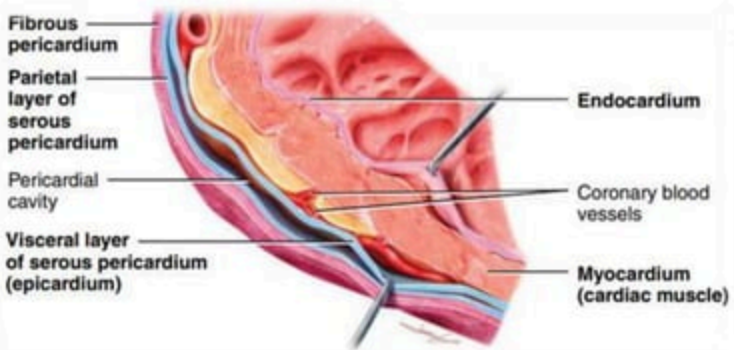


Ascending aorta
Superior vena cava
Right pulmonary artery
Right pulmonary veins
Opening of superior vena cava
Pulmonary valve
Fossa ovalis
Right atrium
Opening of coronary sinus
Opening of inferior vena cava
Tricuspid valve
Right ventricle
Inferior vena cava

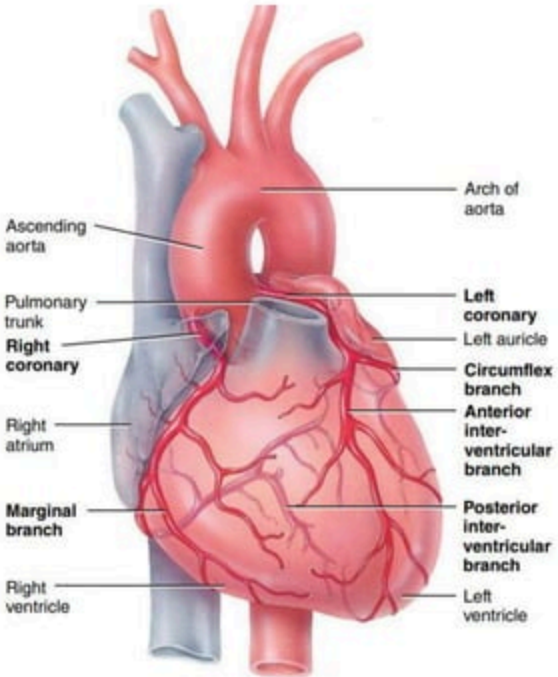
Left common carotid artery
Left subclavian artery
Brachiocephalic trunk
Arch of aorta
Ligamentum arteriosum
Left pulmonary artery
Pulmonary trunk
Left pulmonary veins
Left atrium
Aortic valve
Bicuspid (mitral) valve
Chordae tendineae
Left ventricle
Papillary muscle
Trabeculae carneae
Interventricular septum
Descending aorta

❑ Layers of the Heart Wall

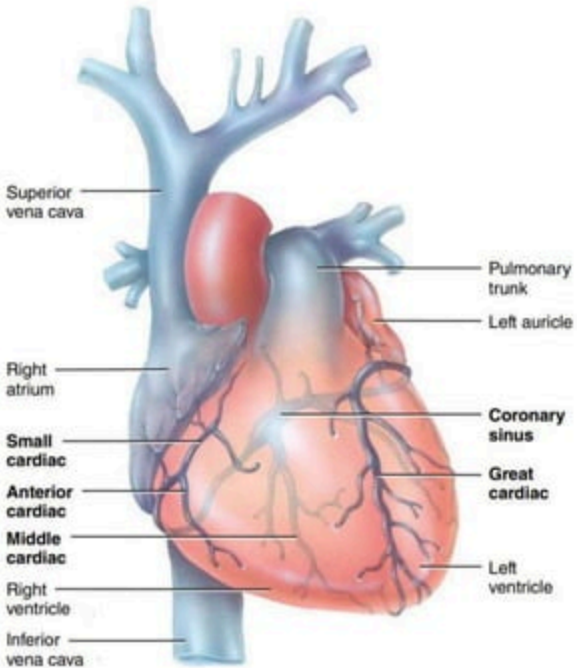
- The superficial fibrous **Pericardium** is composed of tough, inelastic, dense irregular connective tissue.
- The middle **Myocardium** is **responsible** for the **pumping** action of the heart and is composed of **cardiac muscle** tissue. It makes up approximately 95% of the heart wall
- The innermost **Endocardium** is a thin layer of **endothelium** overlying a thin layer of **connective tissue**. It provides a smooth lining for the chambers of the heart and covers the valves of the heart.



❑ Coronary Circulation



(a) Anterior view of coronary arteries



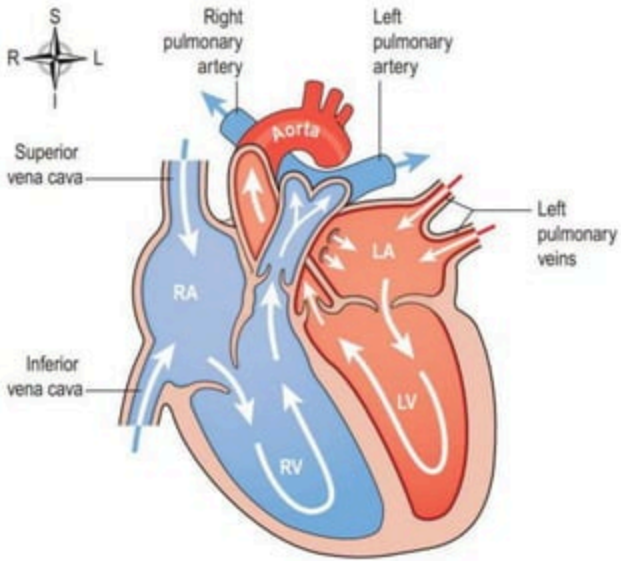
(b) Anterior view of coronary veins

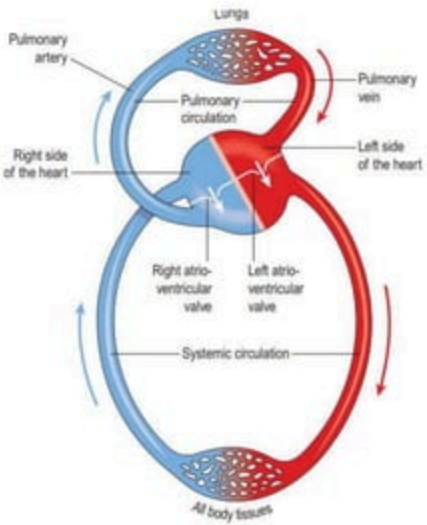
Systemic and Pulmonary Circulations

- In postnatal circulation, the heart pumps blood into two closed circuits with each beat **systemic circulation** and **pulmonary circulation**
- As each chamber of the heart contracts, it pushes a volume of blood into a ventricle or out of the heart into an artery. Valves open and close in response to pressure changes as the heart contracts and relaxes. Each of the four valves helps ensure the one-way flow of blood by opening to let blood through and then closing to prevent its **backflow**.
- The left side of the heart is the pump for **systemic circulation**; it receives bright red oxygenated (oxygen-rich) blood from the lungs.
- The left ventricle ejects blood into the aorta. From the aorta, the blood divides into separate streams, entering progressively smaller systemic arteries that carry it to all organs throughout the body except for the air sacs (alveoli) of the **lungs**, which are supplied by the pulmonary circulation.
- In systemic tissues, arteries give rise to smaller-diameter arterioles, which finally lead into extensive beds of systemic capillaries. Exchange of nutrients and gases occurs across the thin **capillary walls**.

- Blood unloads O2 (oxygen) and picks up CO2(carbon dioxide). In most cases, blood flows through only one capillary and then enters a systemic venule. Venules carry **deoxygenated** (oxygen-poor) blood away from tissues and merge to form larger systemic veins. Ultimately the blood flows back to the **right atrium**.
- The right side of the heart is the pump for **pulmonary circulation**; it receives all of the **dark-red deoxygenated** blood returning from the systemic circulation.
- Blood ejected from the right ventricle flows into the pulmonary trunk, which branches into pulmonary arteries that carry blood to the right and left lungs. In pulmonary capillaries, blood unloads **CO2**, which is exhaled, and picks up **O2** from **inhaled air.**
- The freshly oxygenated blood then flows into pulmonary veins and returns to the **left atrium**.
- **Blood pressure** is the force or pressure that the blood exerts on the walls of blood vessels.

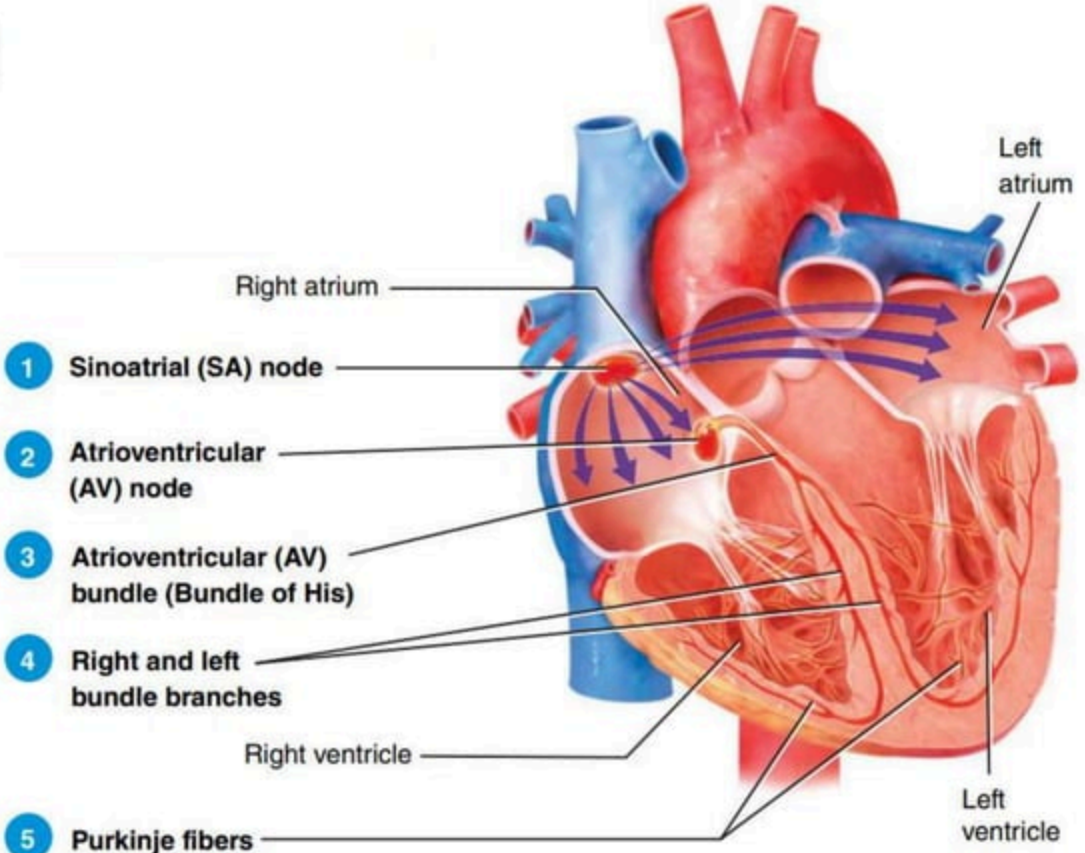
$$BP = \frac{120}{80}\ mmHg$$


S
R
L
I
Right pulmonary artery
Left pulmonary artery
Aorta
Superior vena cava
Left pulmonary veins
RA
LA
Inferior vena cava
RV
LV


Lungs
Pulmonary artery
Pulmonary vein
Pulmonary circulation
Left side of the heart
Right side of the heart
Right atrio-ventricular valve
Left atrio-ventricular valve
Systemic circulation
All body tissues

❑ The Conduction System

- Cardiac excitation normally begins in the **sinoatrial (SA) node**, located in the right atrial wall just inferior and lateral to the opening of the superior vena cava
- By conducting along atrial muscle fibers, the action potential reaches the **atrioventricular (AV) node**, located in the interatrial septum, just anterior to the opening of the coronary sinus
- From the AV node, the action potential enters the **atrioventricular (AV) bundle**. Also known as the **bundle of His**.
- Aft er propagating through the AV bundle, the action potential enters both the **right** and **left bundle branches**.
- Finally, the large-diameter **Purkinje fibers** rapidly conduct the action potential beginning at the apex of the heart upward to the remainder of the ventricular myocardium. Then the ventricles **contract**, pushing the blood upward toward the valves.
- The **SA node** sets the rhythm for contraction of the heart. It is the **natural pacemaker.**

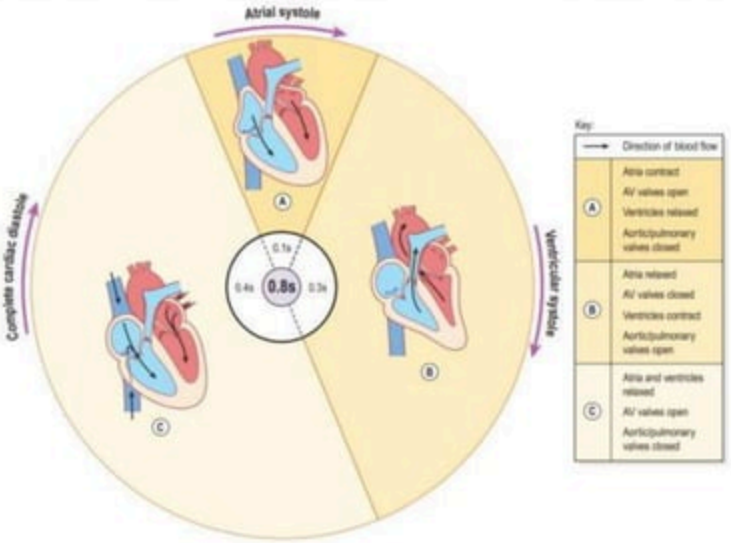

Left atrium
Right atrium
1 Sinoatrial (SA) node
2 Atrioventricular (AV) node
3 Atrioventricular (AV) bundle (Bundle of His)
4 Right and left bundle branches
Right ventricle
5 Purkinje fibers
Left ventricle

❑ Cardiac cycle

At rest, the healthy adult heart is likely to beat at a rate of 60–80 **beats per minute** (b.p.m.). During each heartbeat, or cardiac cycle, the heart contracts (systole) and then relaxes (diastole).

Stages of the cardiac cycle

- **Atrial systole**= contraction of the atria
- **Ventricular systole**=contraction of the ventricles
- **Complete cardiac diastole**= relaxation of the atria and ventricles



❑ Autonomic Regulation of Heart Rate

- Nervous system regulation of the heart originates in the cardiovascular (CV) center in the **Medulla oblongata**.
- This region of the brain stem receives input from a variety of sensory receptors and from higher brain centers, such as the **limbic system** and **cerebral cortex**.
- The cardiovascular center then directs appropriate output by increasing or decreasing the frequency of **nerve impulses** in both the **sympathetic** and **parasympathetic** branches of the **ANS**.

• Chemical Regulation of Heart Rate

1. **Hormones**. Epinephrine and norepinephrine (from the adrenal medullae) enhance the heart's pumping effectiveness.
2. **Cations**. intracellular and extracellular concentrations of several cations e.g. **Na+ and K+**

Cardiac output (CO) is the volume of blood ejected from the left ventricle (or the right ventricle) into the aorta (or pulmonary trunk) **each minute**.

- **Baroreceptors (pressure receptors)**

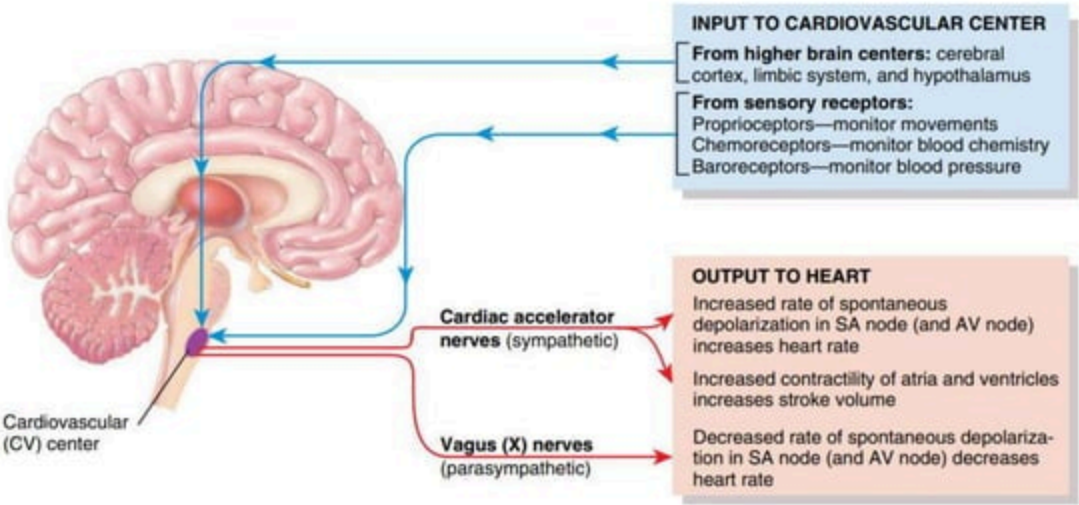
- A rise in blood pressure in these arteries stimulates the baroreceptors, increasing their input to the CVC. The CVC responds by increasing parasympathetic nerve activity to the heart; this slows the heart down.

- At the same time, sympathetic stimulation to the blood vessels is inhibited, causing **vasodilation**. The net result is a fall in systemic blood pressure.

- **Chemoreceptors**

- They sense changes in the levels of carbon dioxide, oxygen and the acidity of the blood (pH) . Rising blood **CO2**, falling blood **O2** levels and/or falling arterial blood **pH** all indicate failing tissue perfusion.

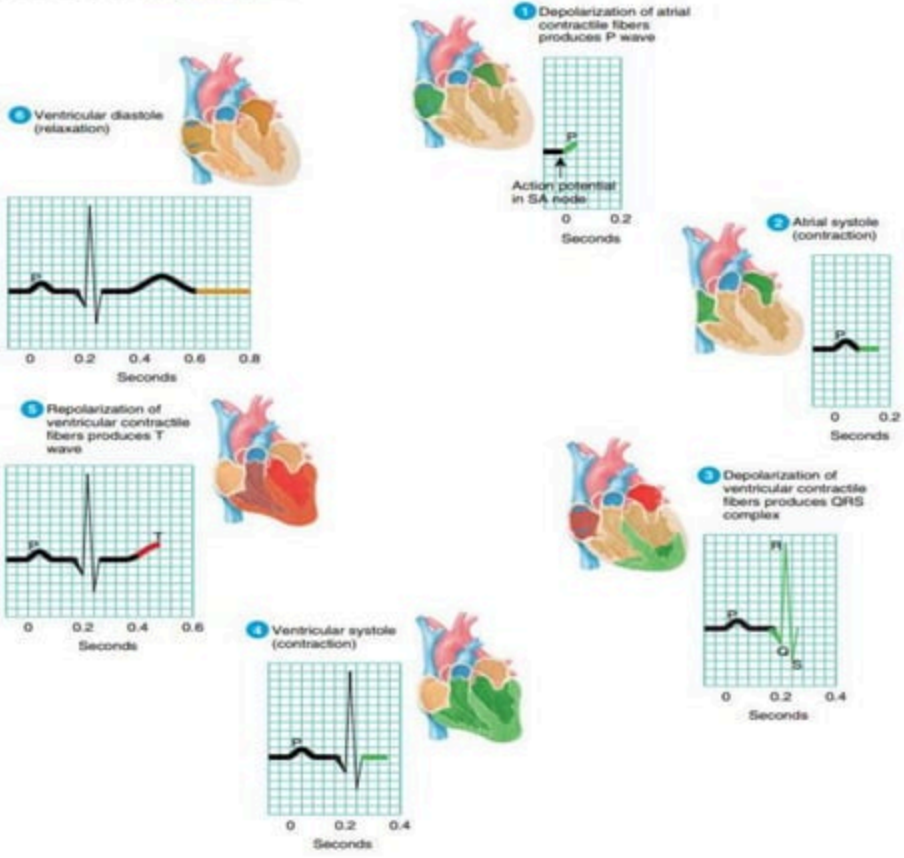
- When these changes are detected by the **chemoreceptors**, they send signals to the CVC, which then increases sympathetic drive to the heart and blood vessels, pushing blood pressure up to improve tissue blood supply.



- **stroke volume (SV)**, the volume of blood ejected by the ventricle during **each contraction**.

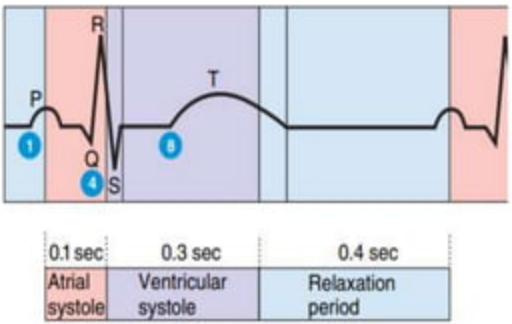
$$\underset{(\text{mL/min})}{\text{CO}} = \underset{(\text{mL/beat})}{\text{SV}} \times \underset{(\text{beats/min})}{\text{HR}}$$

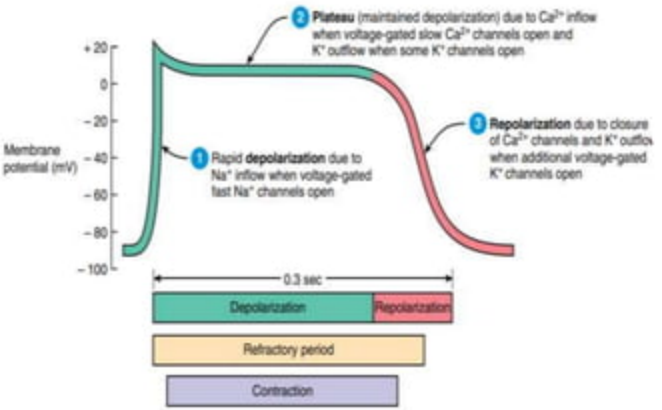
❑ Electrocardiogram



Electrocardiogram

- The instrument used to record the changes is an **electrocardiograph.**
- As action potentials propagate through the heart, they generate electrical currents that can be detected at the surface of the body. An electrocardiogram abbreviated either **ECG** or **EKG** (from the German word **Elektrokardiogram**), is a recording of these electrical signals





Heart sounds

- Blood turbulence from closing valves
- **Lubb**
- **Dupp**
- **Pulse**
- The pulse can be felt with gentle finger pressure in a **superficial artery** when its wall is distended by blood pumped from the left ventricle during contraction (systole).
- **Disorders of heart**
- Atherosclerosis
- Arrhythmias
- Congestive Heart Failure

Reference

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3. **Essentials of Medical Physiology by K. Sembulingam and P. Sembulingam. Jaypee brothers medical publishers, New Delhi.**