

Reading Material for Cardiac Technique – I



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PREFACE

A two years post matric teaching program of Cardiovascular Technology for the students of Allied Health Sciences. The purpose of this reading material is to provide basic education to the paramedics about Basics of Cardiology and techniques. This reading material attempts to cover almost all the basic theoretical knowledge required by students about Cardiovascular Technology so that they can perform their work better in emergency medical situations and provide optimal pre-hospital care for patients with cardiovascular conditions.

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Chapter-1

Anatomy of Heart and blood vessel

Objective:

This chapter provides a fundamental grasp of cardiovascular anatomy for paramedic students. By the end, readers will:

- ❖ Grasp the basics of blood circulation.
- ❖ Locate the heart accurately using surface anatomy.
- ❖ Differentiate heart chambers and understand their functions.
- ❖ Comprehend heart layers and their physiological roles.
- ❖ Appreciate the significance of coronary anatomy.
- ❖ Understand venous drainage pathways.
- ❖ Recognize neural regulation of the heart.
- ❖ Appreciate the role of heart valves in maintaining blood flow.

This chapter aims to provide paramedic students with a solid foundation in cardiovascular anatomy, enabling them to comprehend the intricacies of the heart and blood vessels. Through detailed exploration, readers will develop the knowledge necessary to recognize, assess, and respond effectively to cardiovascular conditions.

1.1 Anatomy of Heart and Blood Vessels

The heart is a vital organ that continuously pumps oxygen and nutrient-rich blood throughout the body. It is made up of four chambers, including the left and right atria, and the left and right ventricles, which are separated by a wall of muscle called the septum. The heart's main function is to move blood throughout the body, and it works in conjunction with other body systems to control heart rate and blood pressure. The circulatory system, which includes the heart and blood vessels, plays a crucial role in supplying the body with oxygen and nutrients. The heart receives nutrients through a network of coronary arteries, which run along its surface and serve the heart itself. The main types of blood vessels in the circulatory system are arteries, veins, and capillaries.

1.2 Circulation:

The cardiovascular (CV) system, also called the circulatory system, maintains the distribution of blood throughout the body and is composed of the heart and the blood vessels—arteries, capillaries, and veins. The circulatory system is composed of two parts: the pulmonary circulation and the systemic circulation. The pulmonary circulation, between the heart and lungs, transports deoxygenated blood to the lungs to get oxygen, and then back to the heart. The systemic circulation carries oxygenated blood away from the heart to the tissues and cells, and then back to the heart (see Figure ■). In this way, all the body's cells receive blood and oxygen.

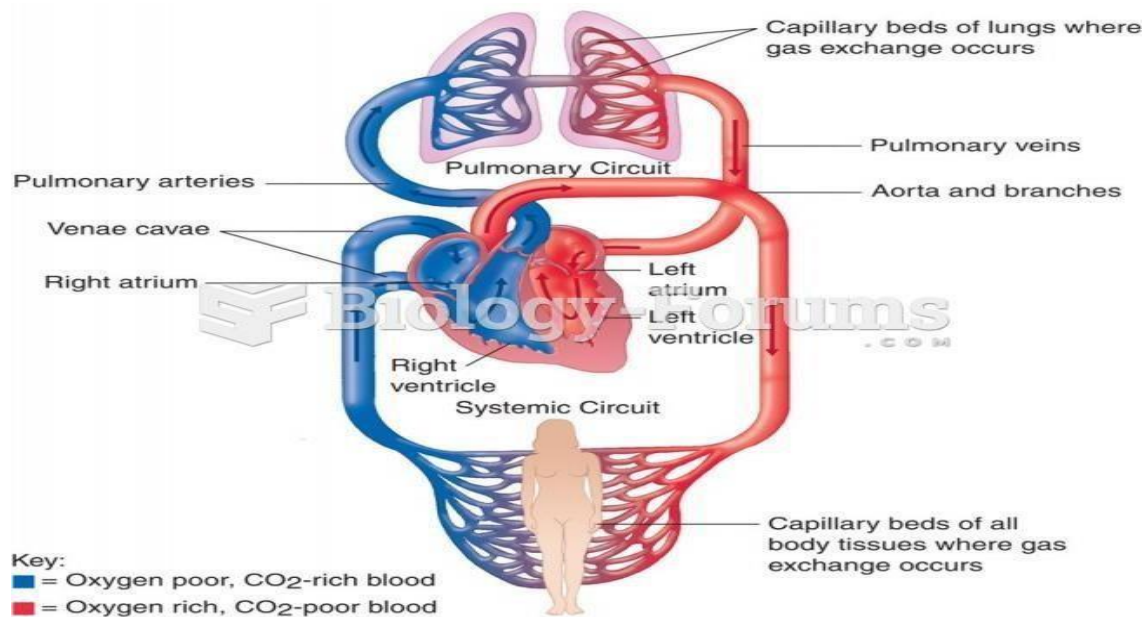


Figure Description: A schematic of the circulatory system illustrating the pulmonary circulation picking up oxygen from the lungs and the systemic circulation delivering oxygen to the body.

In addition to distributing oxygen and other nutrients, such as glucose and amino acids, the cardiovascular system also collects the waste products from the body's cells. Carbon dioxide and other waste products produced by metabolic reaction are transported by the cardiovascular system to the lungs, liver, and kidneys, where they are eliminated from the body.

1.3 Position and Surface Anatomy of Heart:

The heart, a muscular pump made up of cardiac muscle fibers, could be considered a muscle rather than an organ. It has four chambers, or cavities, and beats an average of 60–100 beats per minute (bpm) or about 100,000 times in one day. Each time the cardiac muscle contracts, blood is ejected from the heart and pushed throughout the body within the blood vessels. The heart is located in the mediastinum in the center of the chest cavity; however, it is not exactly centered; more of the heart is on the left side of the mediastinum than the right. At about the size of a fist and shaped like an upside-

down pear, the heart lies directly behind the sternum. The tip of the heart at the lower edge is called the apex.

- The heart is a muscular organ located in the chest, slightly left of the center.
- It consists of four chambers: two atria (upper chambers) and two ventricles (lower chambers).
- The right side of the heart pumps blood to the lungs for oxygenation, while the left side pumps oxygenated blood to the rest of the body.
- The heart contracts (systole) and relaxes (diastole) rhythmically to pump blood and maintain circulation.

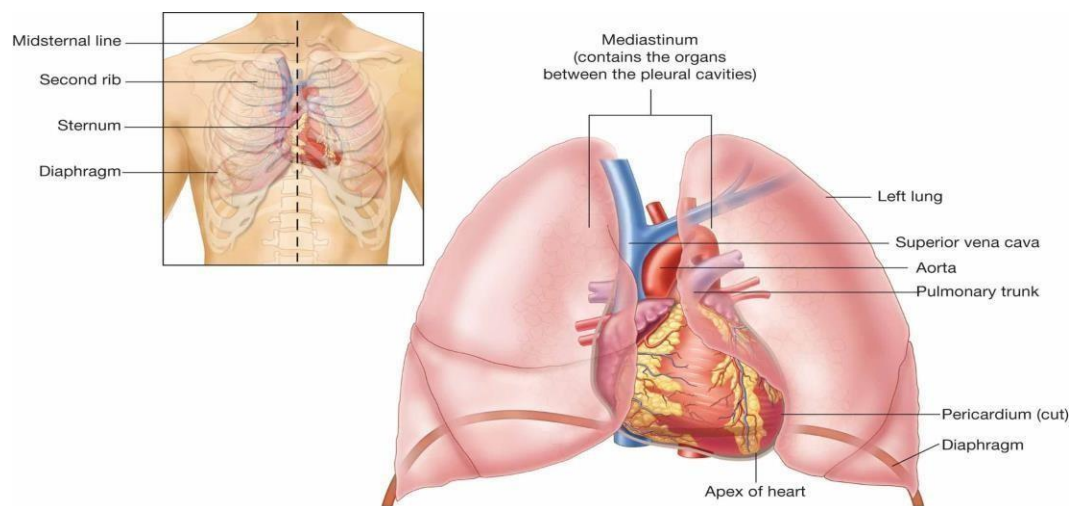


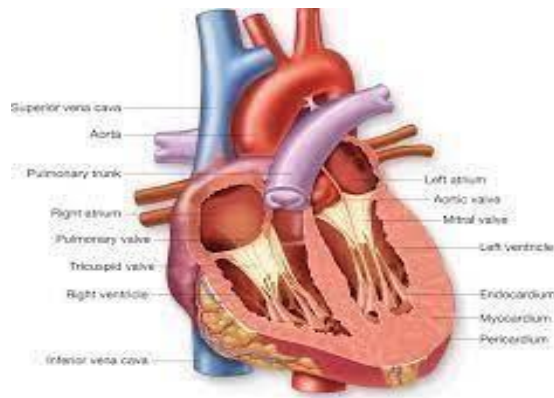
Figure Description: Location of the heart within the mediastinum of the thoracic cavity

1.4 Heart Layers:

The wall of the heart is quite thick and is composed of three layers:

- The endocardium is the inner layer of the heart lining the heart chambers. It is a very smooth, thin layer that serves to reduce friction as the blood passes through the heart chambers.
- The myocardium is the thick, muscular middle layer of the heart. Contraction of this muscle layer develops the pressure required to pump blood through the blood vessels.

- The epicardium is the outer layer of the heart. The heart is enclosed within a double-layered pleural sac, called the pericardium.
- The epicardium is the visceral pericardium, or inner layer of the sac. The outer layer of the sac is the parietal pericardium. Fluid between the two layers of the sac reduces friction as the heart beats



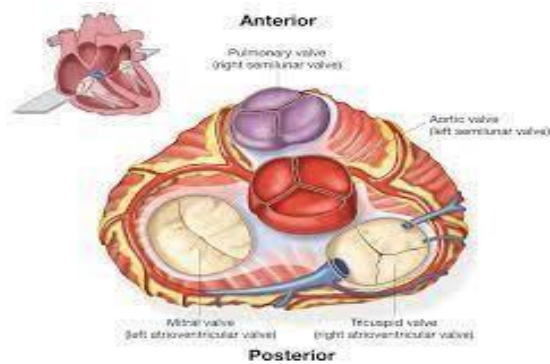
Description: Internal view of the heart illustrating the heart chambers, heart layers, and major blood vessels associated with the heart.

1.4.1 Heart Chambers:

The heart is divided into four chambers or cavities. There are two atria, or upper chambers, and two ventricles, or lower chambers. These chambers are divided into right and left sides by walls called the interatrial septum and the interventricular septum. The atria are the receiving chambers of the heart. Blood returning to the heart via veins first collects in the atria. The ventricles are the pumping chambers. They have a much thicker myocardium and their contraction ejects blood out of the heart and into the great arteries.

1.4.2 Heart Valves:

Four valves act as restraining gates to control the direction of blood flow. They are situated at the entrances and exits to the ventricles. Properly functioning valves allow blood to flow only in a forward direction by blocking it from returning to the previous chamber



Description: Superior view of heart valves illustrating position, size, and shape of each valve.

The four valves are:

- **Tricuspid valve:** an atrioventricular valve (AV), meaning that it controls the opening between the right atrium and the right ventricle. Once the blood enters the right ventricle, it cannot go back up into the atrium again. The prefix tri-, meaning three, indicates that this valve has three leaflets or cusps.
- **Pulmonary valve:** a semilunar valve, with the prefix semi- meaning half and the term lunar meaning moon, indicate that this valve looks like a half moon. Located between the right ventricle and the pulmonary artery, this valve prevents blood that has been ejected into the pulmonary artery from returning to the right ventricle as it relaxes.
- **Mitral valve:** also called the bicuspid valve, indicating that it has two cusps. Blood flows through this atrioventricular valve to the left ventricle and cannot go back up into the left atrium.
- **Aortic valve:** a semilunar valve located between the left ventricle and the aorta. Blood leaves the left ventricle through this valve and cannot return to the left ventricle.

1.5 Coronary Antomy:

The coronary arteries are the blood vessels that supply the heart muscle with oxygen and nutrients. There are two main coronary arteries: the left main coronary artery (LMCA) and the right coronary artery (RCA). The LMCA supplies blood to the left side of the heart muscle, while the RCA supplies blood to the right side of the heart muscle. Both arteries originate from the base of the aorta, which is the main artery in the body, and branch into smaller arteries to supply specific parts of the heart, such as the ventricles, sinoatrial (SA) node, and atrioventricular (AV) node. The coronary arteries run along the coronary sulcus of the myocardium of the heart.

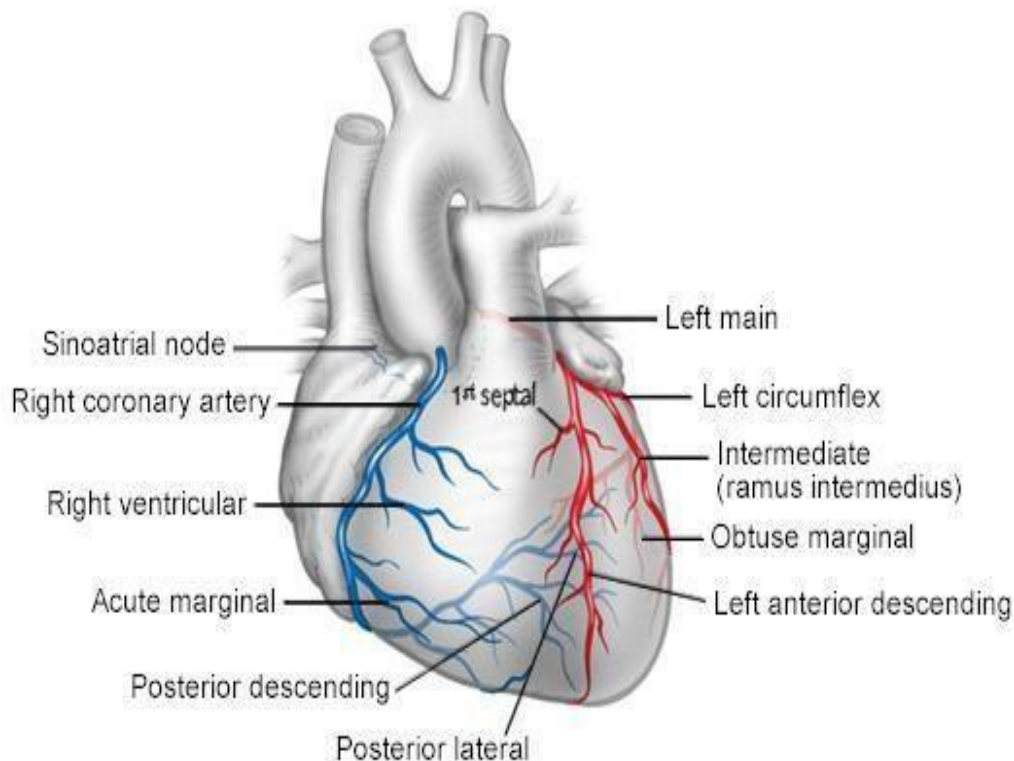


Fig: Coronary Arteries.

1.5.1 Other Aspects of Coronary Circulation:

Coronary Veins: These collect deoxygenated blood from the heart muscle and drain it into the right atrium. The most significant coronary vein is the coronary sinus.

Coronary Circulation: Blood flows through the coronary arteries, capillaries in the myocardium, and then returns to the right atrium through the coronary veins.

1.5.2 Coronary Artery Disease (CAD):

Coronary artery disease occurs when the coronary arteries become narrowed or blocked due to a buildup of plaque (atherosclerosis). This can lead to reduced blood flow to the heart muscle, causing chest pain (angina) or, in severe cases, a heart attack (myocardial infarction).

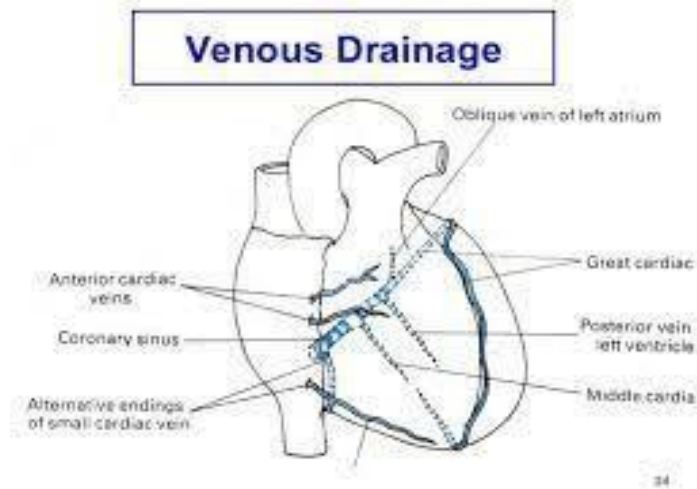
Coronary Anatomy in Imaging:

Coronary Angiography: This is a diagnostic procedure where a contrast dye is injected into the coronary arteries, and X-ray images are taken. It helps visualize any blockages or narrowing in the arteries.

Coronary CT Angiography: This non-invasive imaging technique uses computed tomography to create detailed images of the coronary arteries. Understanding the coronary anatomy is essential for diagnosing and treating cardiovascular conditions. The health and proper functioning of the coronary arteries are critical for maintaining a healthy heart and preventing heart-related complications.

1.6 Venous Drainage:

Venous drainage refers to the process of returning deoxygenated blood from the body's tissues back to the heart. The venous system is composed of superficial and deep veins, which are connected to each other and have one-way valves that prevent backflow of blood. The superficial veins are located just beneath the skin and drain blood from cutaneous tissues to deep veins. The deep veins accompany and share the name of the major arteries in the body and drain blood from deeper fascia, muscles, and bones. The venous drainage of different body parts, such as the lower limb, upper limb, head, and



neck, can be divided into different parts and structures. Venous hypertension can occur when the valves in the veins become incompetent, leading to varicose veins and other complications.

Fig: Venous Drainage

1.7 Nerve Supply of Heart:

The heart is innervated by both parasympathetic and sympathetic fibers, which originate from the autonomic branch of the nervous system. The primary sites for regulating sympathetic and parasympathetic outflow are the medulla and the hypothalamus, respectively. The heart's nerve supply can be divided into the following components:

Parasympathetic supply: The parasympathetic nerves to the heart arise from the vagus nerve, which has three nuclei in the central nervous system (CNS) associated with cardiovascular function. These nuclei are the dorsal motor nucleus, the nucleus ambiguus, and the solitary nucleus. The parasympathetic fibers synapse at ganglia located directly on the heart and short postsynaptic neurons, mainly innervating the sinoatrial (SA) and atrioventricular (AV) nodes.

Sympathetic supply: The sympathetic nerves to the heart originate from the sympathetic trunk, with preganglionic fibers branching from the upper thoracic spinal cord and synapsing in the lower postganglionic neurons in the cardiac plexus. The sympathetic nerves are responsible for increasing heart rate, increasing the force of contraction of the myocardium, and causing the 'fight or flight' response, which leads to a

faster heartbeat.

The cardiac plexus is a network of nerves that supply the heart and is responsible for influencing heart rate, cardiac output, and contraction forces of the heart. It receives contributions from the right and left vagus nerves, as well as contributions from the sympathetic trunk.

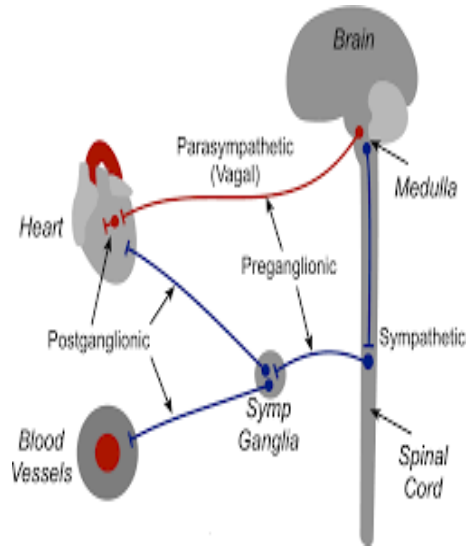


Fig: Nerve supply

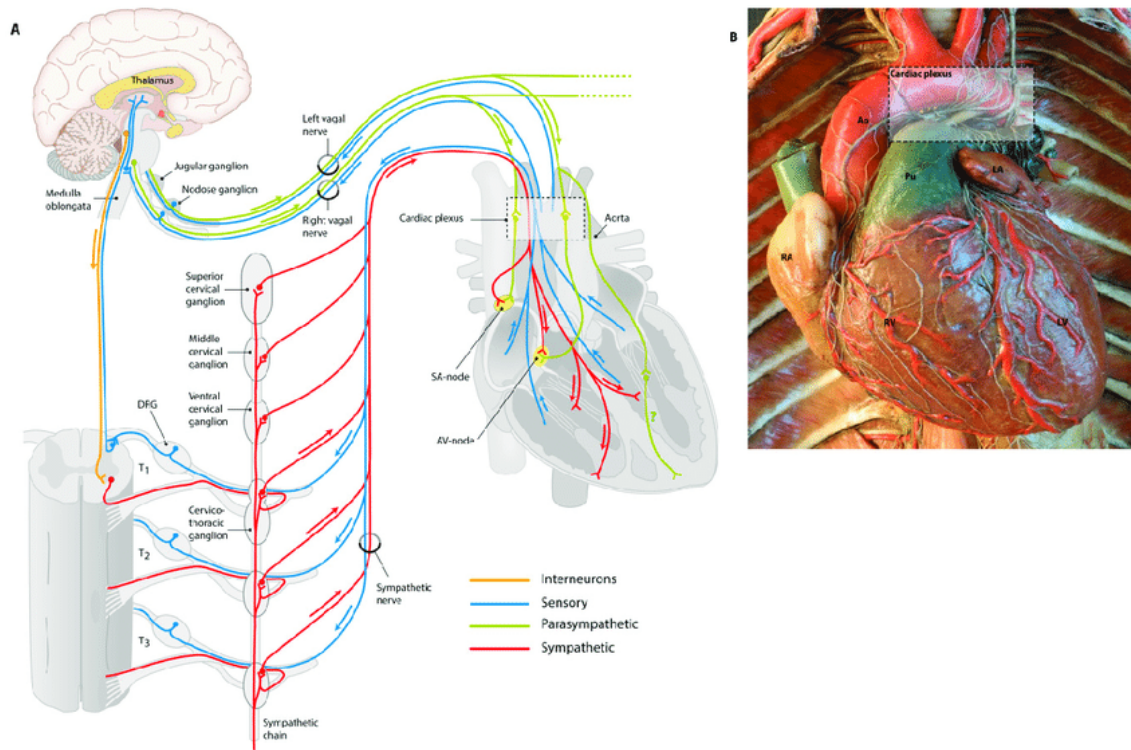


Fig: Intervation of the heart system

Chapter Review Questions: Anatomy of Heart and Blood Vessels

What are the primary functions of blood circulation in the body?

Describe the surface anatomy of the heart and its relevance in clinical practice.

Name and differentiate the four chambers of the heart.

Explain the layers of the heart and their physiological roles.

Why is understanding coronary anatomy crucial for paramedics?

Discuss the pathways of venous drainage in the cardiovascular system.

Elaborate on the nerve supply regulating heart function.

How do heart valves contribute to maintaining blood flow integrity?

These questions assess your understanding of cardiovascular anatomy, vital for effective paramedic intervention.

Chapter-II

Physiology of the Heart

Objective:

This chapter provides paramedics a nuanced understanding of the heart's physiology. Delve into the unique properties of cardiac muscles and comprehend the intricacies of the cardiac cycle, from diastole to systole. Gain insights into the specific functions of atria and ventricles, elucidating their roles in maintaining optimal blood flow.

- ❖ Understand the unique properties of cardiac muscles.
- ❖ Explore the intricacies of the cardiac cycle, from diastole to systole.
- ❖ Gain insights into the specific functions of atria and ventricles.
- ❖ Comprehend the pivotal role of valves in facilitating unidirectional blood movement.
- ❖ Enhance knowledge to assess and respond effectively to cardiovascular emergencies.

2.1 Physiology of Heart:

The physiology of the heart refers to the functions and mechanisms that enable the organ to pump blood throughout the body. The heart is a highly specialized, hollow muscular organ that works in conjunction with the circulatory system to supply oxygen and nutrients to the body's tissues. The main functions of the heart include:

Blood pumping: The heart pumps blood through three types of blood vessels: arteries, veins, and capillaries. This process ensures that oxygen and nutrients reach all parts of the body, while carbon dioxide and waste products are transported back to the lungs for elimination.

Heart rate control: The heart's rate is regulated by the autonomic nervous system, which includes the sympathetic and parasympathetic branches. The sympathetic nerves increase heart rate and the parasympathetic nerves slow it down. This regulation allows the heart to respond to the body's

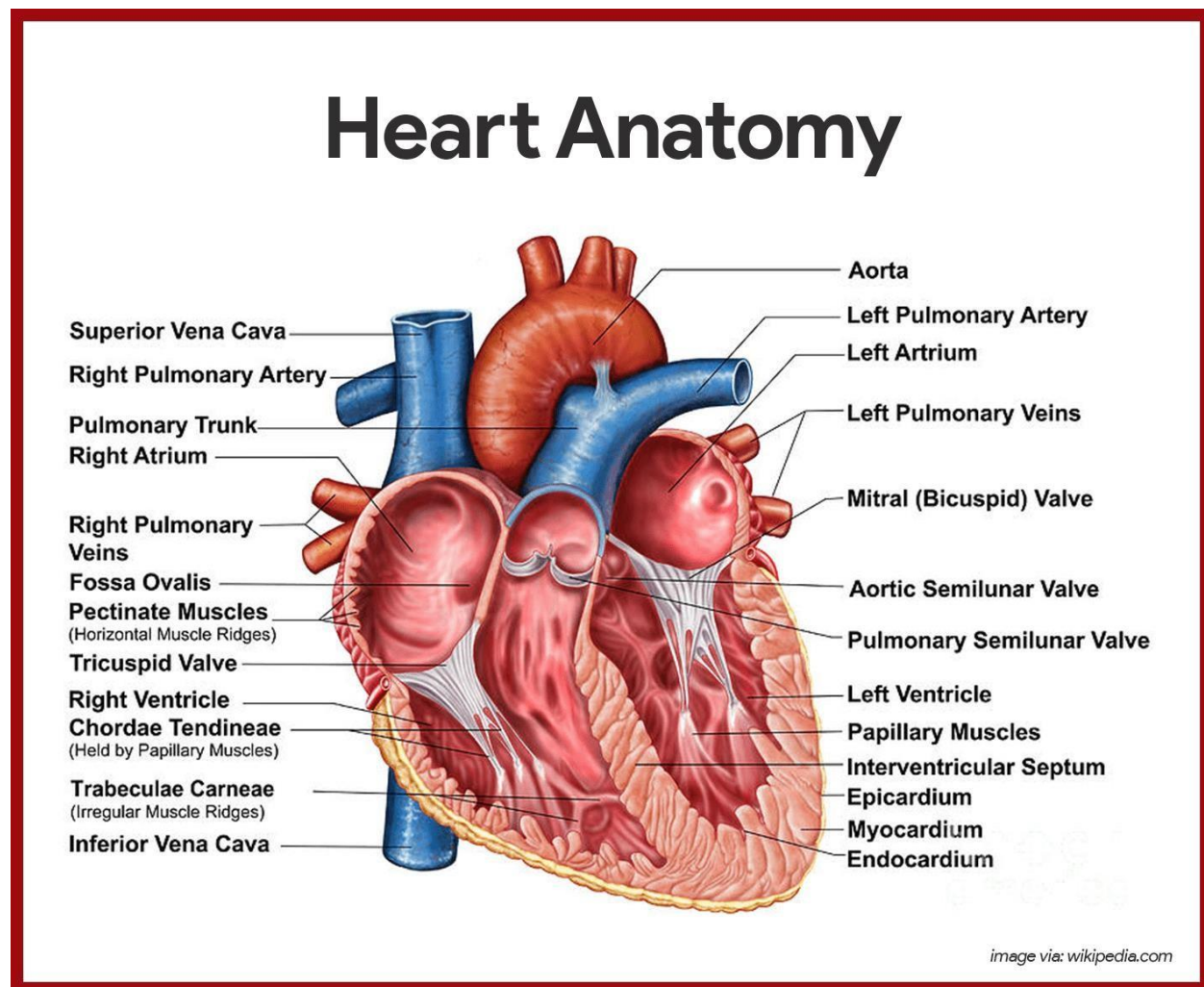
needs and maintain a stable heart rate.

Blood pressure regulation: The heart works in conjunction with other body systems, such as the respiratory and circulatory systems, to control blood pressure. This involves the coordinated function of the heart, blood vessels, and the body's fluid balance.

Nutrient distribution: The heart pumps oxygenated blood to all parts of the body, ensuring that essential nutrients reach tissues and organs. This process is crucial for maintaining the body's overall health and function.

Waste product elimination: The heart's pumping action also helps in the elimination of carbon dioxide and other waste products from the body. This process is essential for maintaining the body's overall health and balance.

The heart's physiology is complex and involves the interaction of various components, such as the heart muscle, blood vessels, and the autonomic nervous system. This coordinated function allows the heart to serve as the primary organ of the circulatory



system, providing oxygen and nutrients to all parts of the body.

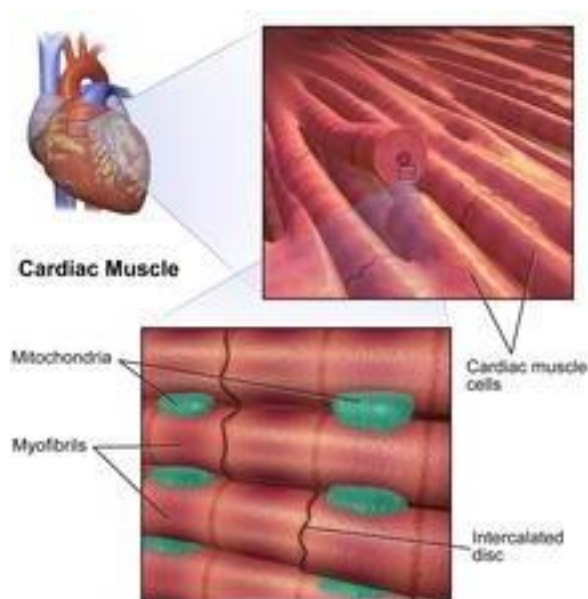
2.2 Cardiac Muscle:

Cardiac muscle, also known as myocardium, is a specialized type of muscle tissue found only in the heart. It is an involuntary, striated muscle that constitutes the main tissue of the heart wall. The cardiac muscle is responsible for the contractility of the heart and the

pumping action, which is essential for maintaining the circulation of blood throughout the body. Unlike skeletal muscle, cardiac muscle is under involuntary control.

It is composed of individual cardiac muscle cells (cardiomyocytes) joined by intercalated discs, and encased by collagen fibers and other substances that form the extracellular matrix. The structure of cardiac muscle has distinct features that allow it to contract in a coordinated manner. The rhythmic contraction of cardiac muscle is regulated by the sinoatrial node of the heart, which serves as the heart's pacemaker. The cardiac muscle possesses contractile units known as sarcomeres, similar to skeletal muscle, but it also exhibits rhythmic contractions and is not fatigable.

The cardiac muscle has its own auto-rhythmicity, and unlike smooth or skeletal muscle, it does not require neural input for contraction. The cardiac muscle is essential for maintaining the heart's pumping action and the circulation of blood, and it has unique



features that distinguish it from other types of muscle tissue.

Fig: Cardiac Muscle

2.3 Action Potential:

The cardiac action potential is a brief change in voltage (membrane potential) across the cell membrane of heart cells, which is essential for the heart's electrical activity and contractile function. Unlike the action potentials found in other types of electrically excitable cells, the cardiac action potential is not initiated by nervous activity. Instead, it arises from a group of specialized cells known as pacemaker cells, which have automatic action potential generation capability. In healthy hearts, these cells form the cardiac pacemaker and are found in the sinoatrial node in the right atrium. They produce roughly 60–100 action potentials every minute. The action potential passes along the cell, leading to the contraction of the heart muscle. The cardiac action potential is characterized by different phases, including depolarization, plateau, and repolarization, each of which is associated with specific ion channels and the movement of ions across the cell membrane. The rate dependence of the action potential is a fundamental property of

cardiac cells, and alterations can lead to severe cardiac diseases, including arrhythmias. The action potential activity within the heart can be recorded to produce an electrocardiogram (ECG).

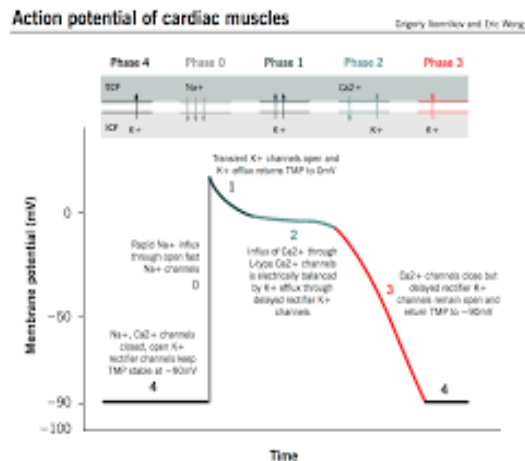


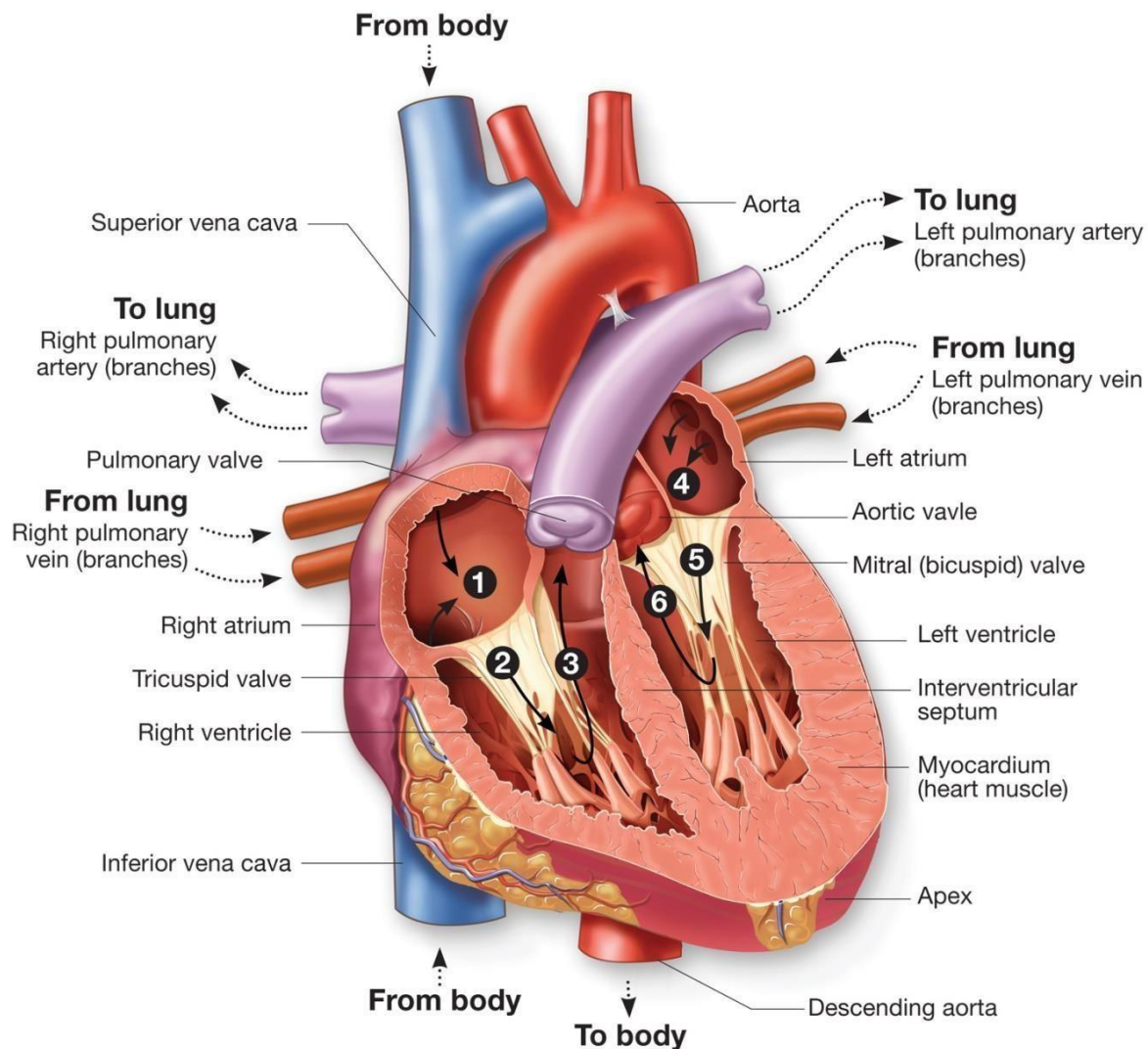
Fig: Physiology of cardiac conduction and contractility.

2.4 Blood Flow through the Heart:

The flow of blood through the heart is very orderly. It progresses through the heart to the lungs, where it receives oxygen; then goes back to the heart; and then out to the body tissues and parts. The normal process of blood flow is:

- Deoxygenated blood from all the tissues in the body enters a relaxed right atrium via two large veins called the superior vena cava and inferior vena cava.
- The right atrium contracts and blood flows through the tricuspid valve into the relaxed right ventricle.
- The right ventricle then contracts and blood is pumped through the pulmonary valve into the pulmonary artery, which carries it to the lungs for oxygenation.
- The left atrium receives blood returning to the heart after being oxygenated by the lungs. This blood enters the relaxed left atrium from the four pulmonary veins.

- The left atrium contracts and blood flows through the mitral valve into the relaxed left ventricle.
- When the left ventricle contracts, the blood is pumped through the aortic valve and into the aorta, the largest artery in the body. The aorta carries blood to all parts of the body. It can be seen that the heart chambers alternate between relaxing, in order to fill, and contracting to push blood forward. The period of time a chamber is relaxed is diastole. The contraction phase is systole.



Description: The path of blood flow through the chambers of the left and right side of the heart, including the veins delivering blood to the heart and arteries receiving blood ejected from the heart.

Valve Function: The tricuspid valve (right side) separates the right atrium from the right ventricle. The bicuspid (mitral) valve (left side) separates the left atrium from the left ventricle. These valves prevent the backflow of blood from the ventricles to the atria during

ventricular contraction.

2.4.1 Overall Function:

- The atria act as receiving chambers that receive blood from the body or lungs.
- The ventricles act as pumping chambers that eject blood into the pulmonary or systemic circulation.
- The valves ensure one-way blood flow, preventing backflow and maintaining the efficiency of the heart's pumping action.

Review Questions:

What are the key properties of cardiac muscles, and how do they differ from skeletal muscles?

Describe the phases of the cardiac cycle and the events that occur during each phase.

What are the specific functions of the atria in the heart?

Explain the role of ventricles in the cardiac system.

How do valves contribute to maintaining unidirectional blood flow in the heart?

Discuss the significance of understanding cardiac physiology for paramedics.

Identify potential complications arising from dysfunction in cardiac muscle properties or the cardiac cycle.

How might an understanding of heart physiology influence emergency response strategies?

Chapter-III

Cardiac Cycle

Objective:

This chapter aims to provide a comprehensive understanding of the cardiac cycle, covering its definition, the intricacies of contraction and relaxation, and the factors influencing cardiac output. Exploring concepts like preload, afterload, ejection fractions, and distinguishing between diastolic and systolic functions, this chapter equips paramedics with essential knowledge for assessing and managing cardiovascular conditions. By the end, readers should grasp the dynamic interplay of events during the cardiac cycle, enabling them to make informed decisions in emergency situations and enhance patient care.

- ❖ Understand the definition and significance of the cardiac cycle.
- ❖ Explore the mechanisms of contraction and relaxation in the cardiac muscle.
- ❖ Examine the factors that influence cardiac output.
- ❖ Learn about preload and its impact on cardiac function.
- ❖ Explore afterload and its role in determining cardiac performance.
- ❖ Understand the concept of ejection fractions in assessing heart function.
- ❖ Differentiate between diastolic and systolic functions of the heart.
- ❖ Gain insights into the dynamic processes governing the cardiac cycle.
- ❖ Acquire knowledge crucial for assessing and managing cardiovascular conditions.
- ❖ Enhance decision-making skills for emergency situations in paramedic practice.

3.1 Cardiac Cycle:

The cardiac cycle is the series of events that occur during one heartbeat, involving the contraction and relaxation of the heart muscle. It consists of two main phases: systole and diastole. Each phase is further divided into specific events that occur in the atria and ventricles. Here is an overview of the cardiac cycle and its phases:

Diastole:

2. **Atrial Diastole:** The heart is in a relaxed state. Blood flows passively from the superior and inferior vena cava into the right atrium, and from the pulmonary veins into the left atrium. Atrial pressure is higher than ventricular pressure, causing the atrioventricular (AV) valves (tricuspid and mitral valves) to open.
3. **Ventricular Diastole:** Atrial contraction (atrial systole) occurs, completing the filling of the ventricles. The semilunar valves (aortic and pulmonary valves) are closed. The ventricles are relaxed and begin to fill with blood. Pressure in the ventricles

remains low.

3.2 Atrial Systole:

The atria contract, pushing the remaining blood into the ventricles. Ventricular filling is completed. The AV valves remain open.

- **Isovolumetric Ventricular Contraction (Ventricular Systole - Phase 1):** Ventricular contraction begins. Pressure in the ventricles rises, closing the AV valves. The volume of blood in the ventricles remains constant (isovolumetric), as the semilunar valves have not opened yet.
- **Ventricular Ejection (Ventricular Systole - Phase 2):** Pressure in the ventricles surpasses that in the aorta and pulmonary artery. The semilunar valves open, allowing blood to be ejected into the pulmonary artery and aorta. Ventricular contraction continues.
- **Isovolumetric Ventricular Relaxation (Diastole - Phase 4):** Ventricular relaxation begins. The semilunar valves close, preventing blood from flowing back into the ventricles.

The heart is briefly in a state of isovolumetric relaxation, as both the AV and semilunar valves are closed. The cycle then repeats with diastole, followed by atrial systole, isovolumetric ventricular contraction, ventricular ejection, and isovolumetric ventricular relaxation. The cardiac cycle is a coordinated sequence of events that ensures the efficient pumping of blood through the heart and into the circulatory system. The heart's ability to contract and relax rhythmically is crucial for maintaining blood flow and delivering oxygen and nutrients to the body's tissues.

CARDIAC CYCLE

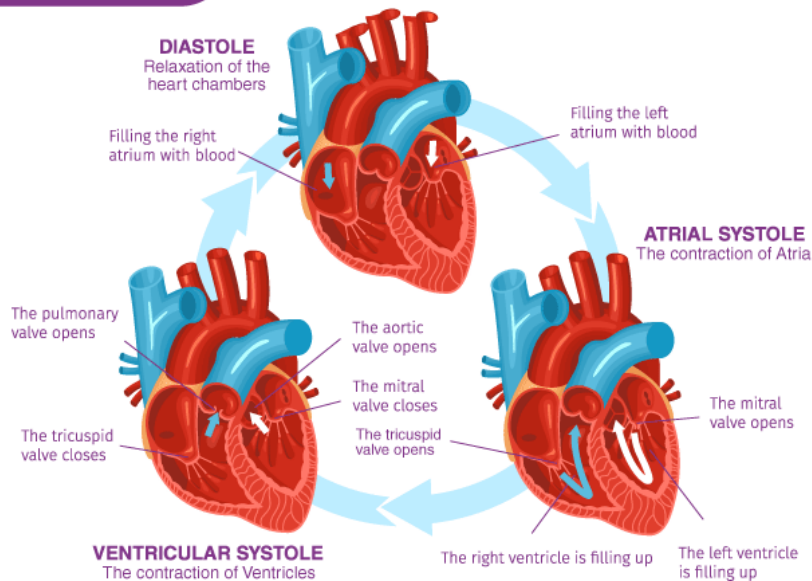


Fig: Cardiac Cycle.

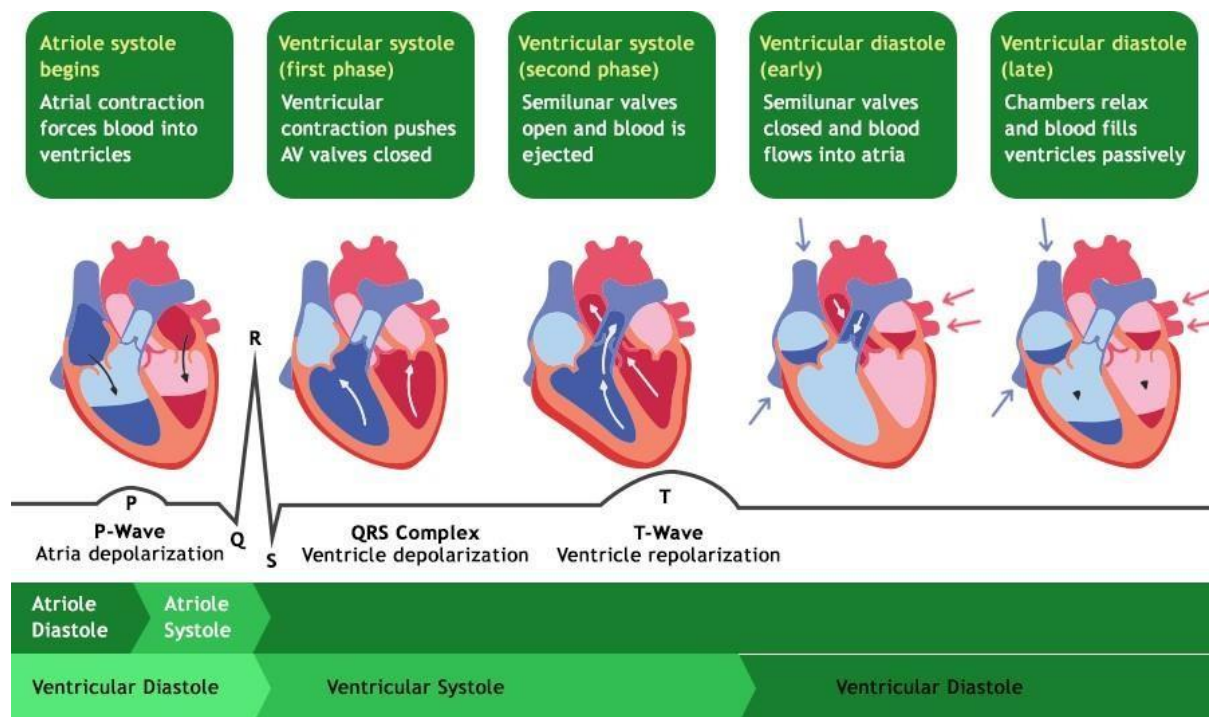


Fig: Phases of Cardiac Cycle

3.3 Cardiac output

The amount of blood pumped by the heart in one minute and is dependent on several factors, including preload, afterload, ejection fraction, and diastolic and systolic function.

Preload: Preload is the degree of stretch of the cardiac muscle fibers at the end of diastole. An increase in preload leads to an increase in the force of contraction, which in turn increases cardiac output.

Afterload: Afterload is the pressure that the heart must work against to eject blood during systole. An increase in afterload can lead to a decrease in stroke volume and cardiac output.

Ejection Fraction: Ejection fraction is the fraction of blood ejected from the heart with each heartbeat. It is a measure of the heart's efficiency and can affect cardiac output.

Diastolic and Systolic Function: Diastolic function refers to the ability of the heart to relax and fill with blood, while systolic function refers to the ability of the heart to contract and eject blood. Both diastolic and systolic function can affect cardiac output. These factors are essential in determining the heart's ability to pump blood effectively and

maintain adequate tissue perfusion. Changes in any of these factors can lead to alterations in cardiac output, which can have significant clinical implications.

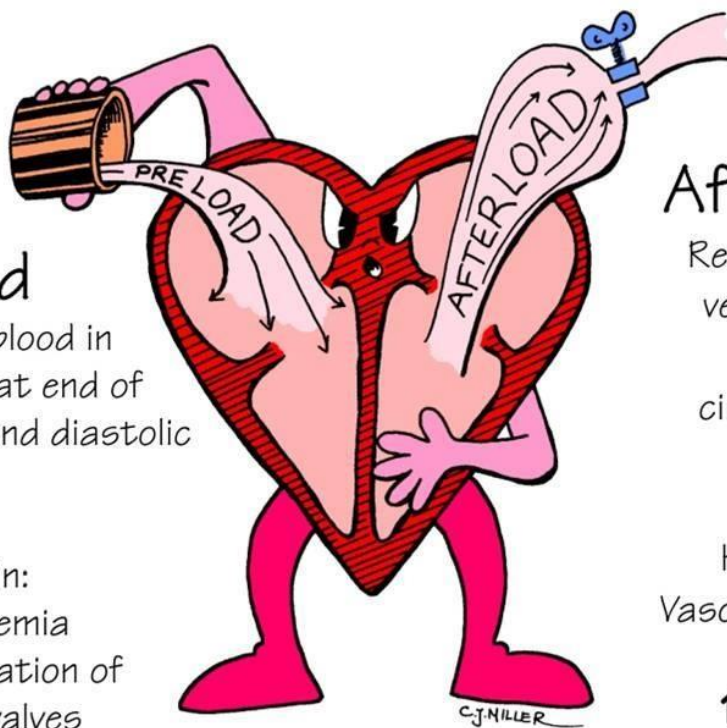
PRELOAD AND AFTERLOAD

Preload

Volume of blood in ventricles at end of diastole (end diastolic pressure)

Increased in:

Hypervolemia
Regurgitation of cardiac valves
Heart Failure



Afterload

Resistance left ventricle must overcome to circulate blood

Increased in:

Hypertension
Vasoconstriction

↑ Afterload =
↑ Cardiac workload

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Review Questions

Define the cardiac cycle and its importance in cardiovascular physiology.

Explain the processes involved in cardiac muscle contraction and relaxation.

What are the factors that affect cardiac output, and how do they influence heart function?

Discuss the significance of preload in the context of the cardiac cycle.

Explore the concept of afterload and its implications for cardiac performance.

How are ejection fractions used to assess heart function, and what do they indicate?

Differentiate between diastolic and systolic functions of the heart.

How does a comprehensive understanding of the cardiac cycle contribute to effective paramedic practice?

Relate the knowledge gained in this chapter to real-life emergency situations in cardiovascular care.

Evaluate the importance of mastering cardiac cycle concepts for paramedics in their daily practice.

Chapter-IV

Conduction System

Objective:

In this chapter, reader will be able to:

- ❖ Understand the automatic and rhythmic nature of the cardiac conducting system.
- ❖ Explore the concept of conductivity and its role in coordinating heart contractions.
- ❖ Examine the significance of the sinoatrial (S.A.) node as a primary pacemaker in the heart.
- ❖ Investigate the functions and importance of the atrioventricular (A.V.) node in cardiac conduction.
- ❖ Learn about the Bundle of His and its branches, elucidating their role in transmitting electrical impulses.
- ❖ Gain a comprehensive understanding of how the conducting system ensures coordinated and efficient heart contractions.
- ❖ Recognize the clinical implications of abnormalities in the cardiac conducting system for paramedic intervention.
- ❖ Relate the knowledge of the conducting system to the paramedic's ability to interpret and respond to cardiac rhythms.
- ❖ Appreciate the importance of a well-functioning conducting system for overall cardiac health and patient outcomes.
- ❖ Apply the acquired knowledge to enhance decision-making in emergency situations involving cardiac arrhythmias.

4.1 Conduction System of the Heart:

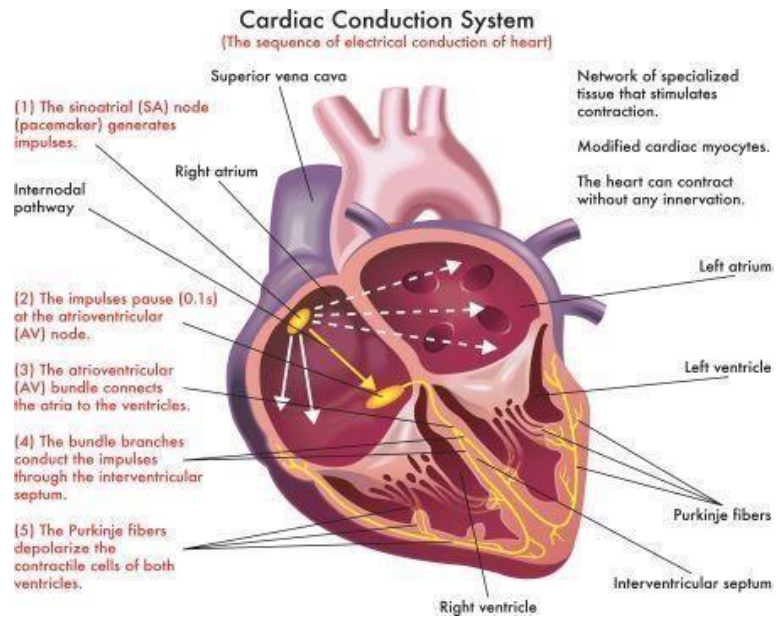
The heart rate is regulated by the autonomic nervous system; therefore, there is no voluntary control over the beating of the heart. Special tissue within the heart is responsible for conducting

an electrical impulse stimulating the different chambers to contract in the correct order. The path that the impulses travel is as follows:

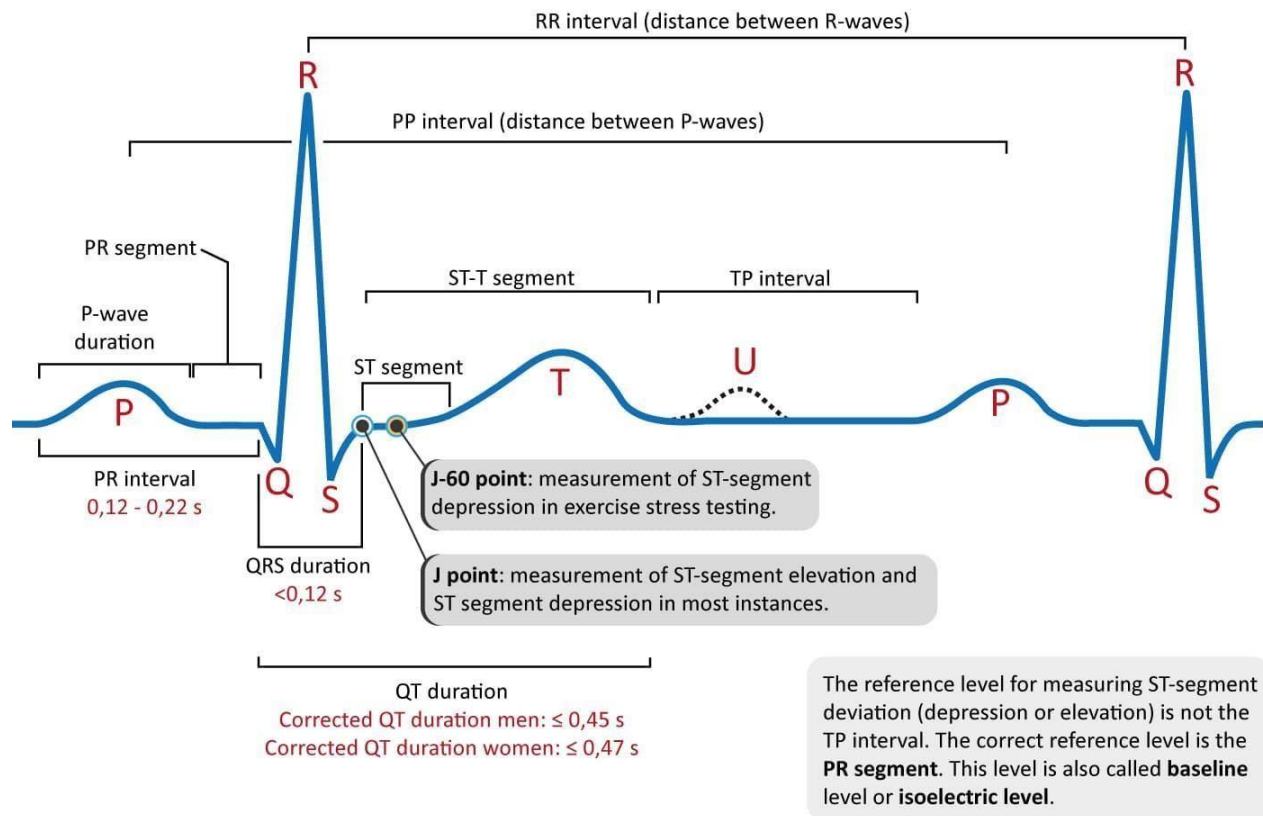
- The sinoatrial (SA, S-A) node, or pacemaker, is where the electrical impulses begin. From the sinoatrial node, a wave of electricity travels through the atria, causing them to contract, or go into systole.
- The atrioventricular node is stimulated.
- This node transfers the stimulation wave to the atrioventricular bundle

(formerly called bundle of His).

- The electrical signal next travels down the bundle branches within the interventricular septum.
- The Purkinje fibers out in the ventricular myocardium are stimulated, resulting in ventricular systole



Description: The conduction system of the heart; traces the path of the electrical impulse that stimulates the heart chambers to contract in the correct sequence.



4.2 Electrical Conduction System:

The electrical conduction system of the heart is responsible for coordinating the heartbeat, ensuring that the heart chambers contract in a synchronized manner to pump blood efficiently. The primary components of the heart's electrical conduction system include the sinoatrial (SA) node, atrioventricular (AV) node, bundle of His, Purkinje fibers, and various cardiac cells.

Additionally, heart valves play a crucial role in regulating blood flow through the heart chambers.

Here's an overview:

- **Sinoatrial (SA) Node:** Located in the right atrium, the SA node is the natural pacemaker of the heart. It generates electrical impulses that initiate each heartbeat. The electrical signals produced by the SA node spread across the atria, causing them to contract.
- **Atrioventricular (AV) Node:** The AV node is located between the atria and ventricles. It receives the electrical signals from the SA node and briefly delays them to allow the atria to contract fully before the ventricles. This delay ensures efficient filling of the ventricles before they contract.
- **Bundle of His:** After passing through the AV node, the electrical signals travel down the bundle of His, a bundle of specialized fibers. The bundle of His conducts the signals to the ventricles.

- Purkinje Fibers: The bundle of His branches into Purkinje fibers, which spread throughout the ventricles. Purkinje fibers conduct the electrical impulses rapidly, causing the ventricles to contract in a coordinated manner. This contraction is essential for pumping blood to the lungs and the rest of the body.
- As for heart valves, there are four main valves in the heart: Tricuspid Valve: Located between the right atrium and right ventricle. Mitral Valve (Bicuspid Valve): Located between the left atrium and left ventricle. Pulmonary Valve: Located at the exit of the right ventricle, leading to the pulmonary artery. Aortic Valve: Located at the exit of the left ventricle, leading to the aorta. Heart valves ensure unidirectional blood flow, preventing backflow and maintaining the integrity of the circulation. The coordinated action of the electrical conduction system and heart valves is crucial for the proper functioning of the heart and the circulation of blood throughout the body.

4.3 Blood Vessels:

There are three types of blood vessels: arteries, capillaries, and veins. These are the pipes that circulate blood throughout the body. The lumen is the channel within these vessels through which blood flows.

Arteries:

The arteries are the large, thick-walled vessels that carry the blood away from the heart. The walls of arteries contain a thick layer of smooth muscle that can contract or relax to change the size of the arterial lumen. The pulmonary artery carries deoxygenated blood from the right ventricle to the lungs. The largest artery, the aorta, begins from the left ventricle of the heart and carries oxygenated blood to all the body systems. The coronary arteries then branch from the aorta and provide blood to the myocardium. As they travel through the body, the arteries branch into progressively smaller-sized arteries. The smallest of the arteries, called arterioles, deliver blood to the capillaries.

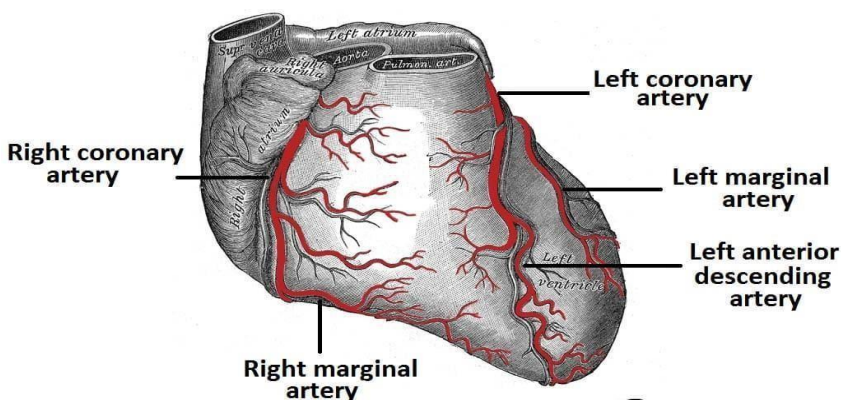


Figure: The coronary arteries.

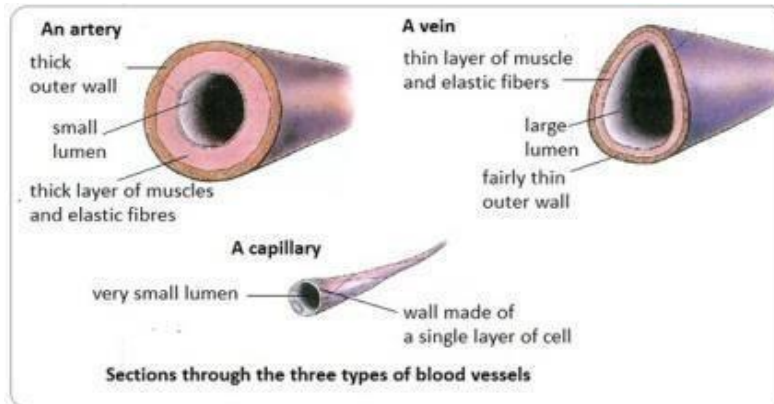


Fig: Comparative structure of arteries, capillaries, and veins.

Capillaries:

Capillaries are a network of tiny blood vessels referred to as a capillary bed. Arterial blood flows into a capillary bed, and venous blood flows back out. Capillaries are very thin walled, allowing for the diffusion of the oxygen and nutrients from the blood into the body tissues (see Figure 5- 8). Likewise, carbon dioxide and waste products are able to diffuse out of the body tissues and into the bloodstream to be carried away. Since the capillaries are so small in diameter, the blood will not flow as quickly through them as it does through the arteries and veins. This means that the blood has time for an exchange of nutrients, oxygen, and waste material to take place. As blood exits a capillary bed, it returns to the heart through a vein.

Veins:

The veins carry blood back to the heart (see Figure 5-8). Blood leaving capillaries first enters small venules, which then merge into larger veins. Veins have much thinner walls than arteries, causing them to collapse easily. The veins also have valves that allow the blood to move only toward the heart. These valves prevent blood from backflowing, ensuring that blood always flows toward the heart. The two large veins that enter the heart are the superior vena cava, which carries blood from the upper body, and the inferior vena cava, which carries blood from the lower body. Blood pressure in the veins is much lower than in the arteries. Muscular action against the veins and skeletal muscle contractions help in the movement of blood.

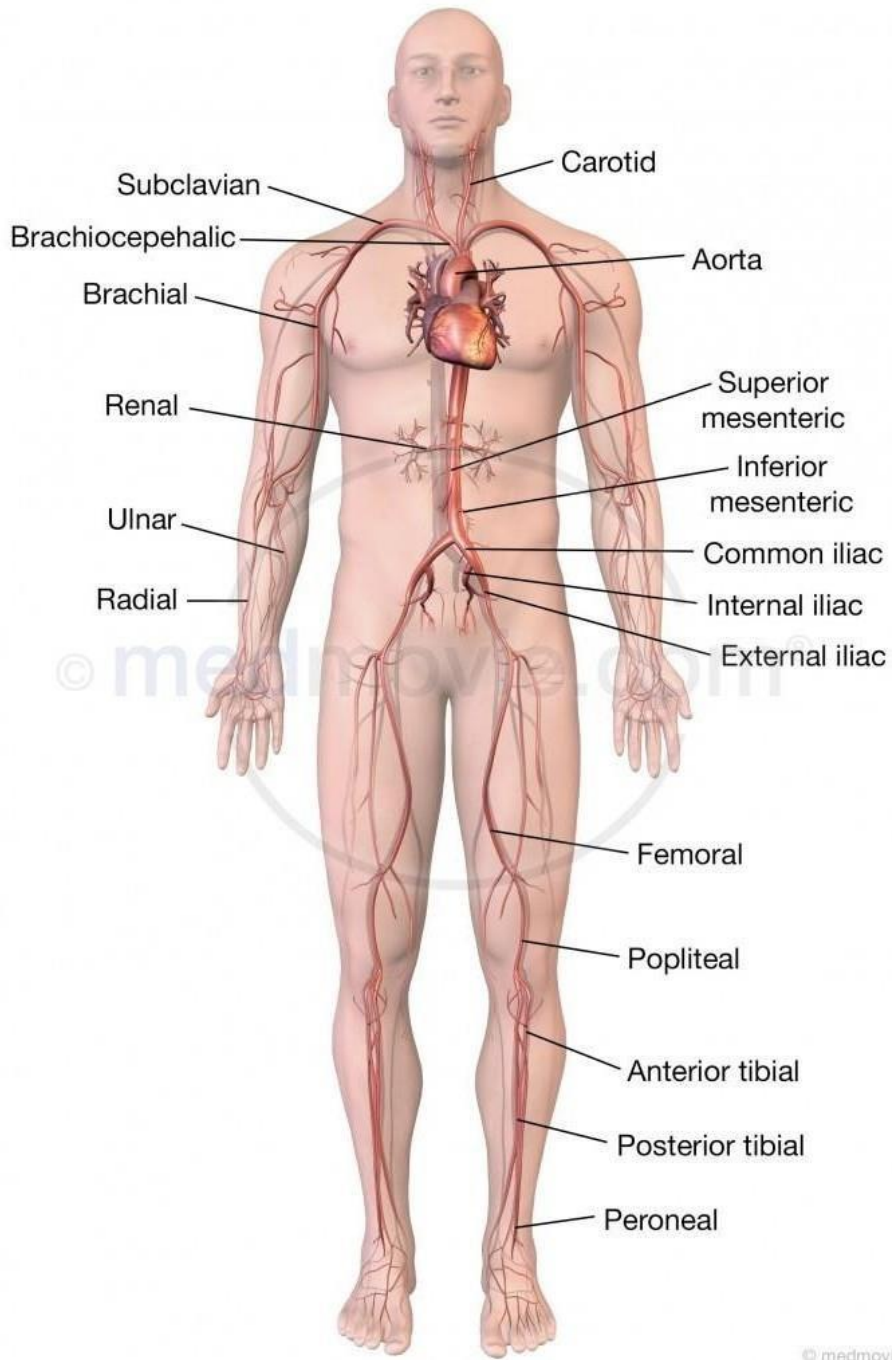


Fig: The major arteries of the body.

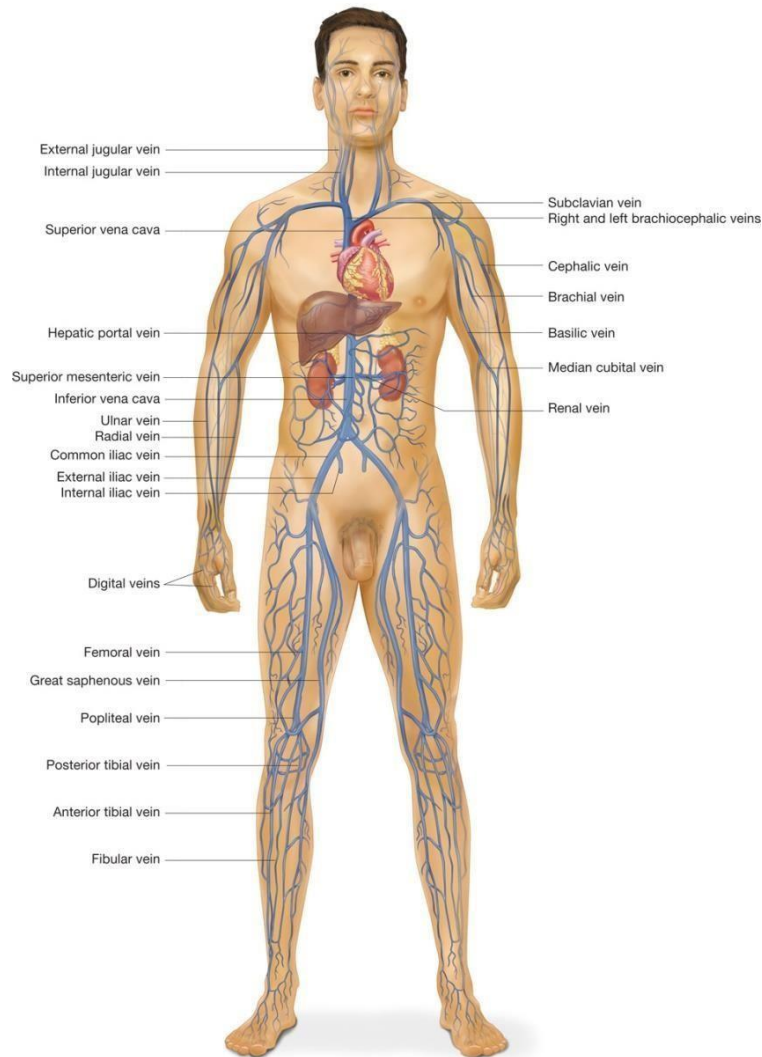


Fig: The major veins of the body.

Review Questions:

What is the automatic and rhythmic nature of the cardiac conducting system?

How does conductivity contribute to the coordination of heart contractions?

Explain the significance of the sinoatrial (S.A.) node as a primary pacemaker in the heart.

What are the functions and importance of the atrioventricular (A.V.) node in cardiac conduction?

Describe the role of the Bundle of His and its branches in transmitting electrical impulses.

How does the cardiac conducting system ensure coordinated and efficient heart contractions?

Discuss the clinical implications of abnormalities in the cardiac conducting system for paramedic intervention.

How can knowledge of the conducting system aid paramedics in interpreting and responding to cardiac rhythms?

Chapter-V Arterial Pressure

Objective:

- ❖ Define arterial pressure and its significance in assessing cardiovascular health.
- ❖ Classify various types of pulses and understand their clinical implications.
- ❖ Explore the concept of Mean Arterial Pressure (MAP) and its relevance in determining perfusion.
- ❖ Examine different methods of recording arterial pressure, differentiating between non-invasive and invasive techniques.
- ❖ Understand the mechanism and significance of Korotkoff's sounds in blood pressure measurement.
- ❖ Break down the different phases of arterial pressure, linking them to the cardiac cycle.
- ❖ Gain proficiency in recognizing and interpreting arterial pressure waveforms.
- ❖ Assess the clinical relevance of arterial pressure parameters in the context of paramedic practice.

5.1 Arterial Pressure:

Arterial pressure refers to the pressure exerted by the blood on the arterial wall. It is the force that is exerted by the blood against the walls of blood vessels and is essential for maintaining adequate tissue perfusion. Arterial pressure is not cardiac output, but it depends on cardiac output and total peripheral resistance. There are different types of pulses that can be felt in different parts of the body, such as the radial pulse, carotid pulse, and femoral pulse. These pulses are generated by the pressure wave created by the heartbeat and can be used to assess the heart's function.

Mean arterial pressure (MAP) is the average arterial pressure throughout one cardiac cycle, systole, and diastole. MAP is influenced by cardiac output and systemic vascular resistance, each of which is influenced by several variables. Arterial pressure can be recorded using non-invasive or invasive methods. Non-invasive methods include the use of a sphygmomanometer or an oscillometric blood pressure device, while invasive methods involve the insertion of a catheter into an artery.

5.2 Korotkoff's sound:

The sound heard when taking blood pressure using a sphygmomanometer. It is caused by the turbulent flow of blood through the compressed artery. The different phases of arterial pressure include systolic pressure, which refers to the maximum pressure within the large arteries when the

heart muscle contracts to propel blood through the body, and diastolic pressure, which describes the lowest pressure within the large arteries during heart muscle relaxation between beating.

In summary, arterial pressure is the pressure exerted by the blood on the arterial wall and is essential for maintaining adequate tissue perfusion. It can be measured using non-invasive or invasive methods and is influenced by several factors, including cardiac output and total peripheral resistance. The different phases of arterial pressure include systolic and diastolic pressure, and the different types of pulses can be used to assess the heart's function.

5.3 Types of Pulse:

- Radial Pulse: Palpated at the radial artery on the wrist.
- Carotid Pulse: Palpated at the carotid artery in the neck.
- Brachial Pulse: Palpated at the brachial artery in the upper arm.
- Femoral Pulse: Palpated at the femoral artery in the groin.
- Dorsalis Pedis Pulse: Palpated at the dorsalis pedis artery on the top of the foot.
- Popliteal Pulse: Palpated at the popliteal artery behind the knee.
-

5.4 Phases of Korotkoff's Sounds:

The series of sounds heard during the auscultation of blood pressure with a stethoscope. They are classified into different phases.

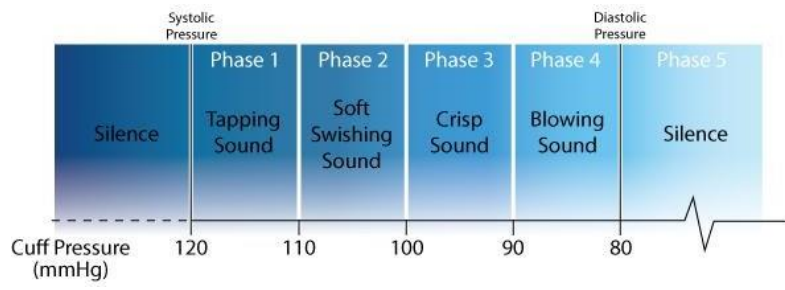
Phases:

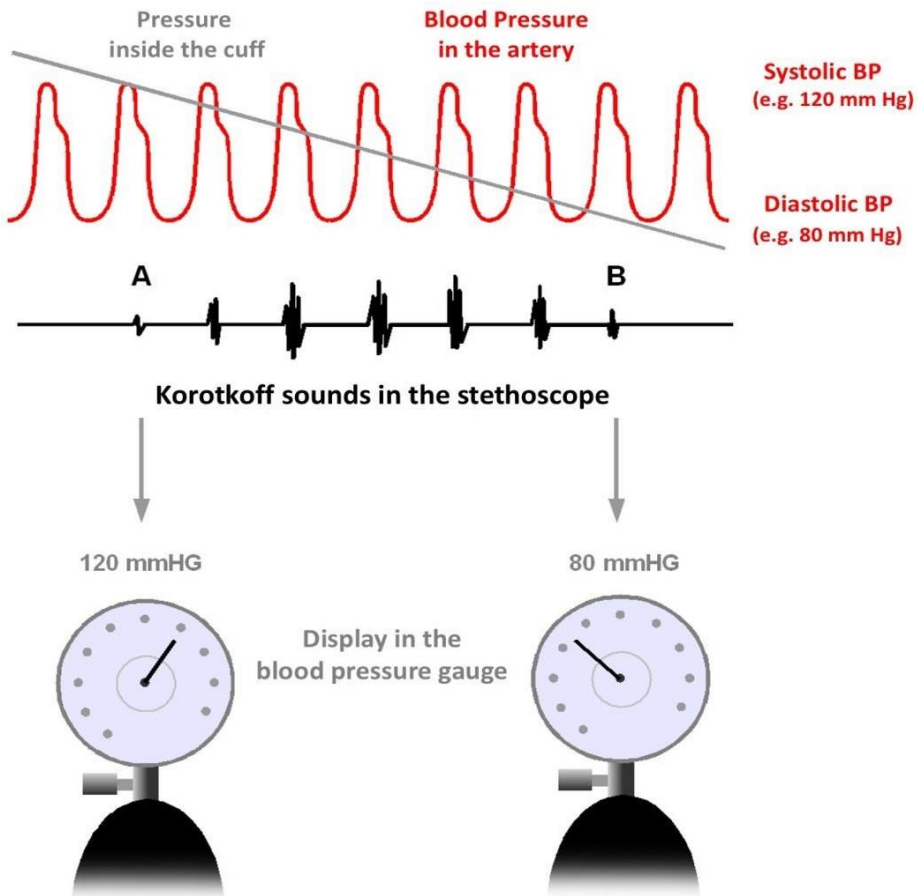
- **Phase I:** The first appearance of faint, tapping sounds (systolic pressure).
- **Phase II:** A swishing or whooshing sound as blood flow becomes more turbulent.
- **Phase III:** The sounds become crisper and more intense.
- **Phase IV:** The sounds become muffled and softer.
- **Phase V:** Sounds disappear completely (diastolic pressure).
-

Different Phases:

Systolic Phase: Represents the highest pressure reached in the arteries during ventricular contraction.

Diastolic Phase: Represents the lowest pressure in the arteries during ventricular relaxation. Understanding arterial pressure and its measurement is crucial for assessing cardiovascular health and managing conditions such as hypertension. Regular blood pressure monitoring is a fundamental aspect of preventive healthcare.





Review Questions:

Define arterial blood pressure and explain its significance in cardiovascular health.

Describe the various types of pulses and their locations in the human body.

What is Mean Arterial Pressure (MAP), and how is it calculated?

Explore the methods used for recording arterial pressure, highlighting both non-invasive and invasive techniques.

Differentiate between non-invasive and invasive approaches in measuring arterial blood pressure. Discuss their respective advantages and limitations.

Explain the significance of Korotkoff's sound in the measurement of blood pressure.

Outline the different phases involved in measuring blood pressure using the Korotkoff's sound technique.

Discuss the clinical importance of accurate blood pressure measurements for paramedics.

How does arterial blood pressure relate to overall cardiovascular function and patient assessment?

Consider scenarios where knowledge of arterial blood pressure is crucial for paramedic decision-making during emergencies.

Chapter-VI Electrocardiography (ECG)

Objective:

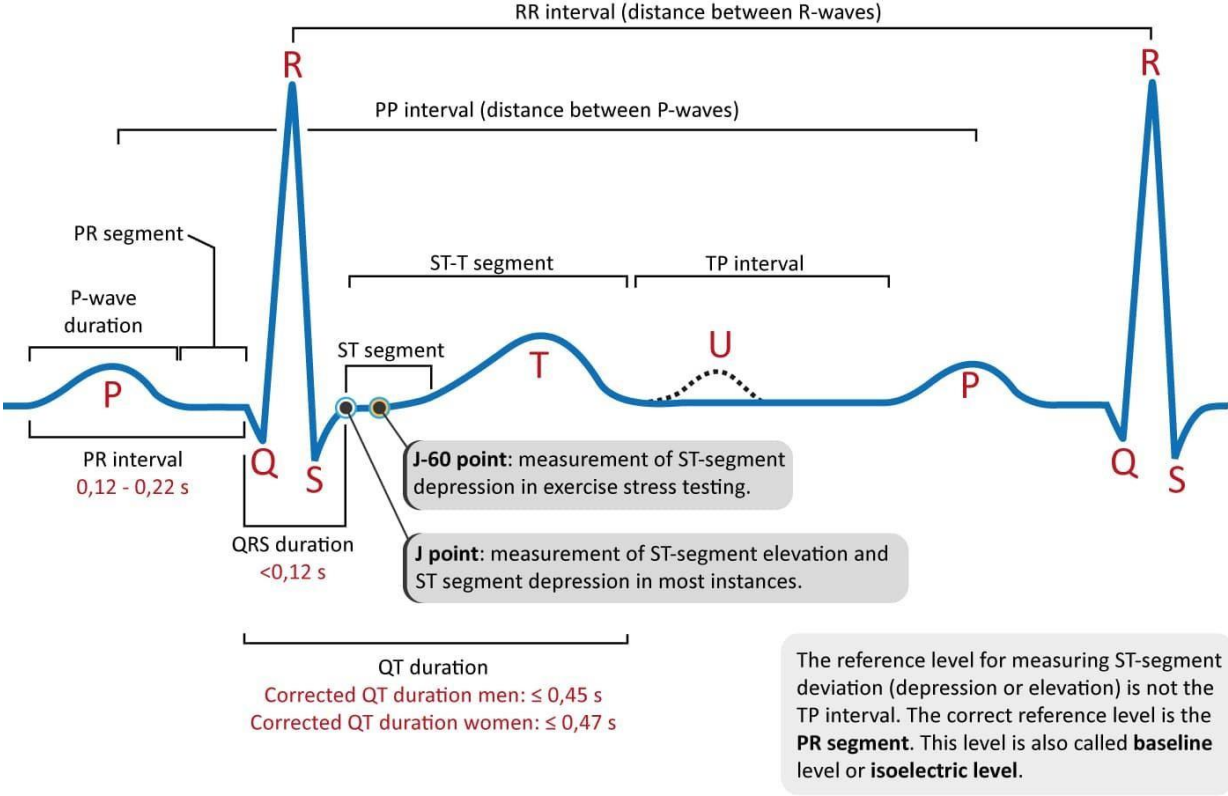
- ❖ Understand the fundamentals of Electrocardiography (ECG) and its role in cardiac monitoring.
- ❖ Explore the components and functions of an ECG machine, emphasizing its importance in diagnosing cardiac conditions.
- ❖ Learn about the various leads used in ECG, their placement on the human body, and the significance of each lead.
- ❖ Understand the anatomical positions of electrodes on the body for optimal ECG recording.
- ❖ Review the cardiac conduction system to establish a foundation for interpreting ECG tracings.
- ❖ Identify and interpret a normal ECG, including the different waves (P, Q, R, S, T) and segments (P-R, S-T).
- ❖ Gain proficiency in determining heart rate through ECG tracings and calculating it accurately.
- ❖ Explore the P-R interval, QRS complex, and T wave in detail, understanding their physiological significance.
- ❖ Understand the concept of cardiac axis and its relevance in ECG interpretation.
- ❖ Interpret different ECG waves (P wave, Q wave, R wave, S wave, S-T segment, T wave) and their implications for cardiac health.
- ❖ Develop a comprehensive understanding of cardiac rhythm and its variations as observed in ECG readings.

This chapter aims to provide paramedics with a solid foundation in ECG interpretation, enabling them to recognize normal patterns and identify potential cardiac abnormalities in emergency situations.

6.1 ECG:

The electrocardiogram (ECG or EKG) is a non-invasive test that records the electrical activity of the heart over a period of time. It is a valuable tool for diagnosing and monitoring various heart conditions. The ECG machine is used to perform the test and consists of leads that are attached to the patient's torso and upper or lower limbs. The machine records the electrical signals from the heart and displays them in an easy-to-read graph. There are different types of ECG machines available, including portable and 12-lead resting ECG machines with interpretation. The ECG can be recorded using non-invasive or invasive methods, and the test can be used to calculate the heart rate, review the conduction system, and assess the rhythm and various components of the ECG, such as the P wave, QRS complex, and T wave. The ECG is an essential tool for diagnosing and monitoring heart conditions and is widely used in medical settings, including hospitals,

clinics, and outpatient facilities.



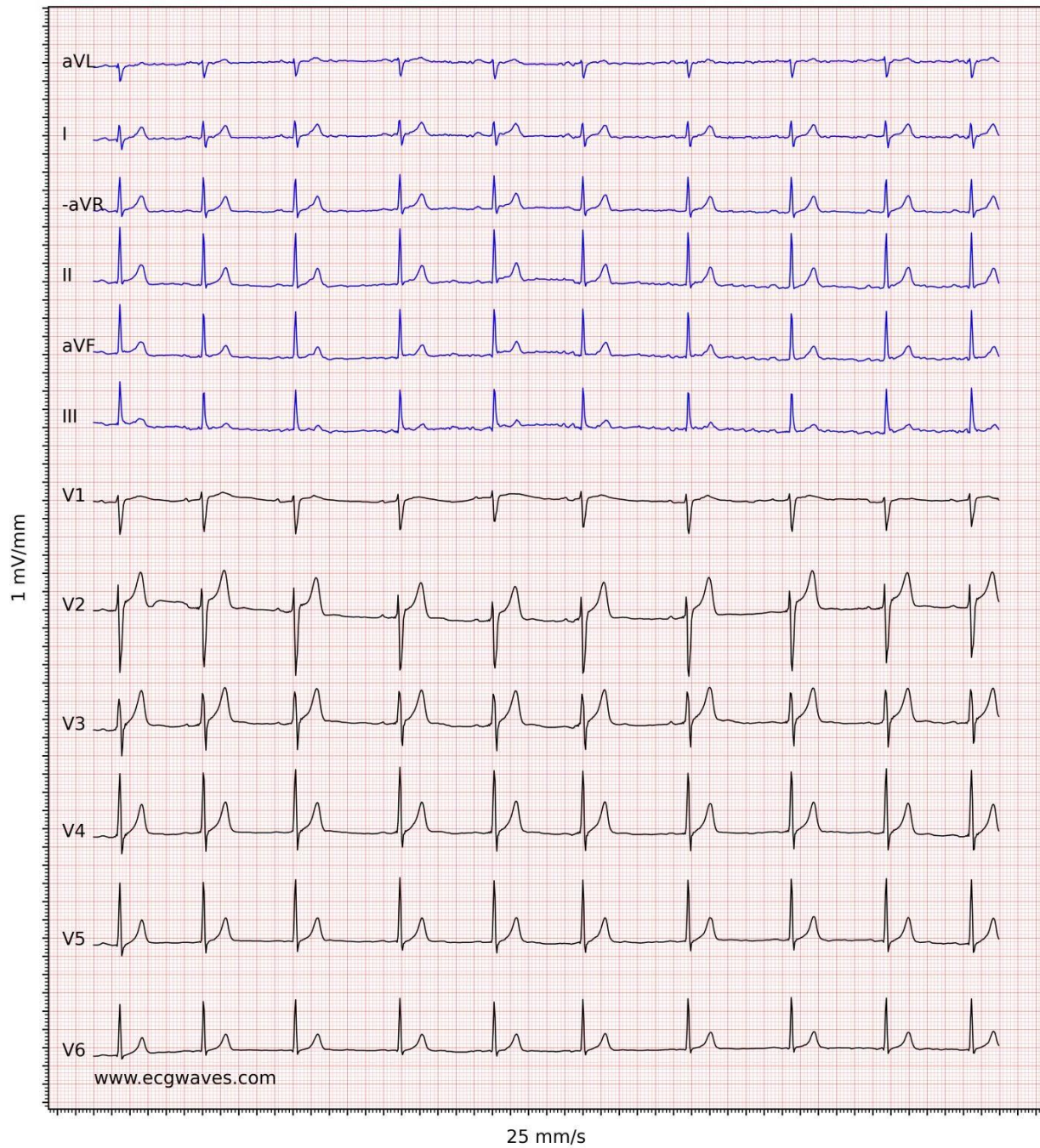


Fig: Characteristics of a normal ECG.

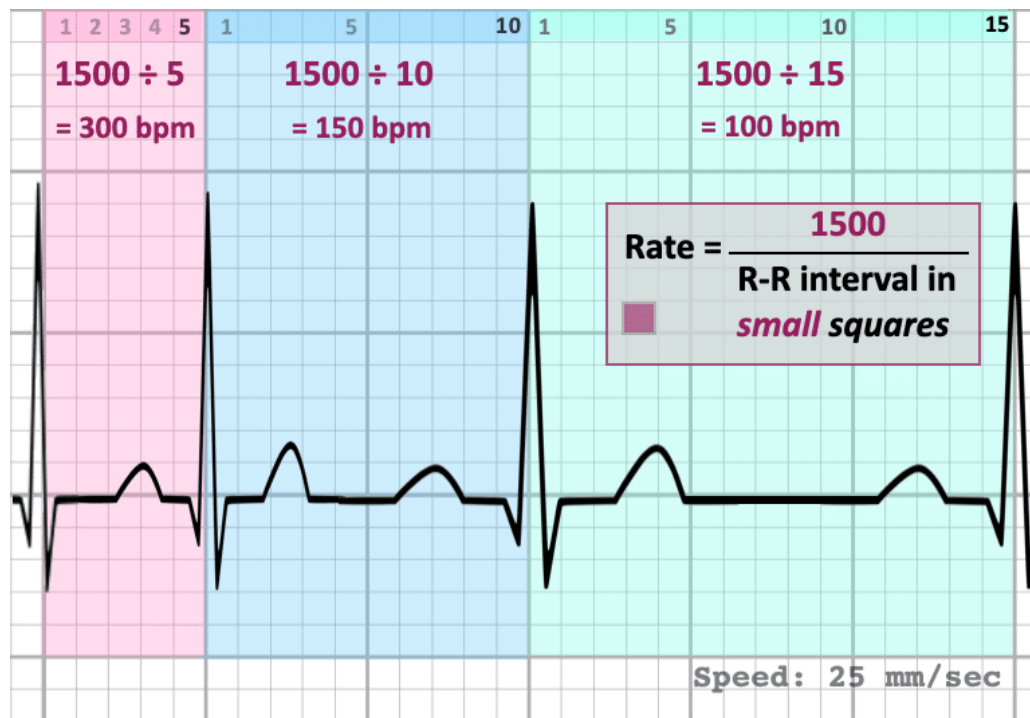


Fig: Calculation of rate in ECG.

6.2 Abnormalities in ECG:

Abnormalities of ECG can provide valuable information about the heart's function and can indicate various heart conditions. Some of the common abnormalities of ECG include:

Types of infarction:

ECG can show different types of infarction, such as ST-segment elevation myocardial infarction (STEMI) and non-ST-segment elevation myocardial infarction (NSTEMI), which are indicative of heart muscle damage due to reduced blood flow.

Bradyarrhythmias:

These are abnormally slow heart rhythms, which can be detected on an ECG. They include conditions such as sinus bradycardia, heart block, and atrioventricular (AV) block.

Tachyarrhythmias:

These are abnormally fast heart rhythms, which can also be detected on an ECG. They include conditions such as atrial fibrillation, atrial flutter, and ventricular tachycardia.

A-V blocks:

A-V blocks are a type of bradyarrhythmia that occurs when the electrical signals between the atria and ventricles are delayed or blocked. They can be first, second, or third degree, depending on the severity of the block.

Hypertrophy:

ECG can show signs of left ventricular hypertrophy, which is indicative of an enlarged and overworked left ventricle. This can be caused by conditions such as high blood pressure and aortic stenosis.

Bundle branch blocks:

ECG can show signs of right or left bundle branch blocks, which are indicative of a delay or blockage in the electrical signals that control the heart's contractions.

Ventricular arrhythmias:

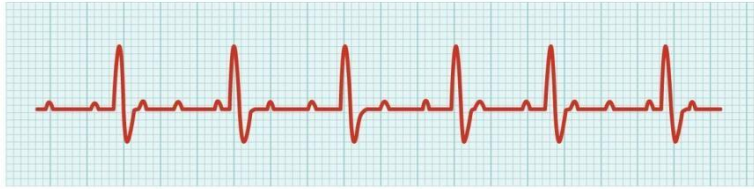
ECG can show signs of ventricular arrhythmias, such as premature ventricular contractions (PVCs)

and ventricular fibrillation, which are indicative of abnormal electrical activity in the ventricles.

ST-T abnormalities:

ECG can show ST-segment and T-wave abnormalities, which can be indicative of myocardial ischemia, injury, or infarction. These abnormalities can be seen in conditions such as angina, myocardial infarction, and pericarditis.

In summary, ECG is a valuable tool for diagnosing and monitoring various heart conditions, and it can provide valuable information about the heart's function. Abnormalities of ECG can indicate various heart conditions, including arrhythmias, conduction abnormalities, and structural heart disease. It is important to interpret ECG findings in the context of the patient's clinical history and other diagnostic tests to make an accurate diagnosis and develop an appropriate treatment plan.



(a) Second-degree (partial) block

Note how half of the P waves are not followed by the QRS complex and T waves while the other half are.

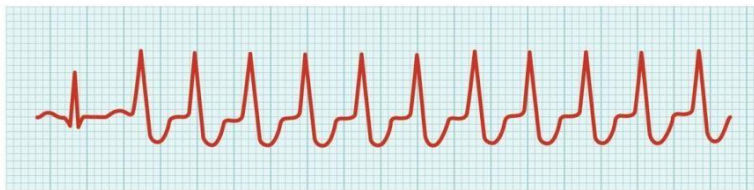
Question: What would you expect to happen to heart rate (pulse)?



(b) Atrial fibrillation

Note the abnormal electrical pattern prior to the QRS complexes. Also note how the frequency between the QRS complexes has increased.

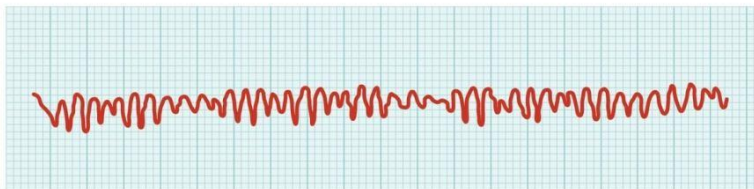
Question: What would you expect to happen to heart rate (pulse)?



(c) Ventricular tachycardia

Note the unusual shape of the QRS complex, focusing on the "S" component.

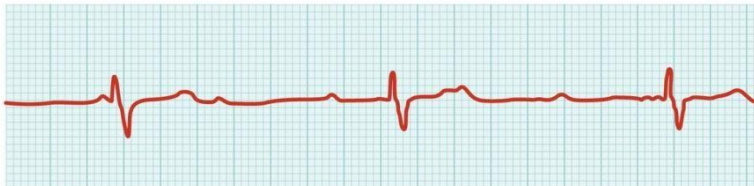
Question: What would you expect to happen to heart rate (pulse)?



(d) Ventricular fibrillation

Note the total lack of normal electrical activity.

Question: What would you expect to happen to heart rate (pulse)?

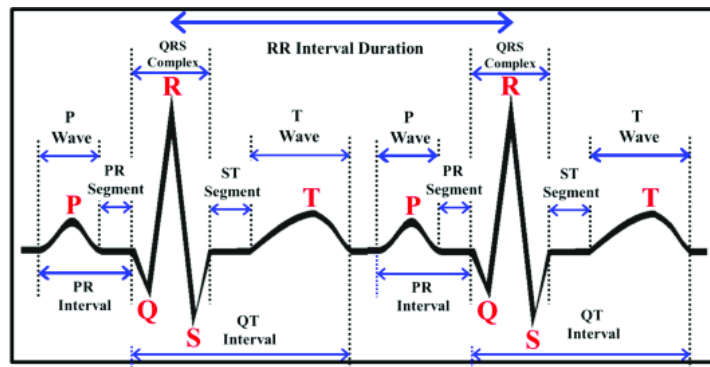


(e) Third-degree block

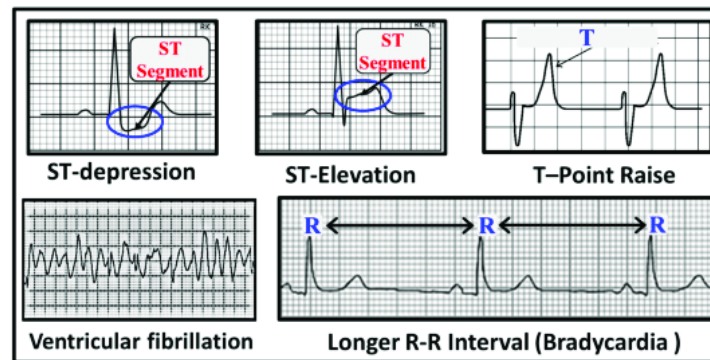
Note that in a third-degree block some of the impulses initiated by the SA node do not reach the AV node while others do. Also note that the P waves are not followed by the QRS complex.

Question: What would you expect to happen to heart rate (pulse)?

Fig: ECG Abnormalities



(a). Normal ECG morphology



(b). Abnormal ECG morphology

Review Question:

What is the primary purpose of Electrocardiography (ECG) in cardiac monitoring?
 Explain the significance of an ECG machine in diagnosing cardiac conditions.
 Differentiate between the various leads used in ECG and their corresponding placements on the human body.
 Why is a thorough understanding of the cardiac conduction system essential for interpreting ECG tracings?
 Describe the anatomical positions of electrodes on the body for optimal ECG recording.
 Identify and interpret the components of a normal ECG, including the waves and segments.
 How is heart rate calculated through ECG tracings, and why is it clinically relevant?
 Discuss the physiological significance of the P-R interval, QRS complex, and T wave in ECG interpretation.
 Explain the concept of cardiac axis and its importance in understanding ECG readings.
 Interpret the different ECG waves (P wave, Q wave, R wave, S wave, S-T segment, T wave) and their implications for cardiac health.
 How does an understanding of cardiac rhythm contribute to effective ECG interpretation?
 In what ways can ECG readings assist paramedics in identifying potential cardiac abnormalities during emergencies?
 These review questions aim to reinforce the key concepts covered in the chapter, ensuring that paramedics grasp the essential knowledge required for interpreting ECG tracings in various clinical scenarios.

Chapter-VII

Advanced Cardiac Monitoring Techniques

Objective:

In this chapter, readers will gain a comprehensive understanding of advanced cardiac monitoring techniques, including the Tilt Test, Holter Monitoring, and Ambulatory Blood Pressure Recording

- ❖ Explore the Tilt Test, understanding its introduction, indications, and detailed methods.
- ❖ Delve into the intricacies of Holter Monitoring, including its introduction, indications, and the processing and analysis of recorded data.
- ❖ Gain insights into Ambulatory Blood Pressure Recording, covering its introduction, indications, and the processing and analysis techniques involved.
- ❖ Acquire valuable knowledge on advanced cardiac monitoring, enabling paramedics to apply these techniques effectively in diverse clinical situations.

7.1 Tilt Test:

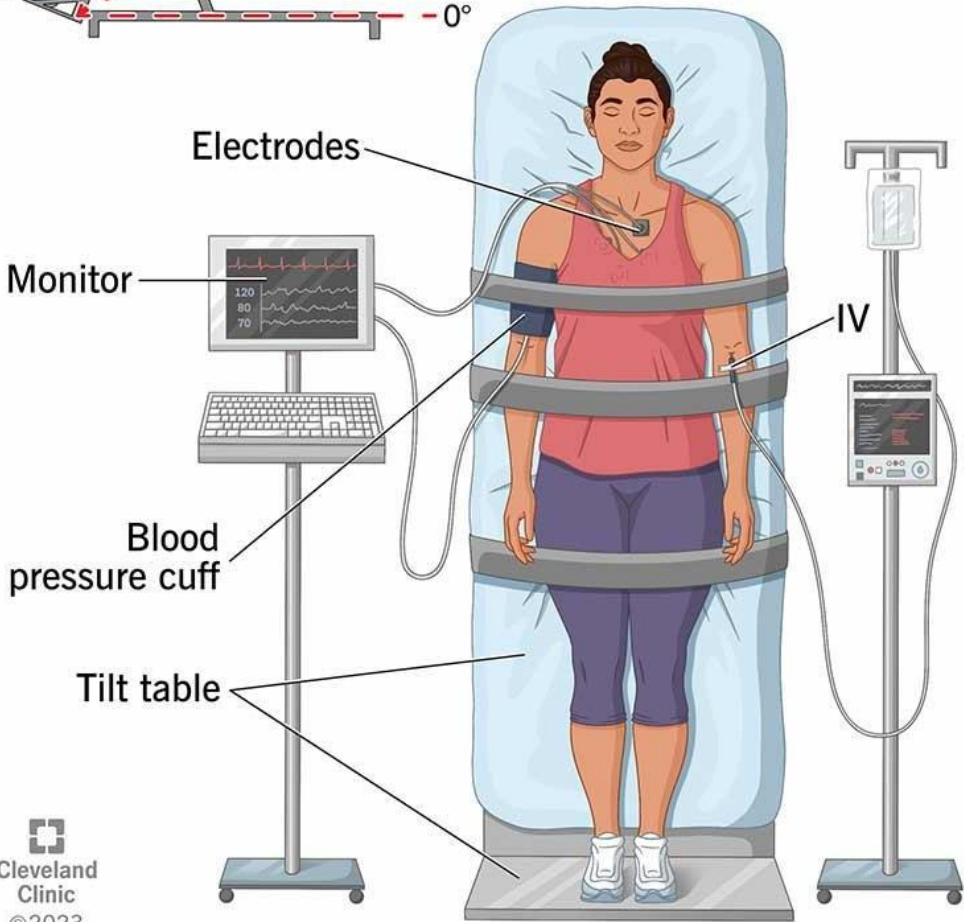
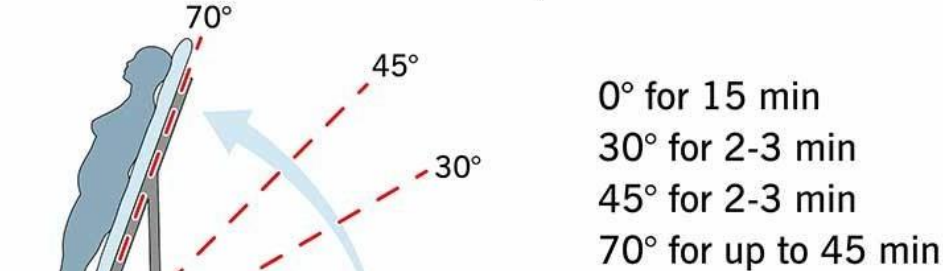
A tilt table test, also known as a passive head-up tilt test, is a diagnostic procedure used to evaluate the cause of unexplained fainting (syncope). The test involves placing the patient on a special table with foot support, then tilting the table upward to observe changes in blood pressure, heart rate, and cardiac rhythms. The test mimics the body's response to standing up after lying down and can help identify the cause of fainting.

7.1.1 Methods:

The patient is initially positioned supine and horizontal on the table, then tilted by degrees to a completely vertical, upright position. During the test, blood pressure, heart rate, oxygen saturation, and cardiac rhythms are recorded and monitored for the endpoint of fainting, which indicates a positive tilt test result. The patient is also observed for signs and symptoms that would necessitate early termination of the test, such as nausea, sweating, lightheadedness, or irregular heartbeats. The test takes about 90 minutes if both parts are completed, but it may take only 30 to 40 minutes, depending on the patient's symptoms and the test's effects on blood pressure, heart rhythm, and heart rate. Indications: Evaluating the cause of unexplained fainting (syncope) assessing the body's response to changes in posture from lying to standing identifying the cause of symptoms such as dizziness, lightheadedness, or irregular heartbeats

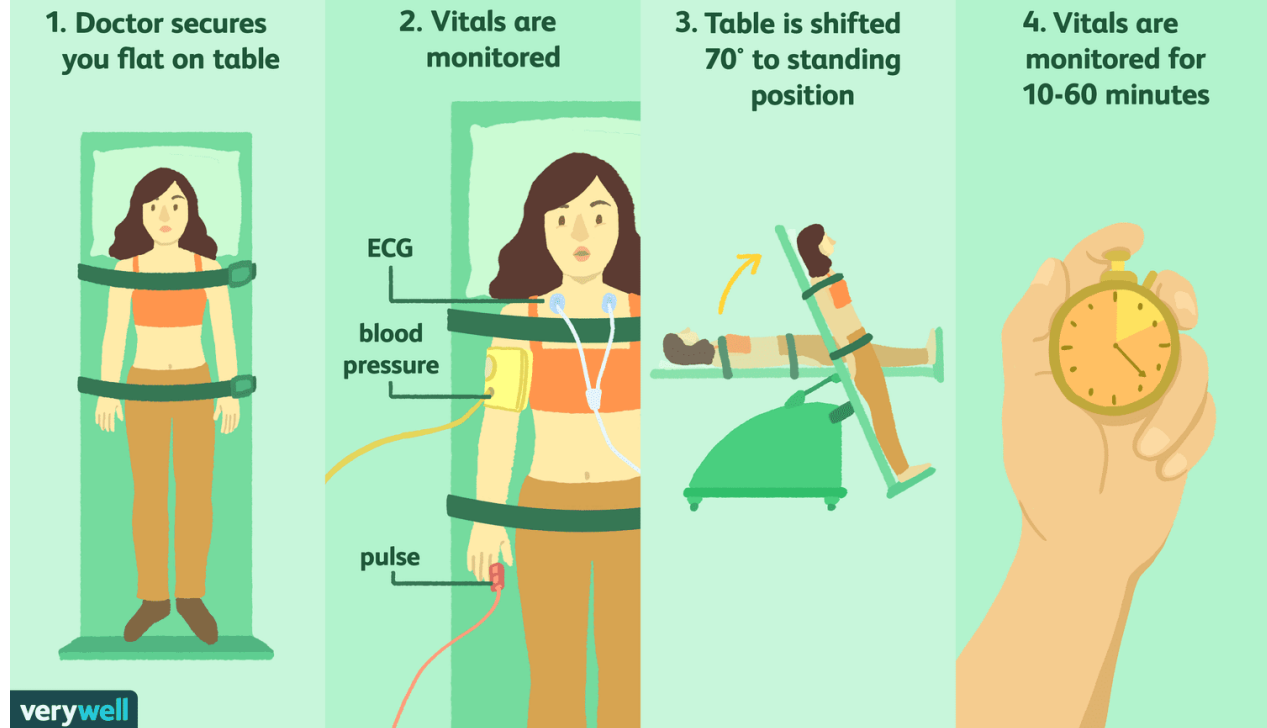
Equipment: Tilt table Blood pressure monitor ECG monitor Nitroglycerin spray or

Tilt Table Test *Passive head-up tilt test*



isoprenaline infusion. Cardioverter-defibrillator (in case of complications) The tilt table test is a safe procedure that can provide valuable information about the body's response to changes in posture and help identify the cause of unexplained fainting. It is typically performed in a hospital or clinic that has a tilt lab or similar facility and is conducted by trained medical personnel. The test results are based on whether the patient faints during the test and the changes in blood pressure, heart rate, and heart rhythm that occur during the test.

What to Expect During a Tilt Table Test



7.2 Holter Monitoring:

A Holter monitor is a small, wearable device that records the heart's rhythm for 24 to 48 hours, allowing it to detect or determine the risk of irregular heartbeats (arrhythmias). It is particularly useful for detecting infrequent arrhythmias that may not be captured by a traditional electrocardiogram (ECG).

Indications:

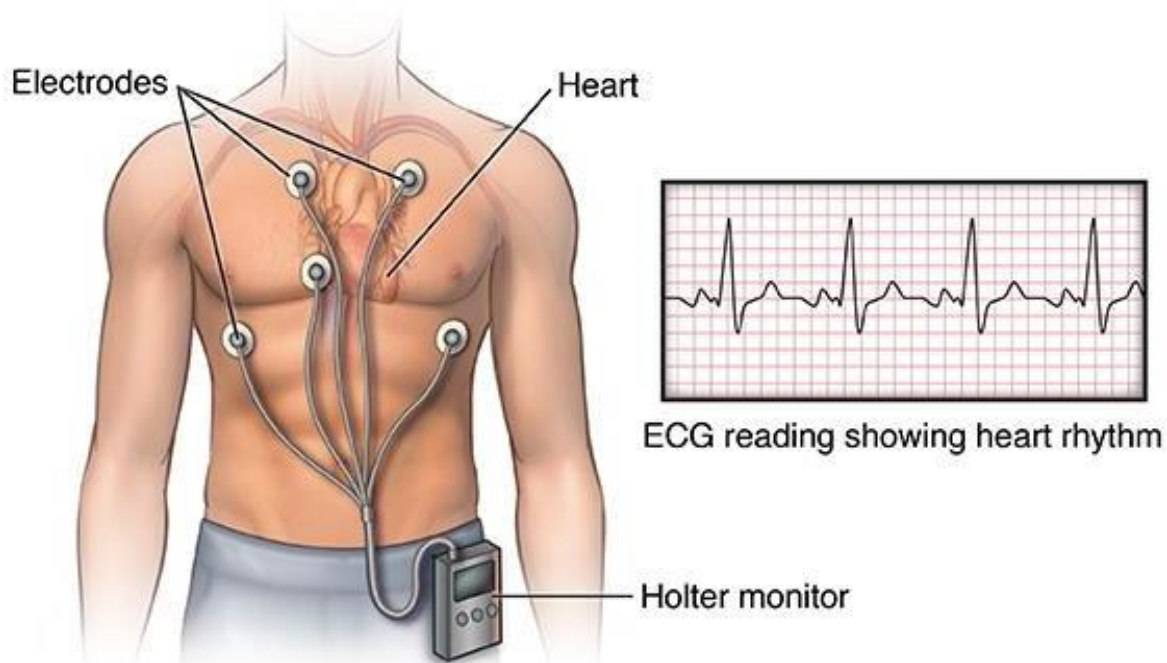
Detection of intermittent or infrequent arrhythmias
Evaluation of heart palpitations
Assessment of unexplained fainting
Monitoring patients with heart conditions and implantable cardioverter- defibrillators (ICDs)

Processing and Analysis:

The Holter monitor records the electrical activity of the heart continuously during the monitoring period. After the monitoring period, the device is returned to the healthcare provider, who processes the recorded heart activity and compares it with the patient's symptoms and activities documented in a diary. The results of the Holter monitor are typically available within one to two weeks. Procedure: The patient wears the Holter monitor for 1 to 2 days, and the device records all of the heartbeats during this period. The monitor is attached to the patient's clothing with wires and electrodes, which are placed on the chest and abdomen. The patient carries the monitor in a pocket or pouch and goes about their daily activities. After the monitoring period, the patient returns the device to the healthcare provider, who processes the data and provides the results. In

summary, a Holter monitor is a wearable device that records the heart's rhythm for an extended period, allowing for the detection and evaluation of arrhythmias and other heart-related issues. It is a valuable tool for diagnosing intermittent or infrequent arrhythmias and providing insights into the patient's heart function and symptoms.

Holter monitor with ECG reading



7.3 Ambulatory BP Recording:

Ambulatory blood pressure monitoring (ABPM) is a diagnostic test that involves the use of a portable monitor connected to a blood pressure cuff, which automatically inflates at regular intervals and records multiple blood pressure readings over a 24-hour period.

This method provides a wealth of data on a patient's blood pressure variations during different activities, including sleep, exercise, and daily routines. ABPM is particularly valuable for diagnosing and managing hypertension, as it can detect abnormal blood pressure patterns that may go unnoticed during in-office measurements. It is also useful for ruling out white coat hypertension, which occurs when a patient's blood pressure is higher in a clinical setting than in other environments.

Processing and Analysis: After the monitoring period, the data from the ABPM device is transferred to a computer for analysis. The recorded blood pressure readings are reviewed to identify patterns and variations in the patient's blood pressure throughout the day and night. This analysis provides a more accurate and comprehensive picture of the patient's blood pressure profile, which can help in diagnosing hypertension, assessing

the effectiveness of antihypertensive medications, and guiding treatment decisions. The results of the ABPM are typically interpreted by a healthcare provider, who considers the patient's clinical history and other diagnostic tests to make an accurate diagnosis and develop an appropriate treatment plan.

In summary, ambulatory blood pressure monitoring is a valuable diagnostic test for assessing a patient's blood pressure variations over a 24-hour period. It is particularly useful for diagnosing and managing hypertension, as it can detect abnormal blood pressure patterns and provide a more accurate picture of the patient's blood pressure profile compared to in-office measurements. The data from the ABPM device is processed and analyzed to identify patterns and variations in the patient's blood pressure, which can help in making an accurate diagnosis and guiding treatment decisions.

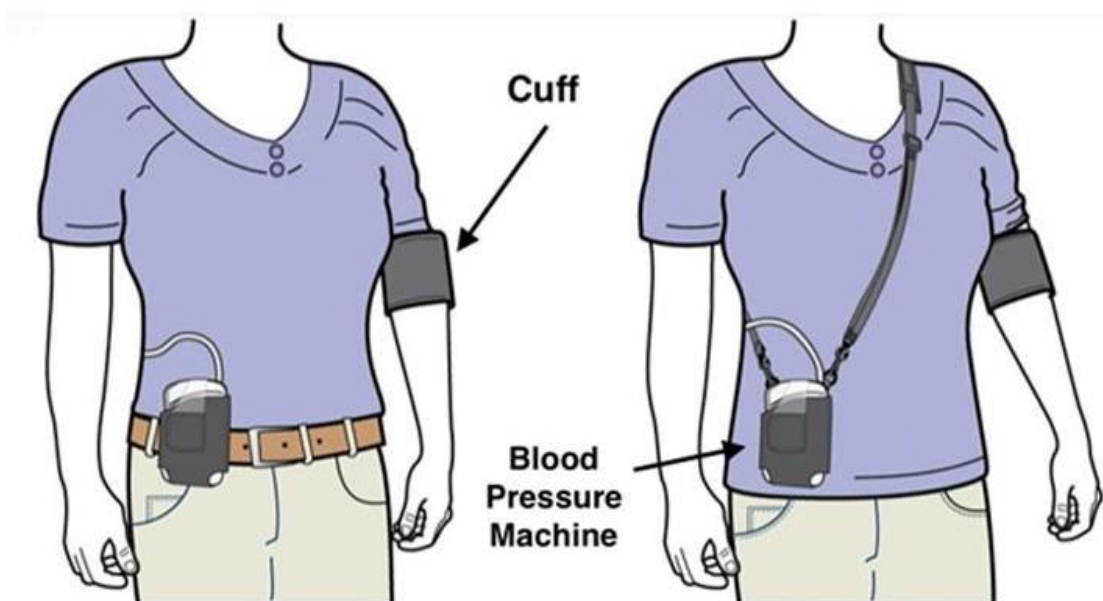


Fig: Ambulatory BP Monitor

Review Questions:

What are the primary indications for performing a Tilt Test?

Describe the methods involved in conducting a Tilt Test and their significance in clinical practice.

How does Holter Monitoring contribute to the diagnosis and management of cardiac conditions?

Discuss the processing and analysis methods used in Holter Monitoring for accurate interpretation.

What are the key indications for implementing Ambulatory Blood Pressure Recording?

Explain the processing and analysis techniques involved in Ambulatory Blood Pressure Recording.

How do these advanced cardiac monitoring techniques enhance the overall assessment of patients with cardiovascular concerns?

Relate the information gathered from Tilt Tests, Holter Monitoring, and Ambulatory Blood Pressure Recording to paramedic decision-making in emergency scenarios.

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