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Paramedics

6-in-1 Handbook

(Medical, Nursing & Allied Health Students)



3rd Edition

GD Mogli

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Contents

Part I: Anatomy, Physiology including Medical Terminology, Medical Examination and Diagnostic Techniques

1. Human Body **3**

Cell *3*

Structure of Cell *3*
Functions of the Cell *4*
Cell Division *4*
Tissue Fluid *5*
Tissues *5*
Organs *8*
Systems *8*
Body Cavities *10*
Anatomical Divisions of the Body *10*
Clinical Divisions of the Abdomen *12*
Anatomical Divisions of the Back (Spinal Column) *12*
Planes of the Body *13*
Positional and Directional Terms of the Body *15*

Medical Terminology *15*

Objectives in Studying the Medical Language *15*

Chief Sources of Medical Words *16*

Anglo-Saxon (Old English) *16*
Greeco-Roman (Greek and Latin) *16*
Arabic *17*
Modern German *17*
Colors *17*
Numerals *18*

Elements of Medical Terms *18*

Suffixes and Compounding Elements *18*
Roots *21*
Prefixes *25*
Common Abbreviations *28*

2. Musculoskeletal System **31**

Muscular System *31*

Properties of Muscle *31*
Characteristics of Muscular Tissue *31*
Muscular Tissue *32*
Functions of Muscle *32*
Different Functions of Muscles *36*
Formation of Bone *37*

Functions of Bone *37*
Types of Bone *37*
Structure and Terms used to Describe the Bones *38*
Bones of Different Locations *40*
Joints *44*
Bursae *45*
Movements of Joints *45*
Musculoskeletal System *46*
Symptomatic and Diagnostic Terms *48*
Operative Terms *52*
Common Abbreviations *53*

3. Cardiovascular System **55**

Arteries *55*
Veins *56*
Capillaries *56*
The Heart *57*
Valves of the Heart *60*
Heart Cycle or Cardiac Cycle *60*
Pulmonary and Systemic Circulation *61*
Blood Pressure *63*
The Pulse *63*
Electrical Conduction of the Heart Pulses *63*
Cardiovascular Disorders *63*
Common Abbreviations *68*

4. Blood and Lymphatic System **72**

Blood *72*
Plasma *72*
Erythrocytes (Red Blood Cells) *74*
Leukocytes (White Blood Cells) *74*
Blood Clotting Mechanism *76*
Blood Group *76*
Lymphatic System *77*
Lymph Nodes *77*
Related Lymphatic Organs *77*
Immunity *79*
Disorders of the Blood and Lymphatic System *80*
Common Abbreviations *83*

5. Nervous System **86**

Structure of Nervous System *86*
Central Nervous System *87*
Peripheral Nervous System *90*
Nervous System *93*
Common Abbreviations *99*

6. Digestive System **101**

Organs of the Digestive System *101*
Accessory Organs of Digestion *108*
Metabolism *110*

Digestive System *110*
Common Abbreviations *118*

7. Endocrine System **120**

Hormones *120*
Different Endocrine Glands Present in the Human Body *120*
Thyroid Gland *120*
Parathyroid Glands *122*
Adrenal Glands *123*
Pancreas *123*
Pituitary Gland *124*
Ovaries *126*
Testes *126*
Endocrine and Metabolic Disorders *127*
Common Abbreviations *131*

8. Respiratory System **133**

Parts of the Respiratory System *133*
Mechanism of External Respiration *136*
Vital Capacity *137*
Factors Influencing the Respiratory System *137*
Respiratory System *138*
Common Abbreviations *143*

9. Sense Organs **146**

Eye *146*
Ear *149*
Skin *151*
Tongue *154*
Nose *154*
Eye *155*
Ear *158*
Nose and Tongue *161*
Disorders of the Skin *162*
Common Abbreviations *165*

10. Excretory System **167**

Parts of Urinary System *167*
Excretion Process of Urine *170*
Excretory System *172*
Common Abbreviations *175*

11. Reproductive System **177**

Male Reproductive System *177*
Semen *179*
Female Reproductive System *180*
Pregnancy *183*

Reproductive System *184*

Male *184*
Female *186*

Maternal, Antenatal and Neonatal Conditions *190*
Antenatal *194*
Neonatal Period *195*
Common Abbreviations *196*

12. Oncology **200**

Differences Between the Malignant and Benign Neoplasm *200*
Carcinomas *200*
Sarcomas *200*
Mixed Tissue Tumors *201*
Staging *201*
Grading *201*
Cancer Treatment *202*
Surgery *202*
Radiation Therapy *202*
Chemotherapy *203*
Oncology *203*

13. Psychiatry **207**

Psychiatry Disorders *208*
Psychiatric Disorders *210*

14. Medical (History and Physical) Examination and Diagnostic Technique **215**

General Remarks on the History *217*
Past Medical History: General *221*
General Remarks on the Physical Examination *226*
Pediatric History and Physical Examination *241*
Diagnostic Formulation *243*
Glossary *244*

Part II: Nursing and Topics of Allied Health Sciences

15. Nursing Services **249**

Definitions *249*
Objectives *250*
Policies *250*
Procedures *250*
Functions *252*
Professional Nursing Practice *252*
Organization *253*
Job Responsibilities, Qualification and Training and Experience of Nursing Staff *254*
Documentation of Records *255*
Performance Appraisals *262*
Problems *262*

16. Pathology **265**

Pathology as a Medical Specialty *266*

17. Laboratory Investigation Cookbook **272**

Description of the Laboratory and Radiological Investigations (Systemwise) *273*
Selected Diagnosis with Required Investigations *278*
Normal Values for Laboratory Investigations *290*
Urine Investigations *296*
Semen Analysis *299*
Cerebrospinal Fluid *299*
Variations of Investigation Values with Normal Values and Resulting Diagnoses *300*

18. Radiology **316**

X-rays *316*
X-radiation *317*
Photostimulable Phosphors *322*

19. Radiation Therapy **332**

Mechanism of Action *333*
Effect on Different Types of Cancer *335*
Types of Radiation Therapy *336*
Allied Health Services *344*

20. Pharmacology **347**

Drugs *347*
Administration of Drugs *347*
Classification of Drugs *348*

21. Pharmacy **350**

Pharmacists *351*
Pharmacy Informatics *355*
Issues in Pharmacy *355*
Future of Pharmacy *356*

22. Physical Therapy **357**

Specialty Areas *358*
Cardiopulmonary *358*
Geriatric *358*
Neurological *359*
Orthopedic Physical Therapy *359*
Pediatric Physical Therapy *359*
Integumentary Physical Therapist *359*

23. Occupational Therapy **365**

Occupation *365*
Occupational Form *366*
Occupational Performance *366*
New Emerging Practice Areas for Therapy *372*
Occupational Therapy Approaches *372*
Activity Analysis *373*
Theoretical Frameworks *374*
United States *374*

Challenges for Occupational Therapy *376*
Occupational Therapy and ICF *376*

24. Optometry **382**

Background *382*
History *383*

25. Nutrition **384**

Overview *384*
Nutrients *385*
Other Nutrients *393*
Intestinal Bacterial Flora *395*
Advice and Guidance *396*
Healthy Diets *398*
Sports Nutrition *399*
Malnutrition *400*
Processed Foods *404*
History *405*
Plant Nutrition *406*
Macronutrients *407*
Micronutrients *407*

26. Medical Psychology **412**

Abnormal *412*
Clinical *413*
Cognitive *414*
Community *414*
Comparative *415*
Counseling *415*
Critical *415*
Developmental *416*
Educational *416*
Evolutionary *417*
Forensic *417*
Global *417*
Health *417*
Industrial/Organizational *418*
Legal *418*
Occupational Health Psychology *418*
Personality *419*
Quantitative *419*
Mathematical Psychology *419*
Social Psychology *420*
School Psychology *420*
Research Methods *421*
Qualitative and Quantitative Research *422*
Practice *422*

27. Medical Social Work **423**

Qualifications *424*
Role of the Professional *425*
Medical Social Worker's Profession *426*

28. Medical Records **428**

Role of Medical Records in Health Care Delivery *428*
Needs and Management of Medical Records Department *431*
Standards for Medical Records Services *432*
Hospital's General Rules and Regulations *433*
Personnel Requirement and Job Description *453*

29. Rights and Responsibilities of a Patient **457**

Patient's Rights *457*
Patient's Responsibilities *458*

Part III: Auxiliary Services such as Public Relations, Medical Secretarial Profession, Communication Skills, and Dictation and Transcription

30. Public Relations **463**

Methods, Tools and Tactics *463*
Other *465*
Hospital Or Health Institution PR *467*

31. Medical Secretarial Profession **469**

Succeeding in the Profession *469*
Professional Development *470*
Tools of the Profession *471*
Competent Secretary *474*
Secretarial Specialties *477*
Special Employment Situations *483*
Secretary's Day *484*
Future *487*
Minutes of a Meeting *487*
Office Memorandums *489*

32. Communication Skills **491**

Telephone Techniques *491*
Office Mail *507*

33. Dictation and Transcription **514**

Types of Dictation *515*
Transcription *519*
Rough Drafts *520*
Envelopes and Mailing Instructions *521*
Signature and Follow-up *522*
Sample Discharge Summary *541*

34. Novel Healthcare Delivery System in the Post-Covid Pandemic Era **596**

Will the Existing Healthcare Delivery System Suffices in the Newly Worst Environment? *596*
Expected Changes *597*
Methodology and Mechanism *598*

Healthcare Delivery System Functioning Methods *602*
Healthcare Transformation with Artificial Intelligence, Robotic and Machine Learning *607*
Current and Future Challenges *612*

35. Healthcare Delivery System in the Post-Covid-19 Pandemic through Electronic Medical Records, Leadership and Motivation **614**

Materials and Methods *614*
Results *618*
Discussion and Conclusion *620*
Leadership *624*
Motivation *629*

36. Brainstorming System—Wide Exercises **634**

Human Body *634*
Musculoskeletal System *635*
Cardiovascular System *638*
Blood and Lymphatic System *639*
Nervous System *641*
Digestive System *643*
Endocrine System *646*
Respiratory System *647*
Sense Organs *648*
Excretory System *651*
Reproductive System *652*

Answers *654-664*

Annexures

Annexure I: Definitions of Medical Specialties **667**
Annexure II: Terms and Definitions used in Healthcare Delivery System **670**
Annexure III: Standardized Abbreviations with a Single Meaning **689**

Index *699*

CHAPTER 3

Cardiovascular System

INTRODUCTION

The various organs in the body need energy from the food substances which reach them after being taken into the body. Food contains stored energy which can be converted into the energy for movements and work. This conversion of stored energy into active energy of work occurs when food and oxygen combine in cells during the chemical process of catabolism. It is obvious then that each cell of each organ is dependent on a constant supply of food and oxygen in order to receive sufficient energy to work well. The cardiovascular system plays a vital role in transporting food and oxygen to all organs and cells of the body through the fluid called blood vessels to carry the blood and the muscular pump called the heart. In addition to this, these blood vessels are used to transport cellular waste materials such as carbon dioxide and urea to the lungs and kidneys respectively, where it is removed from the body. Thus the cardiovascular system is one of the important systems of the human body.

The cardiovascular system is the transport system, carrying oxygen, nutrition, hormones and other substances to the tissues and conveying carbon dioxide to the lungs and other waste products to the kidney.

Arteries, arterioles, veins, venules and capillaries, together with the heart form cardiovascular system for the flow of blood.

ARTERIES

Arteries are the blood vessels which carry oxygenated blood from the heart to the various parts of the body. The microscopic structure of arteries has three layers:

1. Tunica adventia – Outer layer
2. Tunica media – Middle layer
3. Tunica intima – Inner layer

Tunica adventia is composed of fibrous tissue which gives protection and strength to the vessels. Tunica media is composed of smooth muscle with yellow elastic fibers which are arranged in circular manner. It contracts and relaxes to maintain the blood pressure. Tunica intima consists of a layer of

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Table 3.1: Important arteries.

Head and brain	*Upper limb*	*Lower limb*	*Chest*	*Thigh*
• Occipital • Cerebellar • Basilar • Temporal • Supraorbital • Supratrochlear • Maxillary • Carotid • Common carotid • Deep cervical • Vertebral • Thoracic • Subclavian	• Cervical • Vertebral • Common carotid • Suprascapular • Deltoid • Brachial • Radial • Ulnar • Interosseous • Palmar • Digital	• Genicular • Popliteal • Femoral • Tibial • Fibular • Calcaneal	• Subclavian • Brachiocephalic • Axillary • Pulmonary • Aorta • Ascending aorta • Arch of aorta • Descending aorta • Intercostal • Renal • Inferior mesenteric • Common iliac • Thoracic • Clavicular • Pectoral	• Abdominal aorta • Common iliac • Middle sacral • Inguinal • Femoral • Perineal • Urethral • Penis • Rectal

endothelial cells. Arterioles, a minute arterial branch, one just proximal to a capillary.

Important Arteries (Fig. 3.1)

Generally, the names of the arteries mostly coincide with the names of the bone, organs, or cavity, etc. it passes through. However, some of the important arteries are listed in **Table 3.1**.

VEINS

Veins are the blood vessels which carry deoxygenated blood from various parts of the body to the heart. It also possesses three layers same as that of arteries, but they are much thinner. The smooth muscle inside their walls are under the control of the autonomic nervous system. Small veins are called as venules.

Important Veins (Fig. 3.2)

See **Table 3.2**.

CAPILLARIES

Capillaries are only one cell thick and are just large enough to allow red blood cells to pass through. It is in the capillaries that the nutrient/gas exchange (diffusion) takes place. They act as a very important link in the circulatory system because it is the capillaries that serve all the tissues in the body, by absorbing the energy (glucose) from the blood of the arteries, and transporting the waste materials through the venules to the kidneys.

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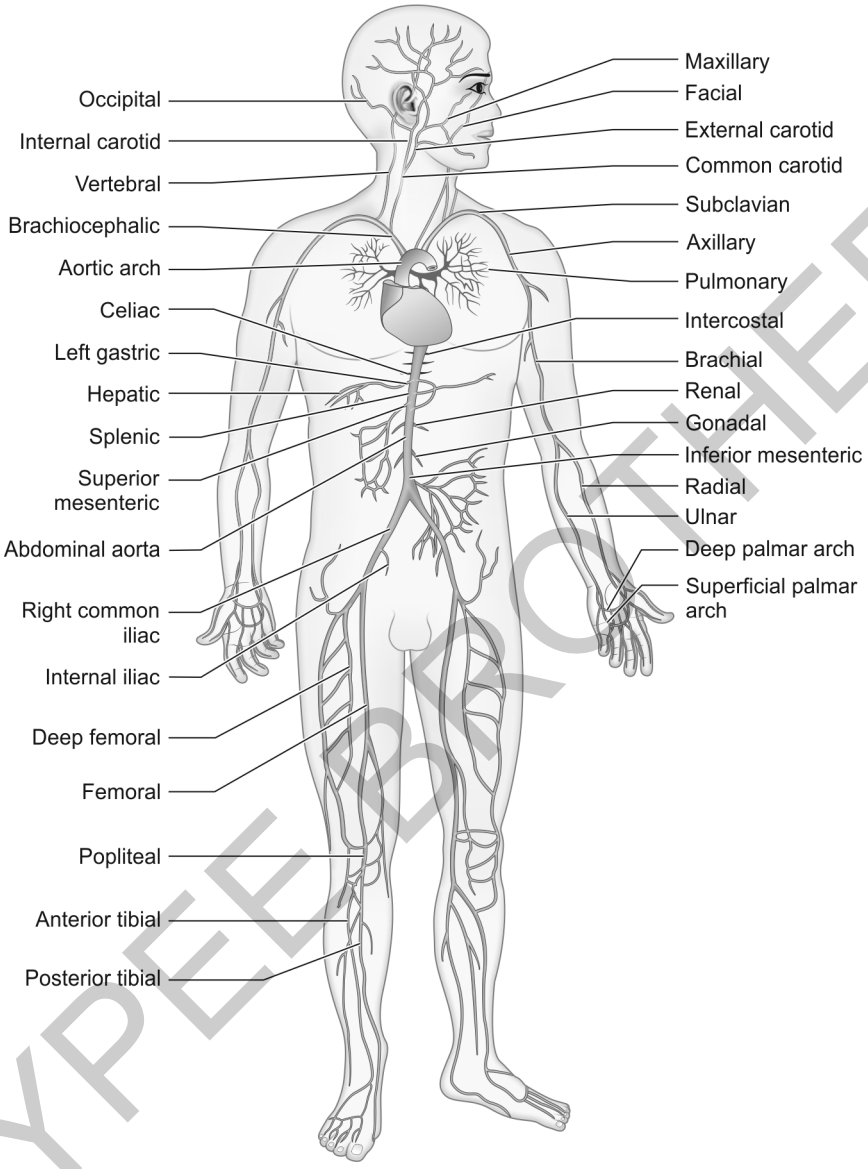


Fig. 3.1: Important arteries.

THE HEART

Heart is a conical-shaped hollow muscular organ situated in the mediastinum, in between the two lungs in the thoracic cavity. It is slightly tilted towards left side. The heart is made of a special type of muscle called the cardiac muscle, composed of striated muscle fibers. The heart has a base above and an apex below and its size will be almost equal to the owner's fist. The heart is divided into two sides the right and left. The right side of the heart

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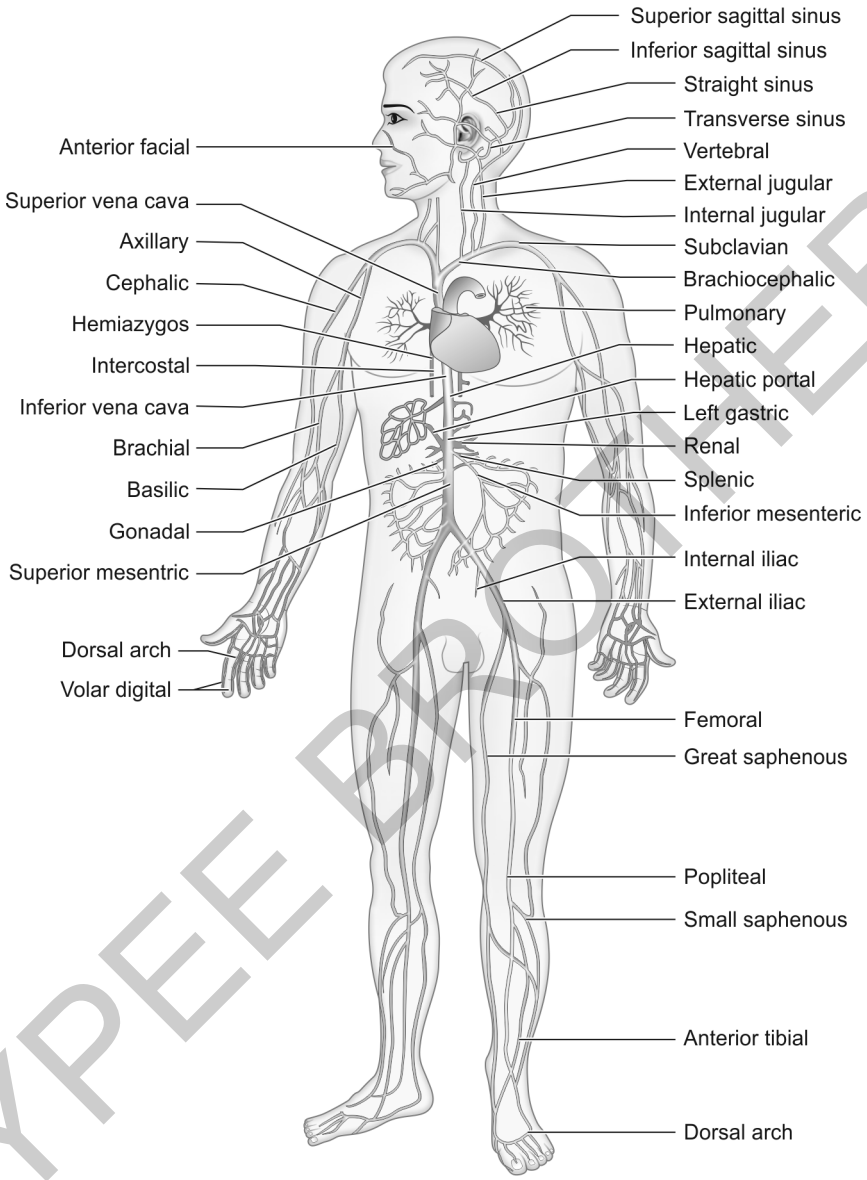


Fig. 3.2: Important veins.

receives the deoxygenated blood and pumps into the lungs for purification and the left side of the heart receives the oxygenated blood from the lung and pumps into the various parts of the body through the aorta and arteries. Each side of the heart is further divided into two chambers which communicate by means of valves. The upper chambers are the thin walled atria or atrium or auricle. The lower chambers are the thick walled ventricles. Usually they are represented as right atrium and left atrium and right ventricle and left ventricle **(Fig. 3.3)**.

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Table 3.2: Important veins.

Head and neck	*Upper limb*	*Lower limb and thigh*	*Thoracic cavity*
• Sagittal sinus • Straight sinus • Transverse sinus • Facial • External jugular • Internal jugular • Subclavian • Brachiocephalic	• Axillary • Brachial • Cephalic • Basilic • Palmar digital	• Superior iliac • Superior epigastric • Femoral • Great saphenous • Popliteal • Small saphenous • Anterior tibial • Dorsal venous arch • Dorsal digital	• Superior vena cava • Left subclavian • Portal • Splenic • Mesenteric • Inferior vena cava • Colic • Superior mesenteric • Ileocolic • Rectal • Deep femoral

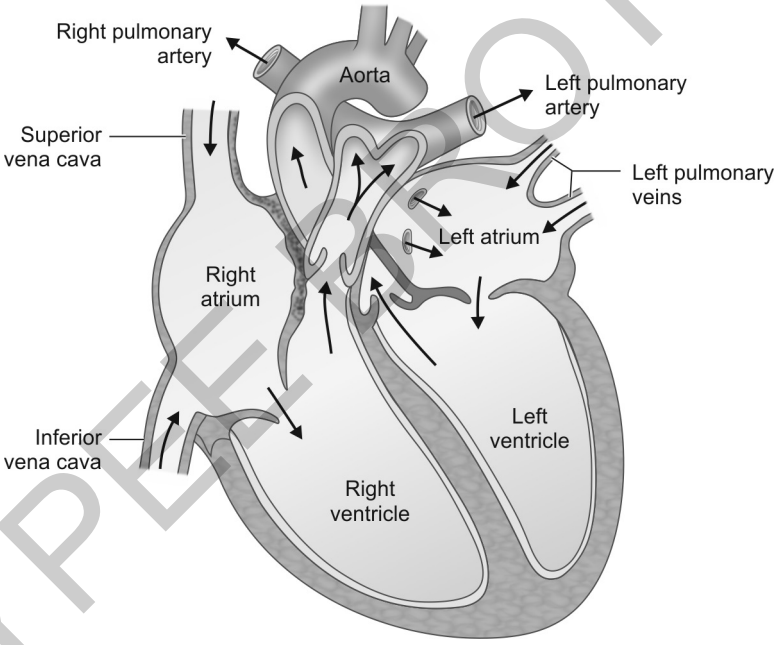


Fig. 3.3: Structure of heart and blood flow.

The four chambers of the heart are separated by partitions called septa (singular septum). The interatrial septum separates the two upper chambers (atria), and the interventricular septum is a muscular wall which comes between the two lower chambers.

The heart wall is composed of three layers. They are:

1. *Endocardium:* Smooth layer of cells which lines the interior of the heart.
2. *Myocardium*: Middle muscular layer of the heart wall and is the thickest layer.

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3. *Pericardium:* Delicate, double-folded membrane which surrounds the heart like a sac.

VALVES OF THE HEART

The valves of the heart play an important role to prevent the backflow of the blood into the chambers.

Mitral valve: Bicuspid valve is situated between the left atrium and ventricle (left side of the heart).

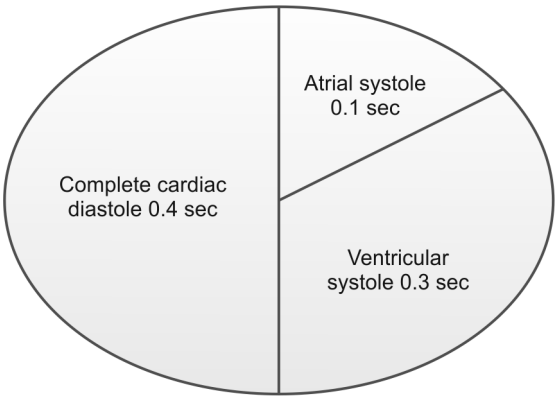
Tricuspid valve: Lies between the right atrium and right ventricle.

Semilunar valves: Lies on the mouth of the pulmonary artery, which arises from the right ventricle and on the mouth of the aorta which arises from the left ventricle.

HEART CYCLE OR CARDIAC CYCLE

The heart cycle consists of two phases. The first phase is called diastole (relaxation) and the second is systole (contraction). During diastolic phase the ventricles relax and deoxygenated blood flows into the right atrium of heart through the vena cava and the oxygenated blood from the lungs pours into the left atrium through pulmonary veins. The tricuspid and mitral valves are open in diastolic phase and the blood passes from the right and left atria into the ventricles.

The next phase is systolic phase. During this phase the walls of the ventricle contract and the semilunar valves open and the blood is pumped into the pulmonary artery and aorta from the right and left ventricles respectively. The diastole-systole cardiac cycle last about 0.8 seconds and occurs between 70 and 80 times per minute. The cardiac cycle consists of atrial systole—contraction of the atria, ventricular systole—contraction of ventricles, complete cardiac diastole—relaxation of atria and ventricles. Thus, the heart pumps about 70 mL of blood with each contractions. This can be picturized to understand easily as follows:



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PULMONARY AND SYSTEMIC CIRCULATION

The circulation of blood through the vessels from the heart to the lungs and then back to the heart again is known as the **pulmonary circulation.** The circulation of blood from the body organs (except the lungs) to the heart and back again is called the **systemic circulation.**

Systemic Circulation (Fig. 3.4)

Deoxygenated blood enters the heart through the two largest veins in the body, the superior vena cava and inferior vena cava to the right atrium. The right atrium contracts to force the blood through the tricuspid valve into the right ventricle. As the right ventricle contracts to pump deoxygenated blood to the lungs through the pulmonary artery, the tricuspid valve is closed to prevent any blood from pushing back into the right atrium. The pulmonary (semilunar) valve, between the right ventricle and pulmonary artery opens as the blood is pumped into the pulmonary artery.

Similarly, the newly oxygenated blood enters into the left atrium through the pulmonary vein. The walls of the left atrium contract to force blood through the mitral valve into the left ventricle. The left ventricle pumps blood with great force so that the blood is pumped through the aortic valve, into the aorta which have three branches ascending aorta, arch of aorta and descending aorta and the blood is pumped to all parts of the body through the arteries. The aortic valve prevents the return of aortic blood to the left ventricle once it has been pumped out.

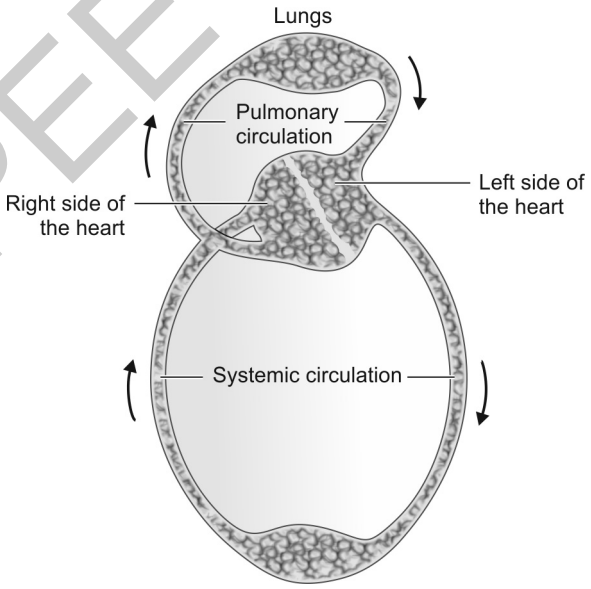


Fig. 3.4: Systemic circulation.

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Pulmonary Circulation

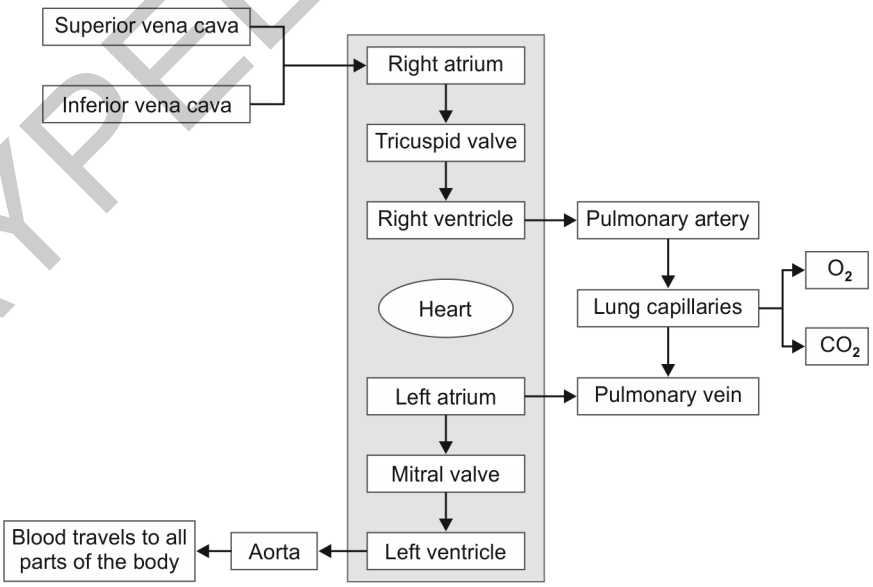
During the contraction of the ventricle, the deoxygenated blood is pumped into the pulmonary artery through the pulmonary (semilunar) valve from the right ventricle. This blood when reaches the capillaries of the lung, the exchange of the carbon dioxide and oxygen occurs and the blood is purified. The newly purified blood is brought back to the heart through the pulmonary vein to the left atrium. This is called pulmonary circulation. The important point to be noted is that in pulmonary circulation, the arteries carry deoxygenated blood, whereas the veins carry oxygenated blood, which is reverse in the systemic circulation.

Note: The reader should keep in mind, the differences between the systemic arteries and veins and pulmonary arteries and veins. For instance, the sytemic arteries carry oxygenated blood, whereas the pulmonary arteries carried deoxygenated blood, similarly, the systemic veins carry deoxygenated blood, whereas the pulmunary veins carry oxygenated blood.

Portal Circulation (Flowchart 3.1)

Portal circulation is an important sub-division of the general circulation. Blood from the stomach, pancreas and spleen is collected by the portal vein and passed to the liver. Here the capillary network unites with the capillary network of the hepatic artery. This double blood supply is collected by the hepatic vein and passed to the inferior vena cava.

Flowchart 3.1: Block diagram representing the functioning of the heart and blood circulation.



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BLOOD PRESSURE

The force exerted by the blood against the arterial walls during the systole and diastole of heart is called blood pressure. The blood pressure is expressed as systolic pressure/diastolic pressure separated by a slash. The normal BP is 120/80 but it may vary due to the influence of age, emotional stress, constriction of blood vessels, etc.

The diastole (dilation) and systole (contraction) cardiac cycle last about 0.9 seconds and occurs between 70 and 80 times per minute (100,000 times a day).

THE PULSE

The arterial pulse is a wave of increased pressure felt in the arteries when blood is pumped out of the heart. The pulse is most readily felt where an artery passes over a bone and lies near the surface, e.g. the radial pulse at the wrist. The pulse rate is usually described as the number of heart beats per minute. The adult range is between 60 and 80 beats per minute. In children the rate is higher.

ELECTRICAL CONDUCTION OF THE HEART PULSES

An electrical impulse originates from small muscle tissue, in the right atrium called the sinoatrial node (SA node), this is called the pacemaker of the heart. The impulse from the pacemaker radiates to the posterior portion of the interatrial septum (AV node). The AV node sends electrical impulses to the bundle of His, which further divides into right and left branches and carries the impluse to the right and left ventricles, resulting them to contract. Thus systole of ventricles occurs and the blood is pumped away from the heart. After a short duration, the way of excitation is initiated by the pacemaker again. Electrocardiogram is the instrument to record the electrical impulse of the heart, commonly called as ECG.

CARDIOVASCULAR DISORDERS

Origin of Terms

S. No.	Terms	Meanings	S. No.	Terms	Meanings
1.	Angi/o	Vessel	12.	Oxy/o	Oxygen
2.	Aort/o	Aorta	13.	Phleb/o	Vein
3.	Arteriol/o	Little artery	14.	Pulsus	Stroke, beat
4.	Artery	Air duct	15.	Sphygm/o	Pulse
5.	Cardi/o, cardiac, cardium, cor	Heart	16.	-stenosis	Narrowing
			17.	Systole	Contraction
6.	Cuspid	Point, cusp	18.	-tension	Pressure
7.	Diastole	Expansion	19.	Thromb/o	Clot (of blood)
8.	Embol/o	Embolus, plug	20.	Varix	Swollen vein
9.	Hemangi/o	Blood vessel	21.	Vas/o	Vessel
10.	Luna	Moon	22.	Vena	Vein
11.	Corona	Crown	23.	Venul/o	Venule

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Symptomatic and Diagnostic Terms

S. No.	Terms	Meanings
1.	Acrocyanosis	Bluish discoloration of finger tips and toes especially extremities
2.	Aneurysm	A dilation or bulging out of the wall of the heart, aorta or any other artery
3.	Angina pectoris	Short attacks of substernal pericardial pain which radiates to the shoulder provoked by exercise and relieved by rest
4.	Angiospasm, vasospasm	Involuntary contraction of the muscular coats of the blood vessels
5.	Arrhythmia	Variation from normal rhythm of the heart by tachycardia or bradycardia
6.	Ascites	Fluid in peritoneal cavity
7.	Atrial septal defect	Abnormality resulting in a shunting of oxygenated blood from the left into the right atrium
8.	Blood pressure	Pressure of blood flow felt on blood vessels
9.	Bradycardia	Slow heart action
10.	Cardiac arrest	Cessation of effective heart action usually caused by a systole or ventricular fibrillation
11.	Cardiac edema	Retention of water and sodium in congestive heart failure due to circulatory impairment
12.	Cardioversion	Conversion of a pathological cardiac rhythm such as ventricular, fibrillation to normal sinus rhythm usually accomplished by use of a device called cardiac averter, which administers counter shock to the heart through electrodes placed on the chest wall
13.	Carditis	Inflammation of the heart
14.	Claudication	Limping due to occlusive arterial disease
15.	Coarctation	Narrowing of a vessel, especially the aorta (coarctation of aorta)
16.	Congestive cardiac failure (CCF)	Condition in which the heart is unable to pump adequate amounts of blood to tissues and organs
17.	Cor pulmonale/ Pulmonary heart disease	Heart lung disease characterized by the right ventricular hypertrophy due to pulmonary disorders resulting in pulmonary hypertension
18.	Coronary occlusion	Complete obstruction of coronary artery
19.	Cyanosis	Bluish discoloration of skin due to reduced hemoglobin in blood
20.	Diastole	Resting time of heart or period of dilatation of heart

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S. No.	Terms	Meanings
21.	Dyspnea	Pain on breathing or difficulty in breathing
22.	Embolism	Obstruction of blood vessels by blood clot or foreign body
23.	Endocarditis	Acute or subacute disease of the lining of the heart and especially valve leaflets marked by inflammation of endocardium
24.	Fibrillation	Small, local, involuntary muscular contraction due to spontaneous activation of single muscle cells or muscle fibers
25.	Flutter	Rapid regular cardiac action of beats 200 to 400 per minute
26.	Heart block	Loss of conduction through the atrioventricular junction tissue due to pathologic factors, with atrioventricular disassociation in which a sinus or atrial beat excites the atria. Condition of prolonged impulses transmitted may result in cardiac stand still
27.	Hemopericardium	Effusion of blood into the pericardium
28.	Hypertension	High blood pressure
29.	Hypotension	Low blood pressure
30.	Hypothermia	Having a body temperature below normal
31.	Ischemia	Lack of blood supply to a part due to functional constriction or obstruction
32.	Ischemic heart disease	Cardiac disease marked by reduced blood supply to the heart muscle due to coronary atherosclerosis, which may lead to myocardial infarction, heart failure or angina pectoris
33.	Mitral regurgitation or Mitral insufficiency	Back flow of blood from the left ventricle into the left atrium due to inadequate functioning (insufficiency)
34.	Mitral stenosis	A very common sequel of rheumatic fever marked by thrombi which narrow the orifice of the mitral valve leaflets
35.	Murmur	A soft blowing sound heard on auscultation; may result from vibrations associated with the movement of blood and or valvular action
36.	Myocardial	Relating to the myocardium
37.	Myocardial infarction	Clinical syndrome manifested by persistent usually intense cardiac pain, unrelated to exertion and often constrictive nature followed by diaphoresis, pallor. The underlying disease is usually coronary artherosclerosis, which progressed to coronary thrombosis and

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S. No.	Terms	Meanings
		occlusion and resulted in a sudden curtailment of blood supply to the heart muscle and myocardial ischemia. Gross necrosis of myocardium may occur due to interruption of blood supply to that area, commonly called as heart attack
38.	Myocarditis	Inflammation of heart muscle which may result in myocardial fibroses followed by cardiac enlargement and congestive heart failure
39.	Palpitation	Subjective sensation of skipping, pounding or racing heart beats
40.	Paroxysmal	Sudden rapid regular heart beat or sudden intensification of symptoms
41.	Pericarditis	Inflammation of the covering membranes of the heart
42.	Phlebitis	Inflammation of the veins
43.	Phlebosclerosis	Hardening of the walls of the veins
44.	Rheumatic heart disease	Clinically manifested by rheumatic fever, damaging the myocardium, pericardium and endocardium, with the valvular endocardium as the site of predilection
45.	Subacute bacterial endocarditis (SBE)	Infectious endocarditis caused by various bacteria including streptococci, staphylococci, enterococci, gonococci, gram negative bacilli
46.	Syncope	Faint
47.	Systole	Contraction of ventricles/atria to propel blood
48.	Tachycardia	Rapid heart action
49.	Tetralogy of Fallot	A combination of four factors of congenital defects of heart: 1. Pulmonary stenosis 2. Interventricular septal defect 3. Dextra position of aorta 4. Ventricular hypertrophy
50.	Thrombophlebitis	Inflammatory reaction of the walls of the veins associated with intravascular clotting
51.	Thrombosis	Formation of blood clot
52.	Varicose veins, varicosity	Distended veins
53.	Vasoconstriction	Narrowing of vascular lumen resulting in decreased blood supply
54.	Vasodepression	Collapse due to vasomotor depression

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