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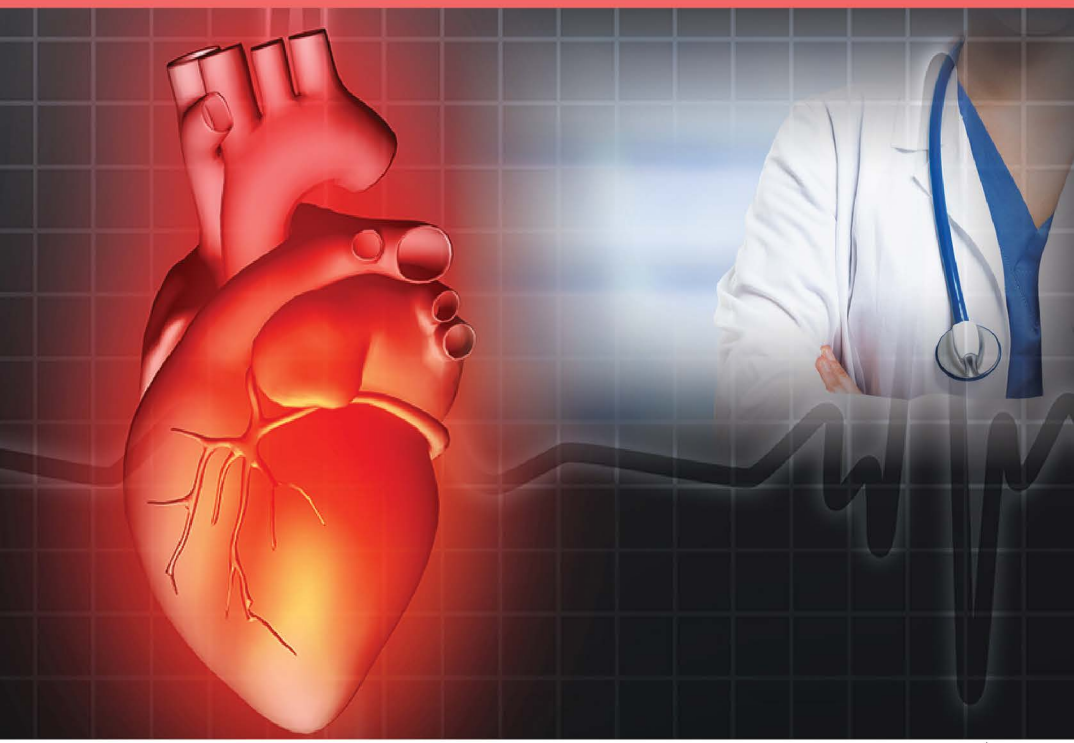
Textbook of CARDIAC NURSING



Reena George

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Contents

1. Introduction **1**

2. Anatomy and Physiology of Cardiac System **2**
- Heart *2*

3. Cardiac Assessment **15**
- History Collection *15*
- Objective Data *20*
- Cardiac Assessment Form *32*

4. Diagnostic Procedures used in Cardiology **34**
- Laboratory Tests *34*

5. Inflammatory Heart Disease **64**
- Endocarditis *64*
- Myocarditis *75*
- Pericarditis *80*
- Rheumatic Fever and Rheumatic Heart Disease *84*

6. Coronary Artery Diseases **94**
- Coronary Artery Disease *94*
- Angina Pectoris *111*
- Myocardial Infarction *123*

7. Structural Abnormalities of Heart/Valvular Heart Disease **142**
- Mitral Valve Disease *143*
- Aortic Valve Disease *149*
- Tricuspid Valve Disease *153*
- Community-based Care *159*

8. Cardiac Dysrhythmias and Conduction Defects **160**
- Dysrhythmias *160*

9. Cardiomyopathies **179**
- Classification *179*
- Incidence and Etiology *179*
- Pathophysiology *180*
- Clinical Manifestations *183*
- Diagnositc Evaluation *183*

10. Congestive Heart Failure **190**
- Incidence *191*
- Etiology and Risk Factors *191*
- Pathophysiology *195*

- Types of Heart Failure *198*
- Clinical Manifestations *200*
- Diagnostic Evaluation *201*
- Complications *202*
- Management *203*
- Nursing Management/Interventions *207*
- Patient Education *210*

11. Cardiac Emergencies **211**
- Cardiac Tamponade *211*
- Cor Pulmonale *214*
- Pulmonary Edema *219*
- Cardiogenic Shock *222*
- Cardiac Arrest *229*

12. Congenital Heart Disease **233**
- Classification *233*

13. Disorders of Aorta **246**
- Aortic Arch Syndrome *247*
- Dissecting Aorta *248*
- Aneurysm *252*

14. Hypertension **260**
- Blood Pressure *260*

15. Cardiopulmonary Resuscitation **281**
- Goals *281*
- General Procedure *282*
- Cessation of CPR *287*
- Child CPR *288*
- Infant CPR *288*
- Complication of CPR *291*
- Definitive Therapy *291*

16. Cardiac Surgeries and Special Procedures **293**
- Valvular Surgeries *294*
- Types of Valves *296*
- Pacemaker *301*
- Cardioversion and Defibrillation *308*
- Intra-aortic Balloon Pumping *314*
- Cardiac Transplantation *318*
- Cardiopulmonary Bypass *328*

17. Cardiac Tumors and Trauma **332**
- Neoplasms *332*
- Cardiac Trauma *333*

18. Cardiac Drugs **334**
- Cardiac Glycosides *335*
- Vasodilators *336*
- Adrenergic Blocking Agents *338*
- Calcium Channel Blockers *340*
- Antidysrhythmia Medication *341*
- Anticoagulants *344*
- Inotropic Medications *348*
- Angiotensin-Converting Enzyme *349*
- Diuretics *349*
- Adrenergic Agonists *351*
- Cholesterol-lowering Medications *352*

Bibliography *365*
Index *367*

Chapter

4

Diagnostic Procedures used in Cardiology

Diagnosis of cardiac diseases is a challenging responsibility of a clinician. Cardiac diseases are usually diagnosed by various laboratory test results and findings from physical examination. Nurses play a vital role in doing physical examination and performing diagnostic procedures. So, nurse should have a detail understanding of these tests and procedures. The main responsibility of the nurse is to preparing the patient and environment adequately before the procedure. The nurse should able to asses any abnormal finding while caring for the patient before, during and after the procedure.

LABORATORY TESTS

Various laboratory tests are performed to patient, to screen the individual risk for cardiovascular disease. The regular cardiovascular health assessment also includes various test, which help to determine the client's exposure to the risk factors.

Complete Blood Cell Count

For all patient suspected with heart disease, a complete blood cell count (CBC) is been obtained. Red blood cell (RBC) and white blood cell (WBC) count are helpful in diagnosing inflammatory and infectious heart disease like infective endocarditis, pericarditis and myocardial infarction, etc. In myocardial infarction large number of WBC are necessary to dispose increased necrotic tissues forming from infarction.

The erythrocyte sedimentation rate (ESR) will elevate in infectious heart diseases and myocardial infarction. ESR is the measurement of the rate at which RBC's settle out from blood in 1 hour. The rate of settlement will be increased, if the proportion of globulin to albumin is increased or if fibrinogen levels are increased.

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The non-specific elevation of globulin and fibrinogen level is seen, in case of inflammatory response of the body.

Blood Coagulation Test

Blood coagulation tests include prothrombin time (PT), activated partial thromboplastin time (APTT). These tests gives us the information about time and ability of blood to clot. It is mainly used in anticoagulation therapy. People with atrial fibrillation, infective endocarditis and prosthetic valve are most prone to develop thrombi. For these individual it is necessary to check PT and APTT. Increased coagulation factors are seen in myocardial infarction. So, client is at risk for developing thrombophlebitis clot formation in coronary artery.

Blood Urea Nitrogen

Blood urea nitrogen (BUN) analysis is a renal function test to determine the kidney's ability to excrete urea and protein. Decreased cardiac output leading to low renal blood supply, result in reduction of glomerular filtration rate. This will elevate the BUN level.

Elevated BUN level is seen in client with congestive heart failure and cardiogenic shock.

Cardiac Enzymes

Enzymes are special protein, located in all tissues, that catalyze the biochemical reaction of the body. Cardiac enzymes are myocardial tissue specific enzymes, when tissues are damaged the enzymes leak out of the damaged myocardial cell and enter the serum (Table 4.1).

The most common enzymes used to detect myocardial tissue damage are serum aspartate aminotransferase (AST), creatine kinase (CK), troponin and lactic acid dehydrogenase (LDH). These enzymes also located in various body tissues like brain, liver, pancrease, muscles, etc. Fortunately CK, troponin and LDH has isoenzymes, which are exclusive for myocardial tissues. Isoenzymes are detected by electrophoresis, which helps in proper detection of myocardial tissue damage.

Creatine kinase (CK) has three isoenzymes:

- CK-MM: Skeletal muscle
- CK-MB: Myocardial muscles
- CK-BB: Brain.

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Table 4.1: Cardiac enzymes

Enzyme	Onset	Peak	Returns normal
CK-MB*	4–6 hours	18–24 hours	48–72 hours
LDH-1†	4 hours	48 hours	20 days
LDH-2‡	4 hours	48 hours	10 days
Troponin I	< 1 hour	12 hours	7 days

*Ck-MB, Myocardial muscles; †LDH, Lactic acid dehydrogenase.

Isoenzymes CK-MB will be released in case of myocardial damage and is not found in any other tissues. The elevation of CK-MB may occur within 4–8 hours after injury and peak by 18–24 hours, and returns to normal within 3–4 days.

Lactic acid dehydrogenase (LDH) is an another enzyme, it has five isoenzymes numbered, from LDH1 to LDH5. In this LDH1 and LDH2 are only cardiac specific. LDH is the most sensitive indicator of myocardial damage. LDH elevate within 48 hours after myocardial damage. The level rise within 8–12 hours and persist for 8–14 days.

Cardiac troponin is the newest enzyme study for the detection of myocardial damage. It has three protein: Cardiac troponins are, troponin I and troponin T.

Cardiac troponin I is highly specific for myocardial injury. Troponin I rises within 3 hours of myocardial damage and persist up to 7 days.

Nowadays, the most commonly used enzymes are troponin and CK-MB. Each enzyme is released in a sequential pattern.

The different enzymes are released into blood at varying period after myocardial damage. So, the evaluation of enzyme level should be done in related to the time of the onset of chest discomfort.

Blood Lipids

The blood plasma lipids include cholesterol, triglycerides, phospholipid and free fatty acids. These are insoluble in water. These plasma lipids are transported by a protein called as lipoprotein. These lipoprotein are classified as chylomicrons, very low-density lipoprotein and high-density lipoprotein. All these contain cholesterol, triglycerides and phospholipids in varying level.

Chylomicrons are mainly composed of triglycerides. Elevated chylomicrons level do not associated with heart disease. Very low-density lipoproteins (VLDLs) are composed of triglycerides and are

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synthesized in the liver. Elevation of VLDL's are sometimes shown association with formation of atherosclerosis.

Low-density lipoproteins (LDLs) are composed of approximately 50% of cholesterol. LDL can enter the arterial intima and produce arterial endothelial injury. This process results in progressive atherosclerotic plaque formation. So it is described as LDLs have a great correlation with coronary artery disease (CAD). High-density lipoprotein (HDL) are composed of mostly protein, moderately cholesterol and a considerable amount of phospholipids. The studies have proved that HDLs carry cholesterol away from tissues and even provide a protective effect on coronary structures.

Table 4.2: Lipid profile

Normal Values	
Cholesterol	< 200 mg/dL
LDL*	< 130 mg/dL
HDLs†	30–70 mg/dL
Triglycerides	< 200 mg/dL

*LDLs, low-density; lipoproteins; †HDLs, high-density lipoprotein

The lipid profile measures total serum cholesterol, LDLs, HDL and triglyceride level (Table 4.2).

About 12 hours fasting must be advised before obtaining blood sample for lipid profile, no alcoholic beverages or drug such as oral contraceptives, estrogen, steroids and salicylate must be taken, because it influence the result.

Blood Culture

Blood culture is an important method to evaluate infectious conditions of the heart. Culture result is essential to identify the organism responsible for the infection and start appropriate antibiotics .

Blood culture is useful in diagnosis of endocarditis, rhematic heat disease, pericarditis, myocarditis, etc.

Serum Electrolytes

Fluid and electrolyte regulation is essential for proper functioning of cardiovascular system. Any variation in this can interface with normal function of the body. Certain disease condition and medication can alter electrolyte balance of the body.

Potassium: Serum potassium level plays a major role in the normal cardiac function. Hypokalemia, a condition in which serum potassium level in decreased (< 3.5 mEq/L). Hypokalemic can cause a decreased threshold of cells resulting in increased electrical instability. It can be caused by diuretic therapy, vomiting, diarrhea

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and alkalosis. It can result in ventricular dysrhythmias and increase risk of digitalis toxicity. Electrocardiography (ECG) changes can be observed in this conditions as a U wave (> 5.5 mEq/L). Hyperkalemia is a condition with increased serum potassium level. It can result in asystole, ventricular dysrhythmics and a tall T wave. The common cause of hyperkalemia are kidney diseases, potassium—conserving diuretics, and extensive tissue damage (e.g. burns).

Sodium: The serum sodium levels indicate water balance in the body. Excessive use of diuretics and severe sodium restriction can lower serum sodium level, result in a condition called hyponatremia. Increase serum sodium level leads to retention of water in the body result in edema formation and also increase in work load of heart.

Calcium: The low calcium level may leads to serious ventricular dysrhythmias and cardiac arrest. Hypocalcemia can result from renal failure, alkalosis, excess use of phosphate (laxative and antacid use) and multiple blood transfusion. Hypercalcemia or increased serum calcium level can occur with acidosis, use of thiazide, diuretics, vitamin D excess, adrenal insufficiency and immobility. Hyperkalcemia can result in atrioventricular (AV) block, tachycardia, bradycardia, digitalis hypersensitivity and cardiac arrest.

Magnesium: Magnesium plays a major role in neuromuscular excitability. Magnesium helps in the transport of sodium and potassium across the cell membrane. Hypomagnesemia can result from prolonged use of diuretics and leads to some cardiac manifestation like cardiac dysrhythmics, e.g. ventricular tachycardia and fibrillation. Hypermagnesemia can leads to bradycardia with prolonged PR interval and wide QRS complex in ECG and hypotension.

Phosphorus: Only a small amount phosphorus found in the intracellular fluid, remaining is present in bone with calcium. Phosphorus help in maintaining acid base balance and neuromuscular excitability (Table 4.3).

Table 4.3: Normal values

Normal Values	
Serum potassium	3.5 –5.0 mEq/L
Sodium	135 –145 mEq/L
Calcium	8.4 –10.6 mg/dL
Magnesium	1.3 –2.1 mEq/L
Urea nitrogen	11–23 mg/dL
ESR* in male	0–5 mm/h
ESR in Female	0–15 mm/h
PTT†	20–35 second
Prothrombin time	12.0–14.0 second

*ESR, erythrocyte sedimentation rate; †PTT, partial thrombopiastin time

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Blood Glucose

Blood glucose level is an important aspect, to be assessed on a regular basis in cardiovascular disorders. In case of acute cardiac events elevated glucose level is observed, causing unstable hyperglycemia. Diabetes mellitus is a major risk factor in the development of atherosclerosis.

Urinalysis

A routine urinalysis helps to determine the effect of cardiovascular disease on kidney. Kidney function is greatly influenced by cardiovascular status. Presence of RBCs is seen in urine in case of infective endocarditis. Myoglobinuria; myoglobin in urine indicate myocardial infarction.

Electrocardiography

Electrocardiography (ECG or EKG) is a display of the graphical representation of electrical action of the heart. The ECG is a valuable tool for assessment of cardiac function. The electrical impulse produced by the heart can be detected by electrodes attached to the skin. ECG help to determine cardiac disorders, which is associated by rate and conduction. There are several types of ECG monitoring system, they include continuous ECG monitoring, standard 12-lead ECG monitoring.

Standard 12- Lead ECG

The standard 12-lead ECG is the most commonly used diagnostic tool, which has a 12-lead system. It uses 12 points where the electrical activity of the heart recorded. This help to measure the electrical potential difference between various locations.

The common indication for 12-lead ECG are: Dysrhythmics, chest pain, myocardial infarction, cardiac hypertrophy, preoperative assessment, pericarditis and electrolyte imbalance.

The 12-lead ECG interpretation is easy, if we understand the direction of each lead look at the heart, i.e. the 12 different views of the heart.

The standard 12-lead ECG has six limb lead and six precordial lead. Limb lead view the heart in a vertical plane that is from the sides or the feet. The precordial view the heart in a horizontal plane.

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Limb Leads

Limb leads are composed of three bipolar lead called as lead I, II and III, and three unipolar lead called as aVR, aVL and aVF (Fig. 4.1). The bipolar leads consists of two electrodes and measures the difference

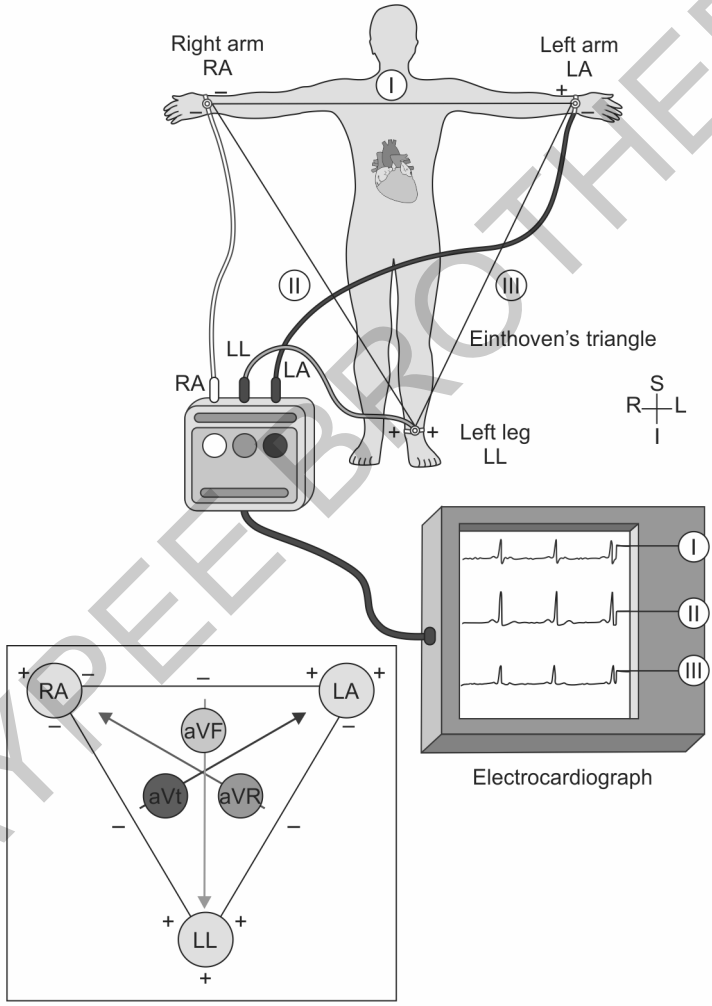

Fig. 4.1: Einthoven's triangle (aVF, augmented vector foot; aVL, augmented vector left; aVR, augmented vector right)

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in electrical potential of heart between two extremities. The unipolar leads measures the electrical potential of a positive electrode placed on one limb and a negative pole within a central terminal, which averages the potential of the other two limb leads. The lead sites are right arm, left arm, right leg and left leg.

The right leg (RL) electrode acts as a grounding electrode. The leads are created by electrodes applied right arm (RA) left arm (LA) and left leg (LL).

1. Lead I: Records the difference between the RA and LA potentials.
2. Lead II: Records the difference between the RA and LL potentials.
3. Lead III: Records the difference between the LA and LL potentials.

The augmented unipolar limb leads are: aVR, aVL and aVF.

1. aVR measures electrical potential between the center of heart and right arm.
2. aVL measures electrical potential between the center of heart and left arm.
3. aVF measures electrical potential between the center of heart and left leg.

Together the augmented and standard limb leads provides the six frontal plane lead.

The standard limb in such a way that they are relatively equidistant from the heart. It forms a triangle, this triangle is called as Einthoven's triangle. Willem Einthoven himself first recognized, that recording ECGs from different lead at the same time was like looking at the heart from different angle.

Precordial Leads

There are six precordial or chest lead represented by the symbol (V_1–V_6) these electrodes are placed on six sites across chest. This six numbered V leads looks at the heart in a horizontal plane, from the front and the left side.

Thus, leads V_1 and V_2 look at the right ventricles, V_3 and V_4 look at the septum, and V_5 and V_6 look at the anterior and lateral wall of left ventricles. So, this unipolar leads compare electrical potential between a positive electrode, three limb leads represents the negative terminal (Fig. 4.2).

All these 12 leads together give a multidirectional electrical activity of heart. Any pathological changes within the heart alter the electrical activity. Location of pathological changes can be noted by electrical representation of each lead.

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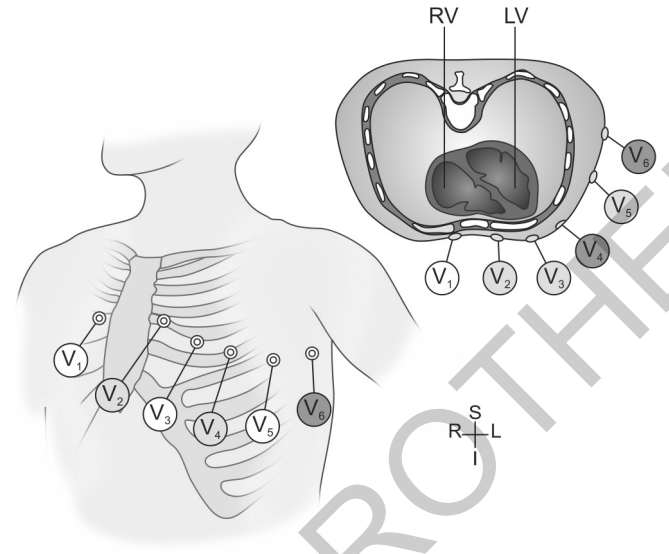

Fig. 4.2: Electrocardiogram chest leads. Electrodes are placed at specific locations across the chest. Each of these is compared with a single virtual lead formed by the combination of all three limb electrodes and electrically positioned approximately over the spine.

1. Lead I aVL, V_5 and V_6 trace the electrical events of lateral surface of the left ventricle.
2. Lead II, III and aVF trace the electrical events of inferior surface of the left ventricle.
3. Lead V_1 and V_2 record electrical events of surface of right ventricle and anterior surface of left ventricle.
4. Lead V_3 and V_4 trace electrical events within septal region of left ventricle.

All leads must be placed on proper location and they should be in good contact with the skin. If necessary shaving of chest should be done. Assure the patient that it is a safe and painless procedure. No special preparation is necessary before the procedure.

Some ECG machine record only one lead at a time, while others can record 3, 6 or all 12 leads at a time. For amputated patient, the electrodes can be attached to the stump of the affected extremity.

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Normal Electrocardiography

The ECG tracing is recorded on a graph paper, which is divided into millimeter squares. Horizontally, each millimeter square represent 0.04 second, each thick line represent 0.20 second. 1,500 small or 300 large square represent 1 minute. Vertically, each small square is 1mm in height and represent 0.1 mV of voltage. The large square represent 5 mm or 0.5 mV.

The baseline of the ECG tracing is a isoelectric line. Waves are deflections, either positively or negatively from the isoelectric line. The waves traced by ECG have been represented by the letters P, Q, R, S, T and U.

The ECG results from electrical changes associated with activation first of the atria and then of the ventricle. The 'p'wave represent depolarization of the atria. P wave is normally a gentle round wave. It is usually less than 0.11 seconds.

Ventricle activation causes the QRS complex and it is often the most significant portion of the ECG. The 'Q' wave is the first negative deflection from the isoelectric line. If the first deflection is downward it is a 'Q' wave and the first positive deflection in an 'R' wave. A downward deflection after an 'R' wave is a 'S' wave. The duration of QRS complex is 0.4–0.11 seconds.

The PR interval is the measurement of the time taken for the impulse to travel from the SA node to the ventricle. It is measured from the beginning of 'P' wave to the beginning of QRS complex. The normal PR interval is 0.12–0.20 seconds.

The ST segment represents the phase 2 of the action potential. Normally it is isoelectric because all cells are at zero potential and no current flows. Abnormal elevation (> 1 mm) or depression (> 0.5 mm) can result from myocardial cell injury, conduction problems, hypertrophy and digitalis toxicity.

The 'T' wave represent phase 3 of action potential. Repolarization of ventricle occurs during this phase. It is normally rounded and slightly asymmetrical. The QT interval is measured from the beginning of the QRS complex to the end of the 'T' wave. It represent the duration of ventricular depolarization and repolarization. QT interval varies with age, sex and heart rate. The 'T'wave termination, sometimes difficult to determine, so accurate measurement of QT interval is not always easy.

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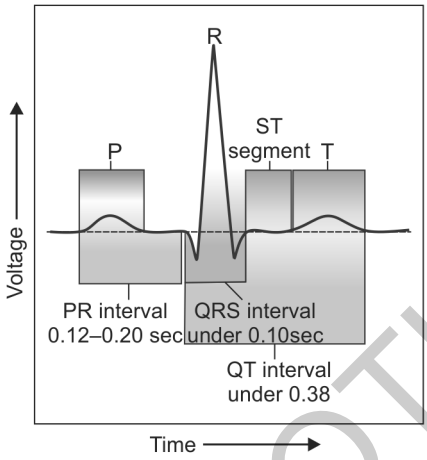

Fig. 4.3: Normal electrocardiogram

The 'U' wave is a small wave, sometimes occur after the 'T' wave. It represents late repolarization of papillary muscles (Fig. 4.3).

Continuous Electrocardiographic Monitoring

Continuous ECG monitoring is a common procedure, especially for patient who are admitted in coronary care unit with cardiac complaints. Two continuous ECG monitoring system are hardwire monitoring and telemetry. Explain the purpose of the procedure to the patient before doing the procedure.

The hardwire monitoring system, help in the continuous monitoring of ECG, when the client admitted with dysrhythmias and conduction disorder. It uses electrodes, which will be attached to clients skin. The electrode may be disk type or floating type. To ensure good contact with skin a conductive gel can be applied to electrode. The popularly used leads for continuous monitoring are lead II and lead V_1. Usually patient wears two, three or five electrode. The electrodes are attached to the monitor by lead wires. The cables and lead wires are color coded to facilitate connection.

If the electrodes are applied properly, the ECG will be clear and distinct. Alarm can be set according to client's baseline heart rate. If heart rate is between 60 and 100 beats per minute, (bpm), low alarm can be set 50 bpm and the high alarm at 140 bpm. False alarm may occur due to poor electrode contact.

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Reena George, Principal in Florence College of Nursing, Bengaluru, Karnataka, India, has done her masters in nursing (Medical Surgical Nursing—Cardiothoracic Nursing) from Dr MV Shetty College of Health Sciences, Mangaluru, Karnataka. She has more than 15 years of experience in teaching. Her experience and constant exposure in the field of cardiology motivated her to prepare this book in such a way that it will help the students to meet the challenges in the field of cardiology. She is the editorial board member of IJMAES (International Journal of Medical and Exercise Science) and also a life member of TNAI (Trained Nurses Association of India), New Delhi. She has published her research in journals and also presented papers in various conferences.

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