SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
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DEPARTMENT OF BIOMEDICAL ENGINEERING

19BMB302 - BIOMEDICAL SIGNAL PROCESSING

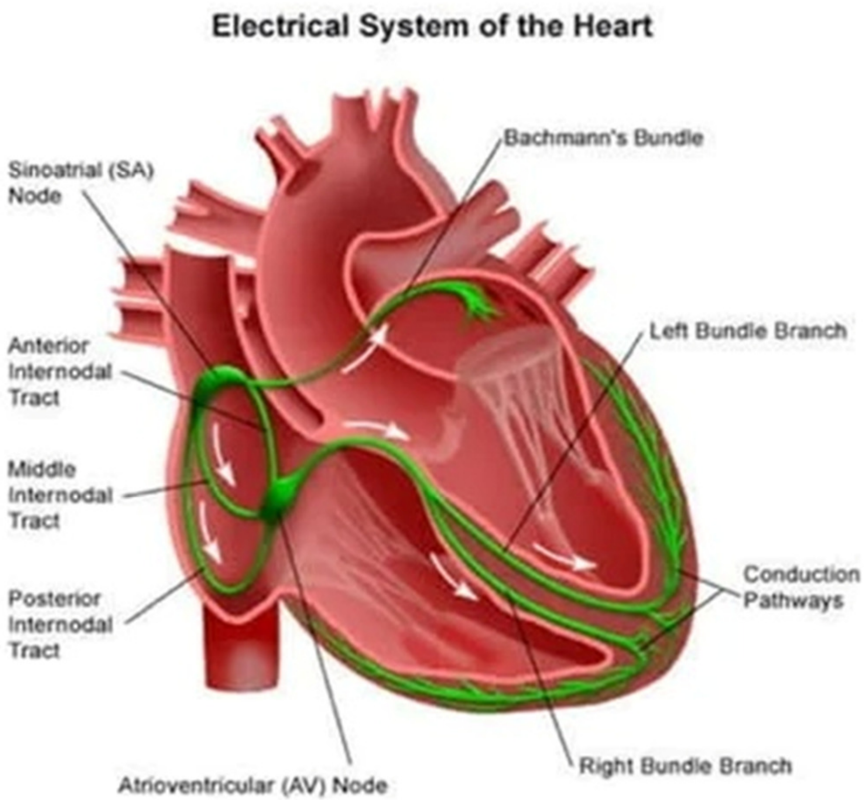
III YEAR/ V SEMESTER

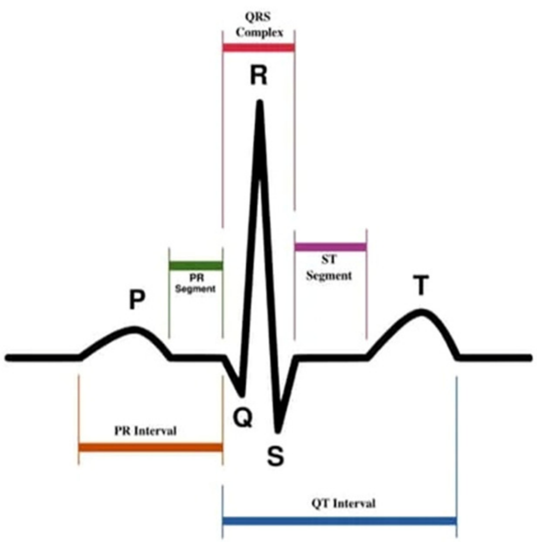
Unit IV : BIOSIGNALS AND THEIR CHARACTERISTICS

- Source of Bioelectric potential
- Resting and action potential
- Propagation of action potentials nerves
- Characteristics of biomedical signals
- The ECG-Cardiac electrophysiology
- Relation of ECG components to cardiac events
- Clinical applications

The ECG-Cardiac electrophysiology

- **Introduction**
- The **Electrocardiogram (ECG)** is a non-invasive diagnostic tool that records the electrical activity of the heart over time.
- It is essential for assessing heart function and detecting abnormalities related to cardiac electrophysiology.
- **Cardiac Electrophysiology** refers to the study of the electrical properties and activities of the heart, crucial for understanding the rhythm and conduction in cardiac tissue.





PQRST = One EKG complex = One Cardiac Cycle

Cardiac Electrophysiology Basics

The heart's rhythmic contractions are controlled by specialized cardiac cells that generate and propagate electrical impulses.

Conduction System of the Heart:

- **Sinoatrial (SA) Node**: The primary pacemaker of the heart located in the right atrium. It initiates electrical impulses at a regular rhythm.
- **Atrioventricular (AV) Node**: Receives impulses from the SA node, briefly delays them, allowing the atria to contract before the ventricles.
- **Bundle of His and Purkinje Fibers**: These conduct impulses from the AV node to the ventricles, leading to synchronized contraction.

The flow of ions (mainly Na^+, K^+, Ca^{2+}) across the cell membrane of cardiac cells leads to action potentials that spread through cardiac tissue, creating the electrical signals recorded in the ECG.

Phases of Cardiac Action Potential

The cardiac action potential has distinct phases:

- **Phase 0 (Depolarization)**: Rapid Na^+ influx causes the cell to depolarize.
- **Phase 1 (Initial Repolarization)**: Brief K^+ outflow begins repolarization.
- **Phase 2 (Plateau)**: Ca^{2+} influx maintains depolarization, prolonging the action potential.
- **Phase 3 (Repolarization)**: K^+ exits the cell, restoring the resting potential.
- **Phase 4 (Resting Phase)**: The cell returns to its resting state, ready for the next impulse.

These phases correspond to the P-QRS-T waves on the ECG.

Understanding ECG Waveform Components

The ECG waveform reflects the heart's electrical activity through specific wave components:

- **P Wave**: Represents atrial depolarization as the SA node triggers an impulse, causing atrial contraction.
- **QRS Complex**: Indicates ventricular depolarization and is larger than the P wave due to the greater muscle mass of the ventricles.
- **T Wave**: Represents ventricular repolarization, where ventricles prepare for the next cycle.
- **PR Interval**: Measures the time from the onset of atrial depolarization to the onset of ventricular depolarization, providing information on AV conduction.
- **ST Segment**: Represents the interval between ventricular depolarization and repolarization. An elevated or depressed ST segment can indicate ischemia or infarction.
- **QT Interval**: The time from the beginning of ventricular depolarization to the end of ventricular repolarization, essential in assessing risks for arrhythmias.

Cardiac Cycle and ECG Correlation

- The ECG cycle correlates with the mechanical phases of the cardiac cycle:
  - **Atrial Systole** (P wave) occurs as atria depolarize and contract, pushing blood into the ventricles.
  - **Ventricular Systole** (QRS complex) follows, with ventricular contraction pushing blood into the arteries.
  - **Ventricular Diastole** (T wave) represents ventricular relaxation and filling for the next cycle

Lead Placement and ECG Interpretation

ECG involves placing electrodes on the body in standard positions to form leads, each offering a different view of the heart's electrical activity.

- **12-Lead ECG**: Provides multiple views of the heart's electrical activity using leads (e.g., I, II, III, aVR, aVL, aVF, V1-V6).
- Each lead detects electrical activity from a specific direction, helping to localize abnormalities.

Einthoven's Triangle: Lead I, II, and III form a triangle that provides a basic three-view perspective on heart activity, crucial for initial interpretation.

Normal and Abnormal ECG Patterns

A normal ECG displays specific patterns in amplitude, duration, and interval that reflect healthy heart function.

Common Abnormalities:

- **Arrhythmias**: Irregular heart rhythms (e.g., atrial fibrillation, ventricular tachycardia).
- **Ischemic Changes**: ST-segment elevation or depression and T-wave inversion indicating myocardial ischemia or infarction.
- **Conduction Blocks**: Delay in the conduction pathway, as seen in AV block or bundle branch block.
- **Hypertrophy Patterns**: Enlarged P wave (atrial hypertrophy) or high-amplitude QRS complexes (ventricular hypertrophy) may indicate heart muscle enlargement due to increased workload.

Clinical Significance of ECG in Diagnosing Heart Conditions

Arrhythmias: Identifies rhythm disorders, such as atrial fibrillation, which can lead to stroke.

Myocardial Infarction (Heart Attack): Detects ischemic patterns, guiding treatment decisions.

Heart Blocks: Determines the location and severity of conduction delays.

Electrolyte Imbalance: Variations in electrolyte levels (e.g., K^+, Ca^{2+}) can affect ECG readings, alerting clinicians to underlying metabolic conditions.

Monitoring Cardiac Health: ECG is used in stress testing, preoperative assessments, and monitoring heart function in ICU patients.

Advancements in ECG and Electrophysiology

Modern ECG devices are portable, allowing for **continuous monitoring** (e.g., Holter monitors, wearable ECGs).

Signal Processing: Advanced algorithms aid in the interpretation of ECG, detecting subtle changes that may go unnoticed in manual readings.

Electrophysiological Mapping: Identifies the precise location of abnormal electrical pathways, helpful in catheter ablation procedures for arrhythmias.

Thank You!