SNS COLLEGE OF ALLIED HEALTH SCIENCE

Affiliated to The Tamil Nadu Dr MGR Medical University, Chennai

DEPARTMENT OF CARDIAC TECHNOLOGY

COURSE NAME : Basic Electrocardiography

UNIT : Basic Principles of Electrocardiography

TOPIC : Fundamental principles of electrocardiography Cardiac electrical field generation

FACULTY NAME: Kavipriya S

Case Study Title - Understanding Cardiac Activation through ECG Principles

Case Overview

Patient: 52-year-old male

Symptoms: Intermittent chest discomfort, mild palpitations, and shortness of breath during exertion

Clinical Findings: Normal heart sounds, but irregular pulse rhythm noted

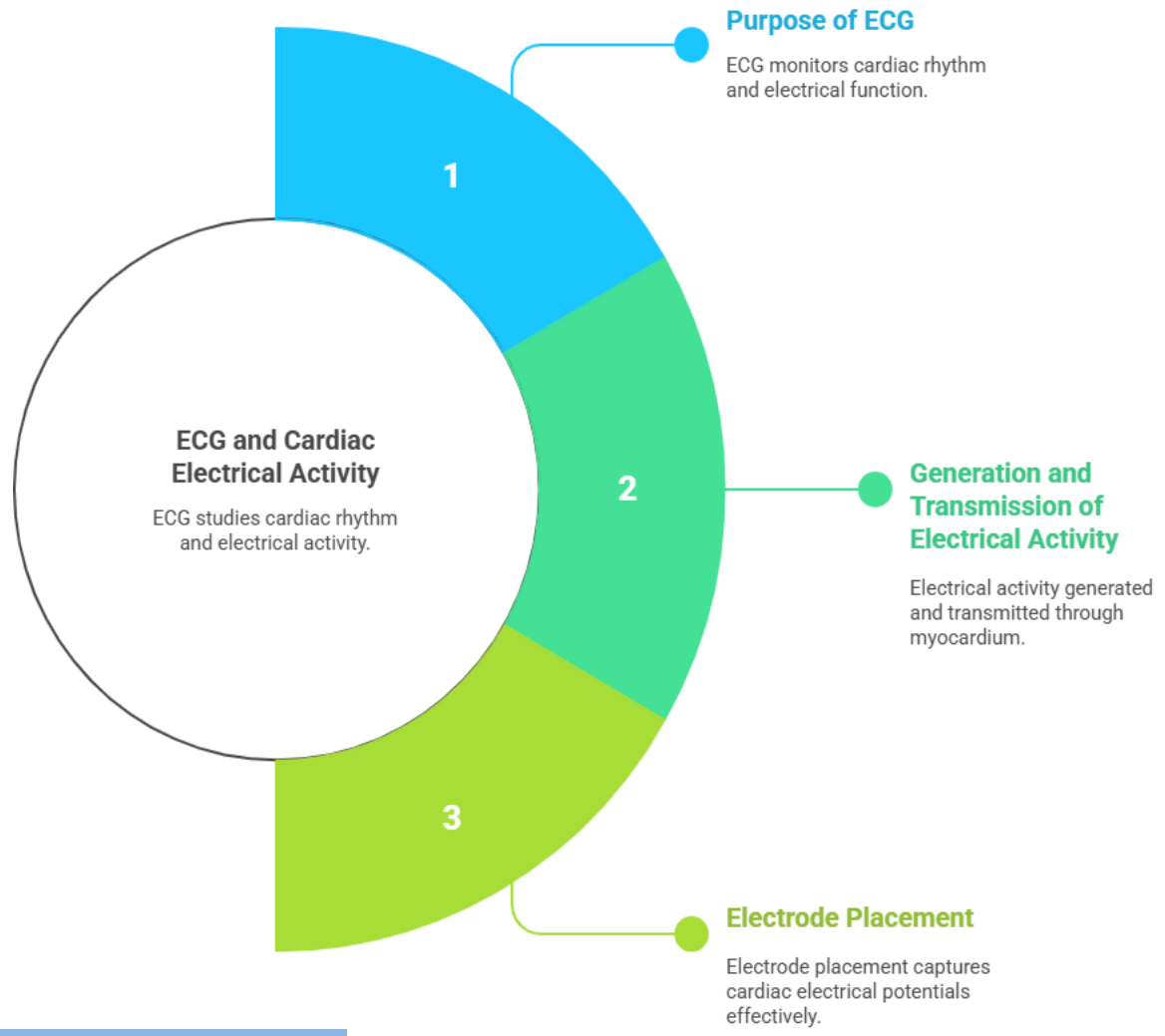
Suspected Problem: Atrial conduction abnormality or premature atrial complexes

Diagnostic Tool Chosen: Electrocardiography (ECG)

EMPATHIZE – Understanding the Clinical and Physiological Need

Objective:

Recognize how electrical activation of the heart produces measurable surface potentials and why understanding this is vital for diagnosis.



Empathize

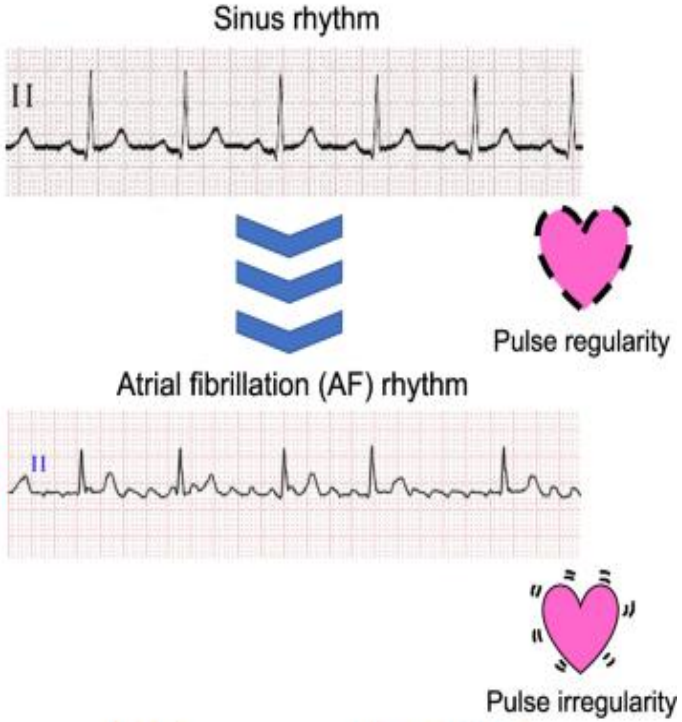
Clinical Observation:

- The patient's palpitations and irregular pulse require understanding of **how atrial and ventricular depolarization** patterns appear on ECG.
- Thus, understanding the **fundamental principles of cardiac electrical field generation** is essential for interpreting the observed rhythm disturbances.

Irregular Heart Beat (IHB) burden
Pulse irregularity burden

"Atrial fibrillation"

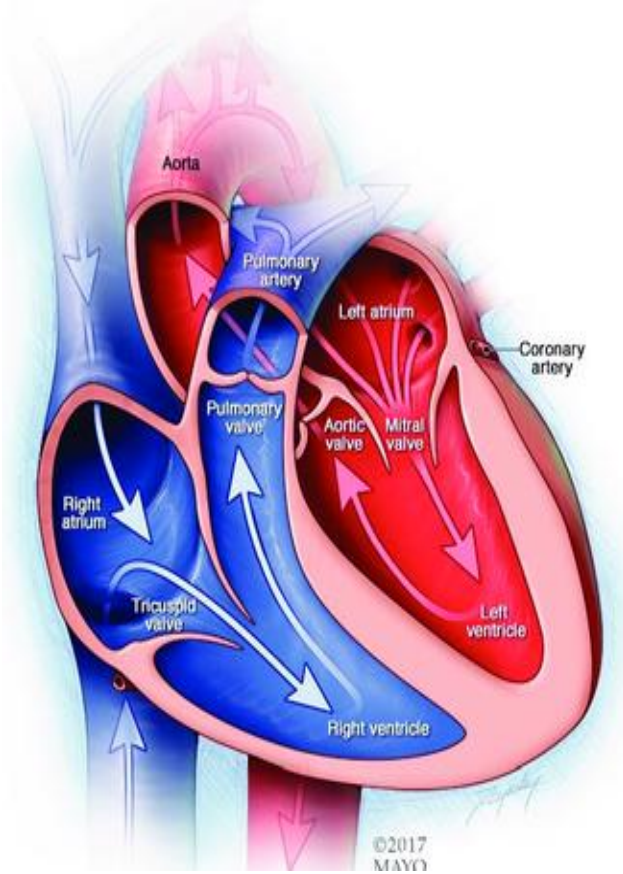
Possible risk indicator ?

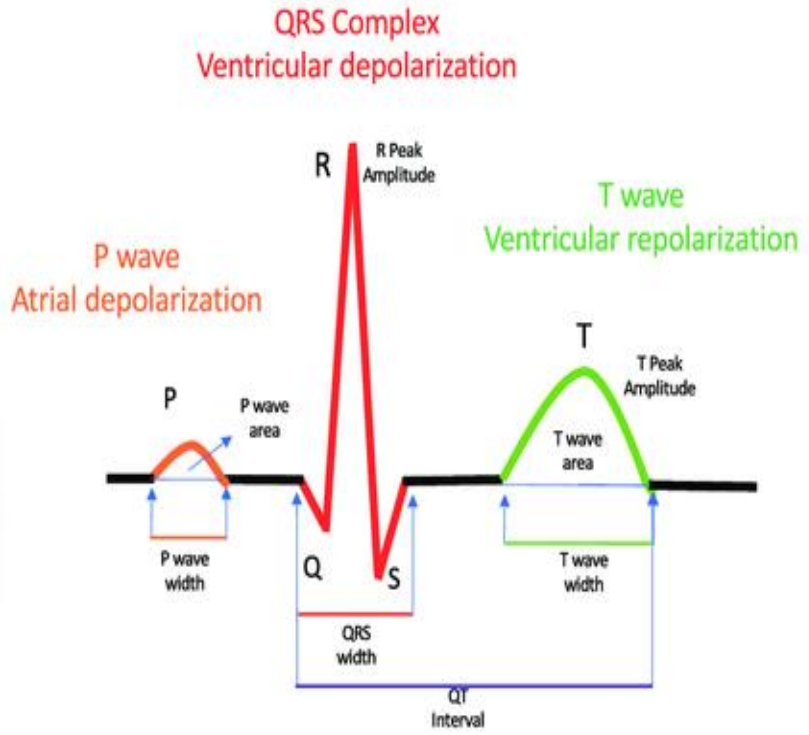


DEFINE – Establishing the Diagnostic and Conceptual Challenge

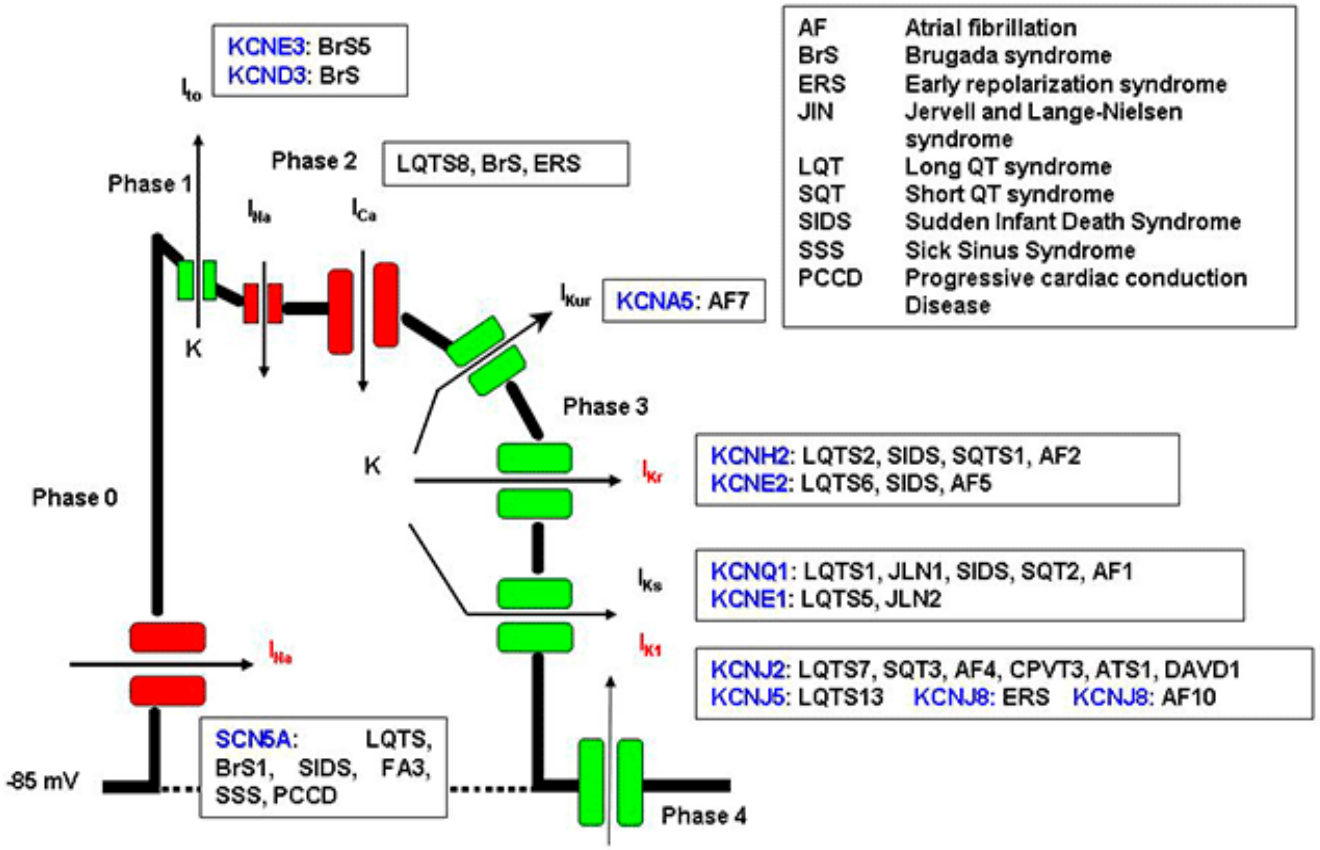
Problem Statement:

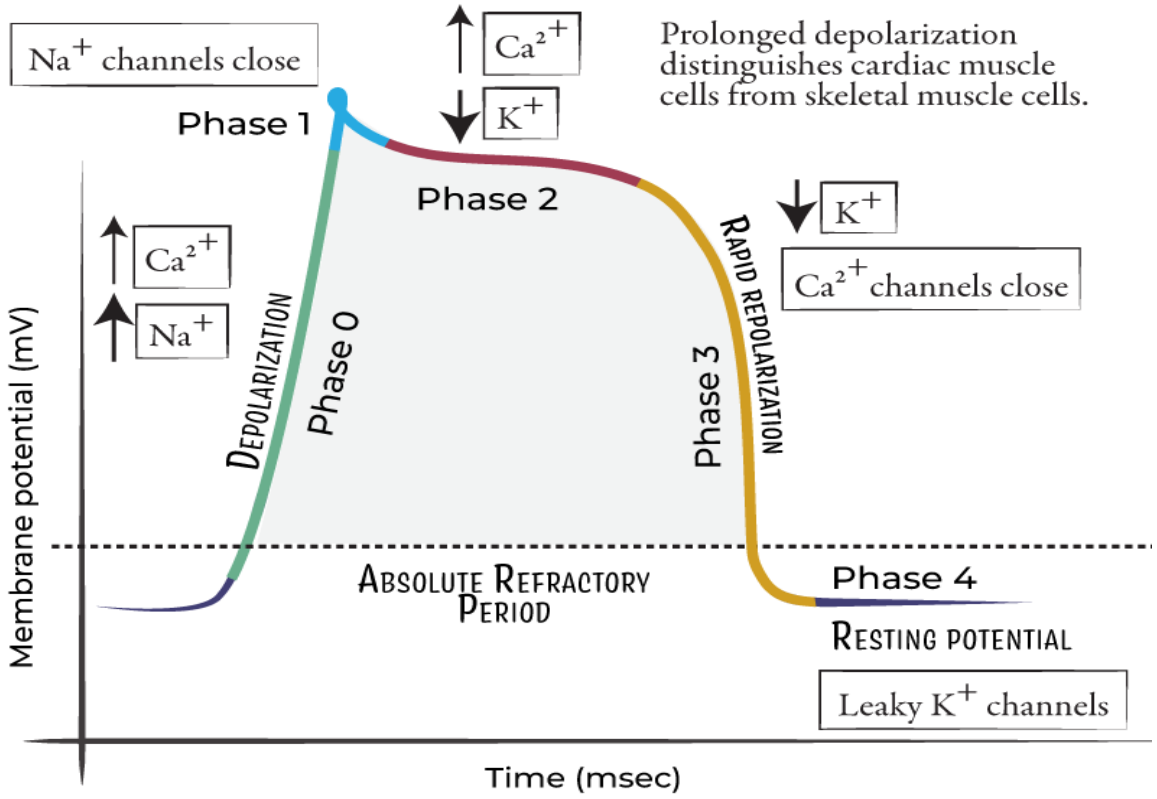
How might we visualize and interpret the cardiac electrical field and wavefront propagation on the body surface using ECG to understand rhythm abnormalities?





Define-Cardiac Action potential





Ideate (Generate Diagnostic and Assessment Approaches)

Concept	Description	Clinical Relevance
Resting Membrane Potential	-90 mV; maintained by ion pumps	Basis of excitability
Depolarization	Influx of Na^+ causing electrical activation	Creates ECG deflection
Repolarization	Efflux of K^+ restoring potential	Corresponds to T-wave
Dipole Formation	Electrical potential difference during depolarization	Source of ECG signal
Cardiac Vector	Direction and magnitude of electrical force	Determines waveform polarity

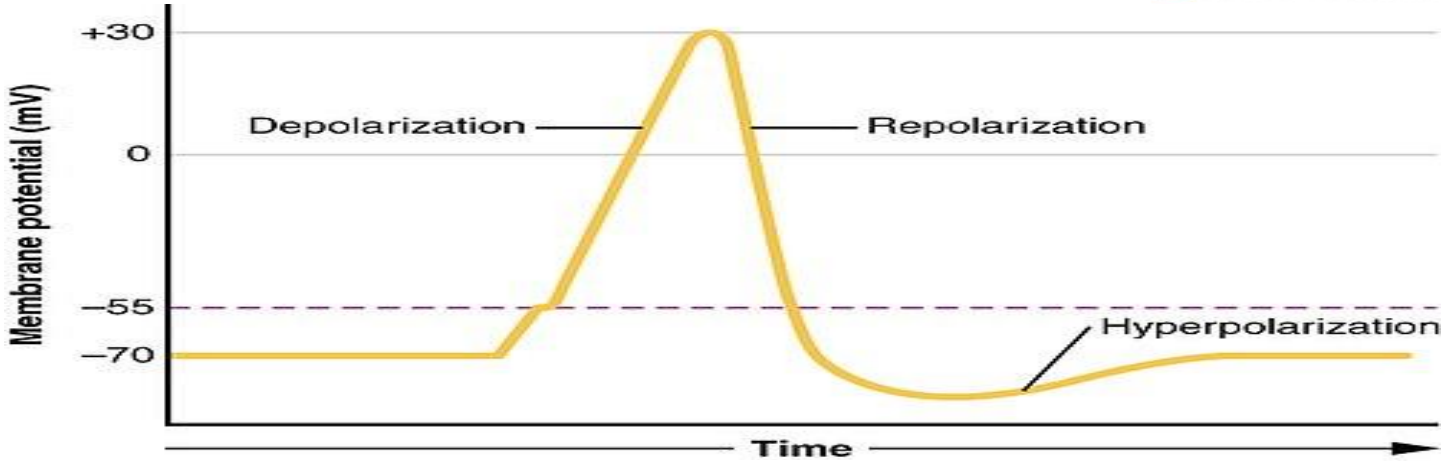
PROTOTYPE – Application to a Clinical Case

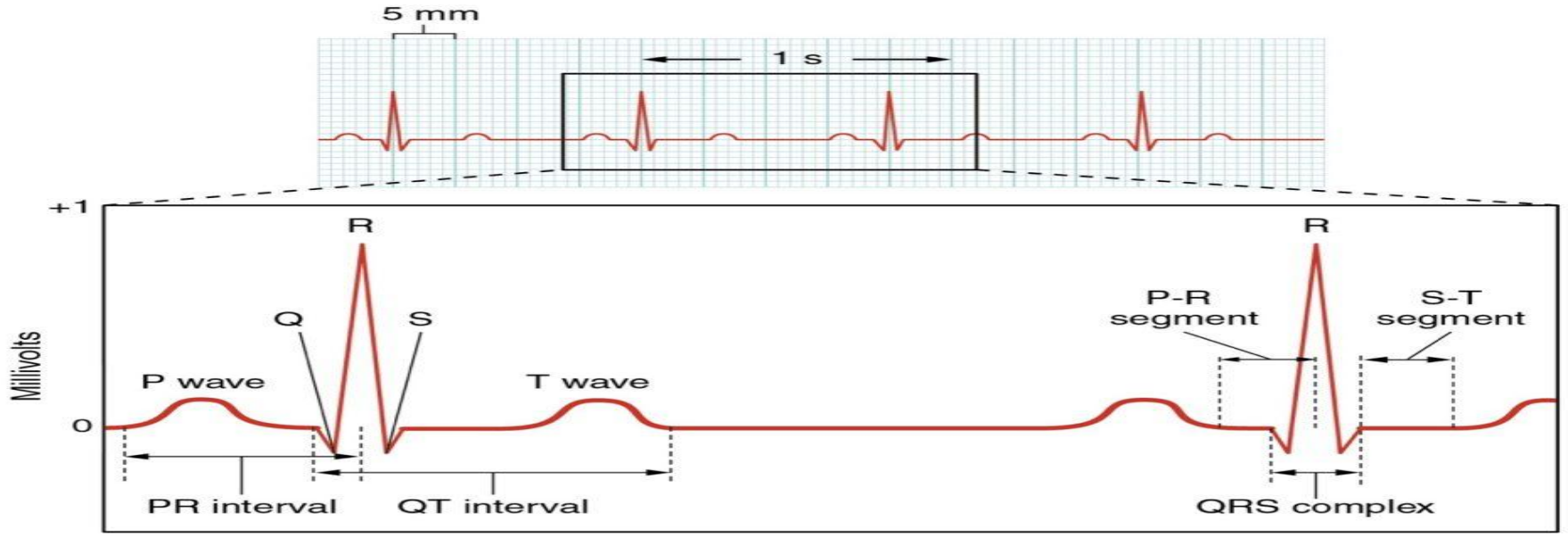
Step 1: Visualize the Cardiac Electrical Field

At rest: Cells are polarized — no current flow → baseline (isoelectric line).

Depolarization:

- Begins in the **SA node → atrial myocardium → AV node → bundle branches → Purkinje fibers → ventricular myocardium.**
- Each phase generates an **electrical vector**.





Step 2: Cardiac Wavefronts and ECG Representation

Activation Sequence	Wavefront Direction	ECG Representation
SA node → Atria	Toward lead II	Positive P wave
AV node delay	No movement	Isoelectric line
Ventricular depolarization (Septal → Apex → Base)	Toward left ventricle	QRS complex
Ventricular repolarization	Opposite to depolarization	T wave (positive in most leads)

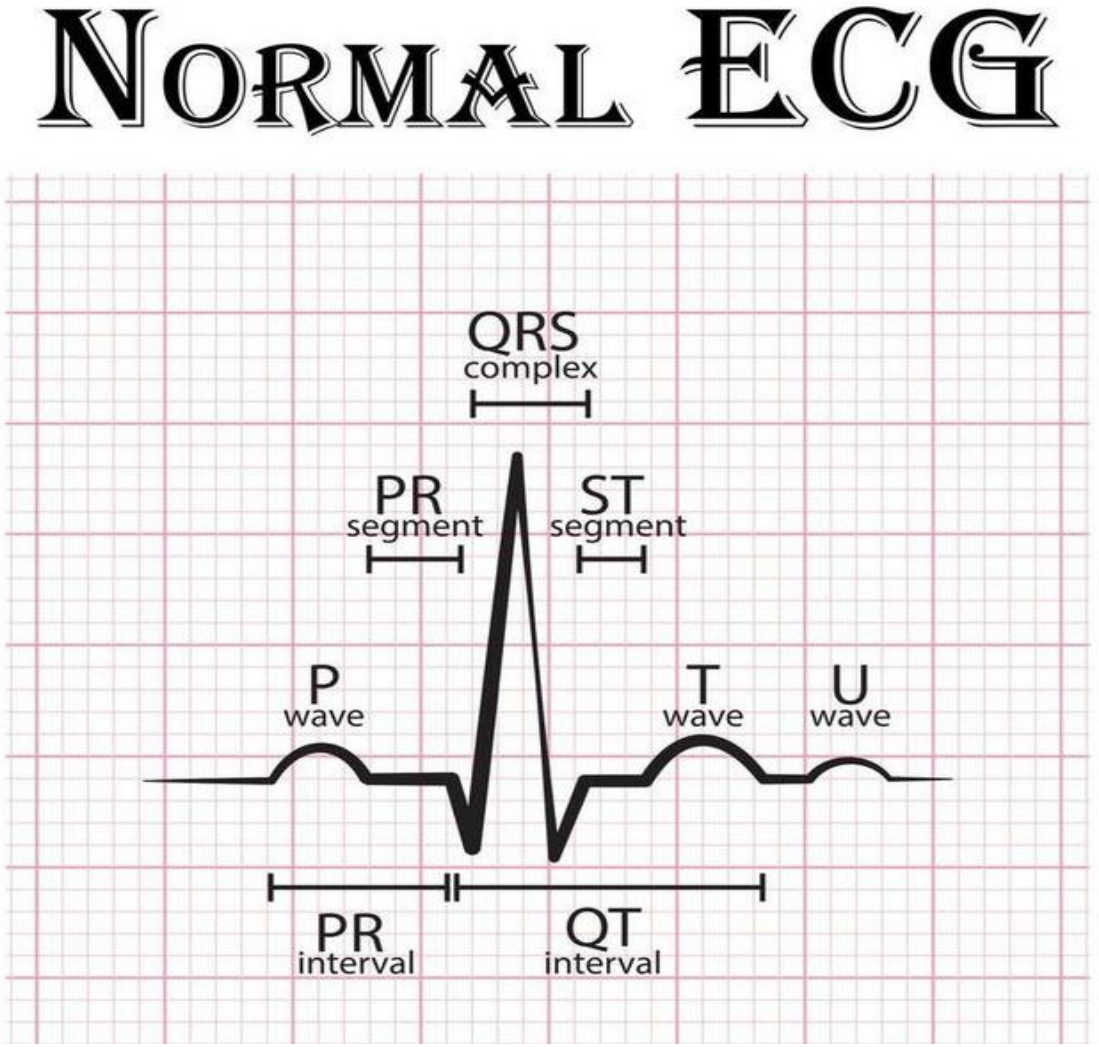
Step 3: Patient ECG Analysis

ECG Findings:

- Irregular P waves before QRS complexes
- Normal QRS morphology
- Normal T waves
- Normal u waves

Interpretation:

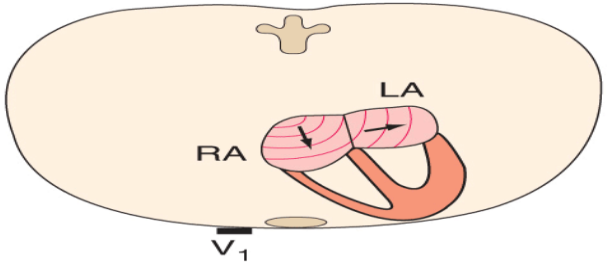
- Atrial premature complexes causing early depolarization wavefronts.
- Cardiac vector changes reflect abnormal atrial activation direction.



Step 4: Relate to Electrical Field Generation

- Abnormal atrial depolarization shifts dipole axis → altered field on body surface → different P-wave shape.

- Demonstrates how cardiac electrical field direction determines ECG morphology.



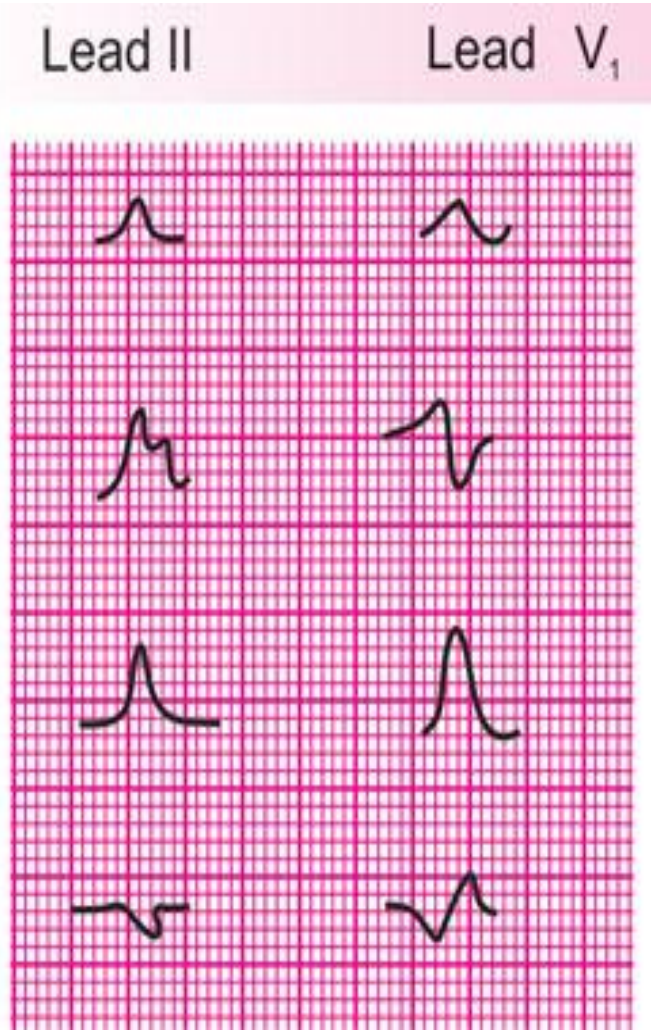
	Normal	Right	Left
II	RA LA	RA LA	RA LA
V_1	RA LA	RA LA	RA LA

Normal P wave

P mitrate
(left atrial hypertrophy)

P pulmonale
(right atrial hypertrophy)

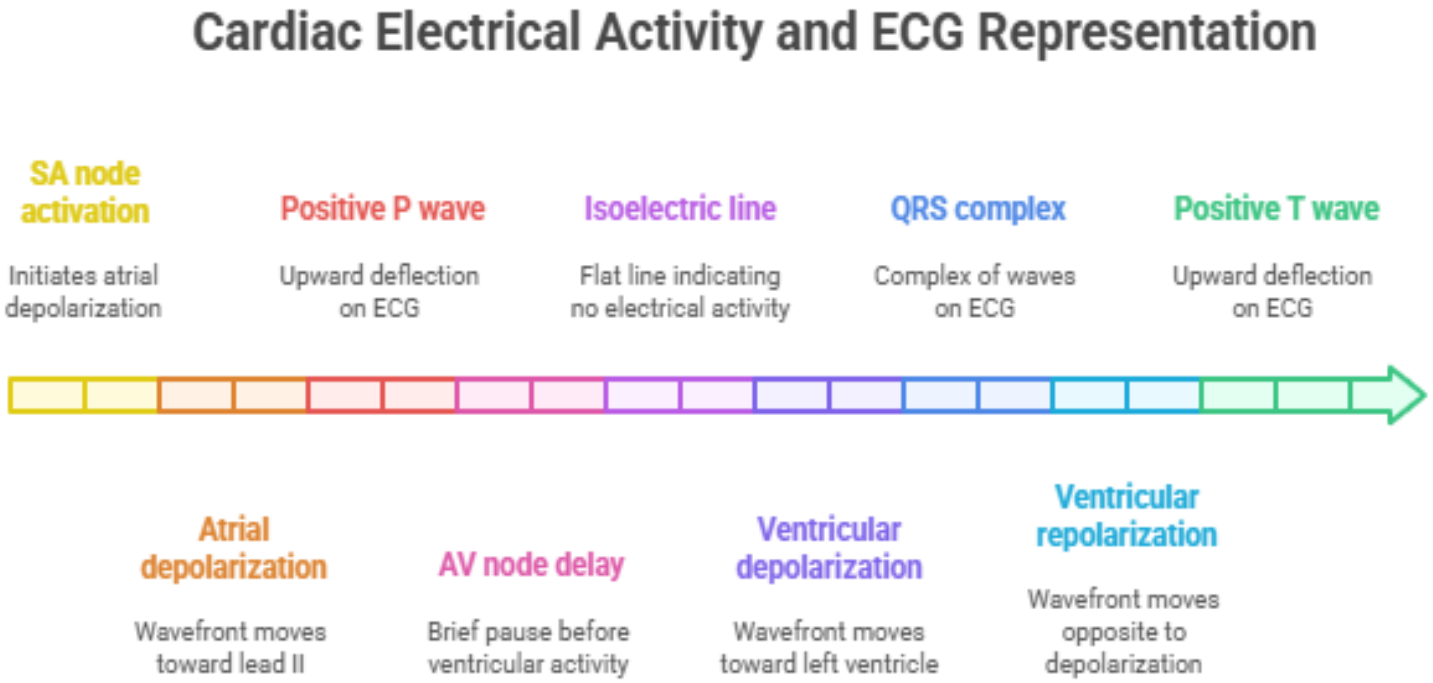
Retrograde P wave

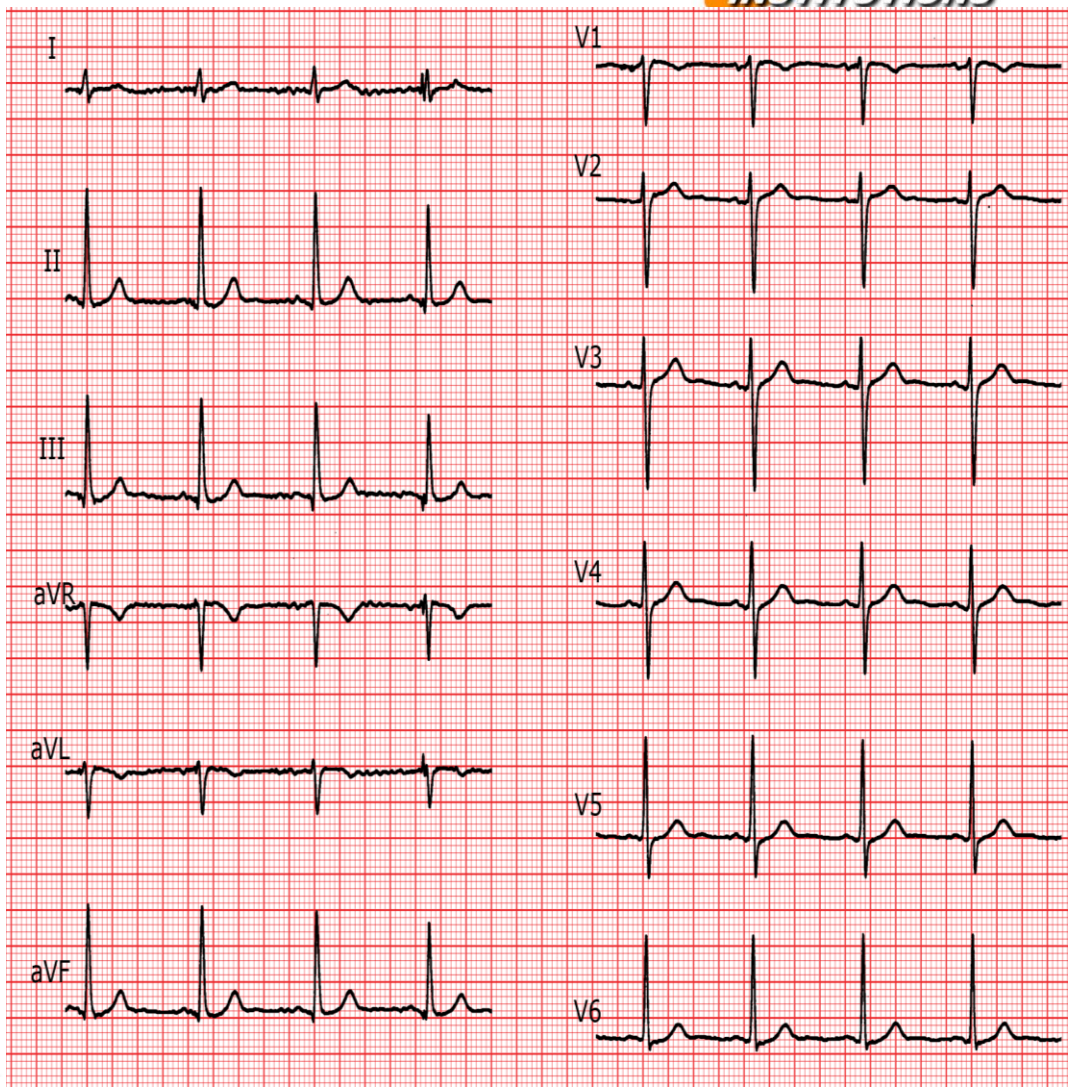


TEST – Evaluation

Outcome Evaluation:

- The ECG correctly reflects wavefront direction and timing differences.
- Confirms atrial premature beats with compensatory pause.





Case Reflection through Design Thinking

Stage	Learning Focus	Application
Empathize	Understand the patient's symptoms and physiology	Why ECG is needed
Define	Frame the diagnostic and physiological problem	How electrical activation maps to ECG
Ideate	Identify key concepts of wavefronts, dipoles, and fields	Concept mapping and visualization
Prototype	Apply theory to ECG tracing	Case-based analysis
Test	Evaluate ECG interpretation and learning outcome	Reflect and refine

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