



Round : Emergency medicine

Group no : B3

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ELECTROCARDIOGRAPHY



INTRODUCTION

- **What is an ECG?**

Measures heart's electrical activity, using leads placed on the chest and limbs.

- **Purpose :**

To detect ischemia, infarction, arrhythmia , electrolytes abnormalities, pericardial diseases , valvular diseases and other cardiac abnormalities

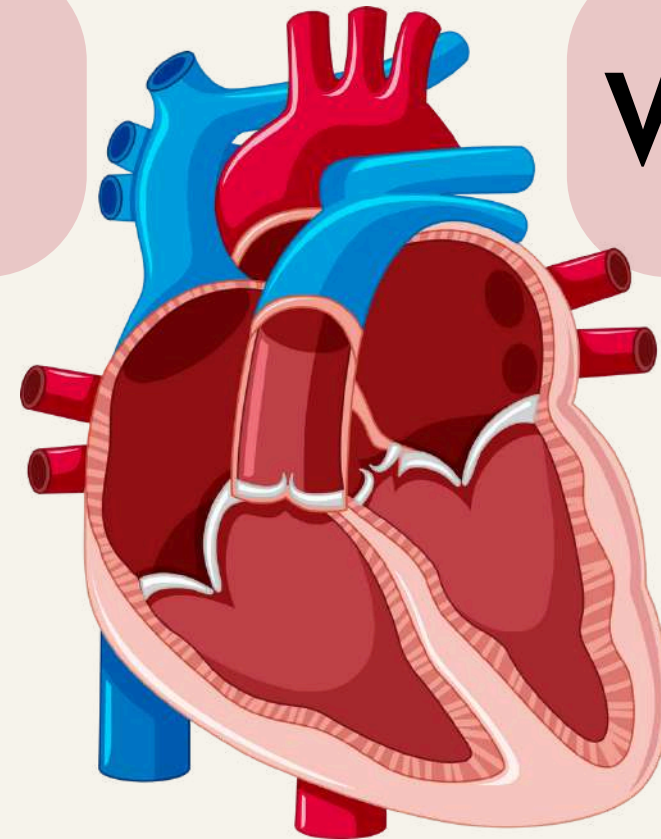


INTRODUCTION

Contraction = Depolarization

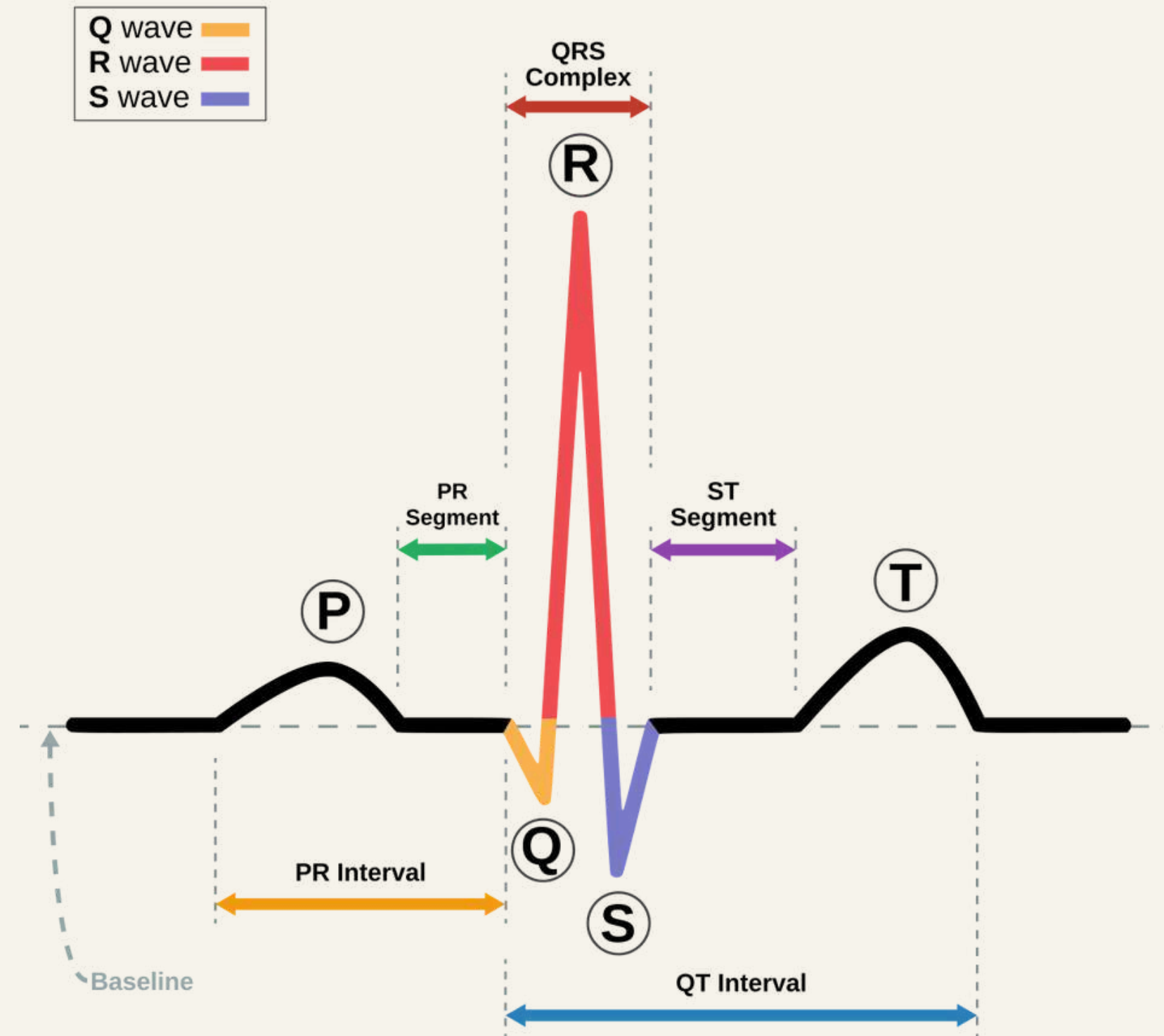
Relaxation = Repolarization

Atrial Contraction = ??



Ventricular Relaxation = ??

NORMAL WAVES



Prolonged in risk for arrhythmias

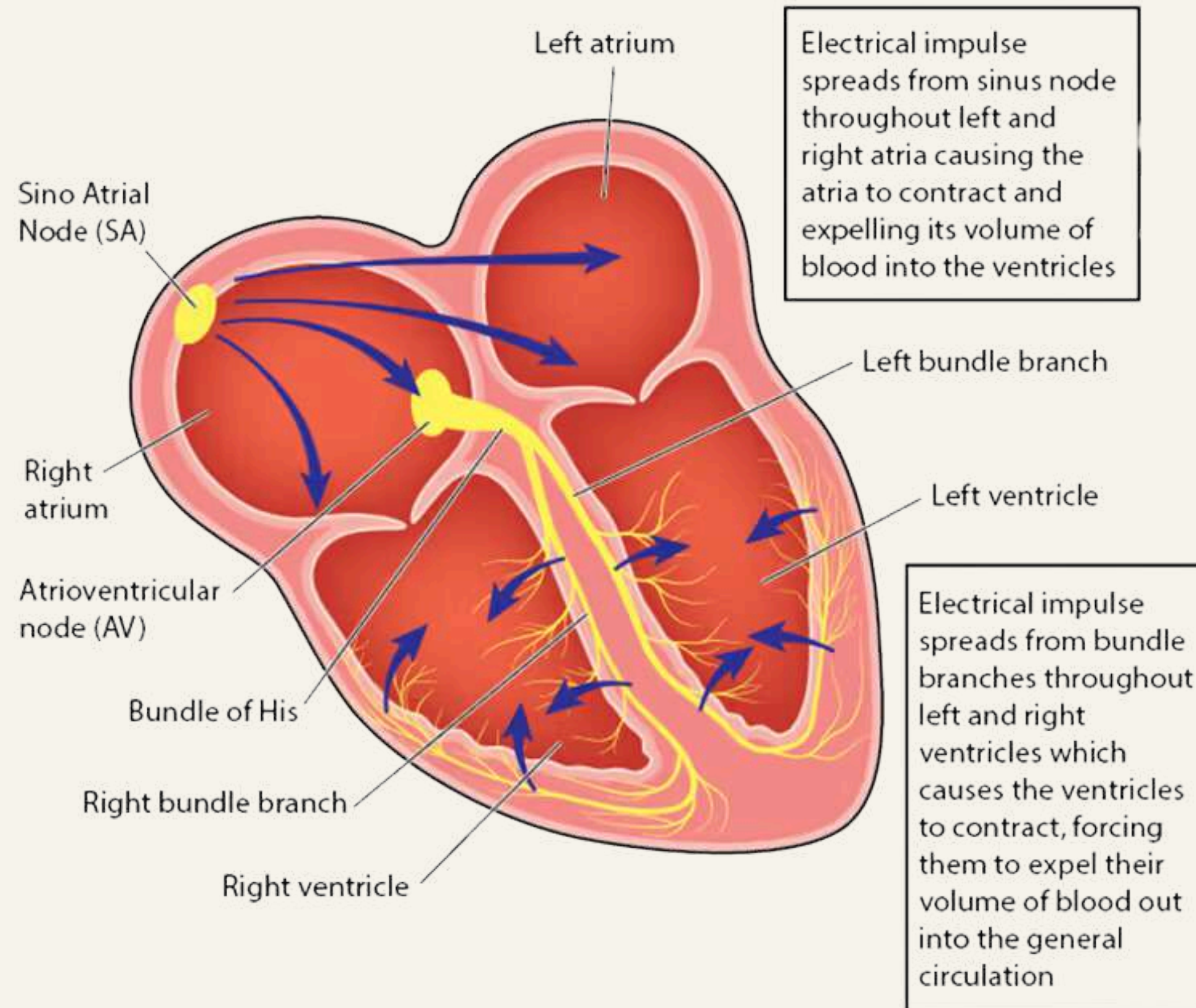
Pacemakers of the Heart

- **SA Node - Dominant pacemaker** with an intrinsic rate of 60 – 100 beats/ minute.

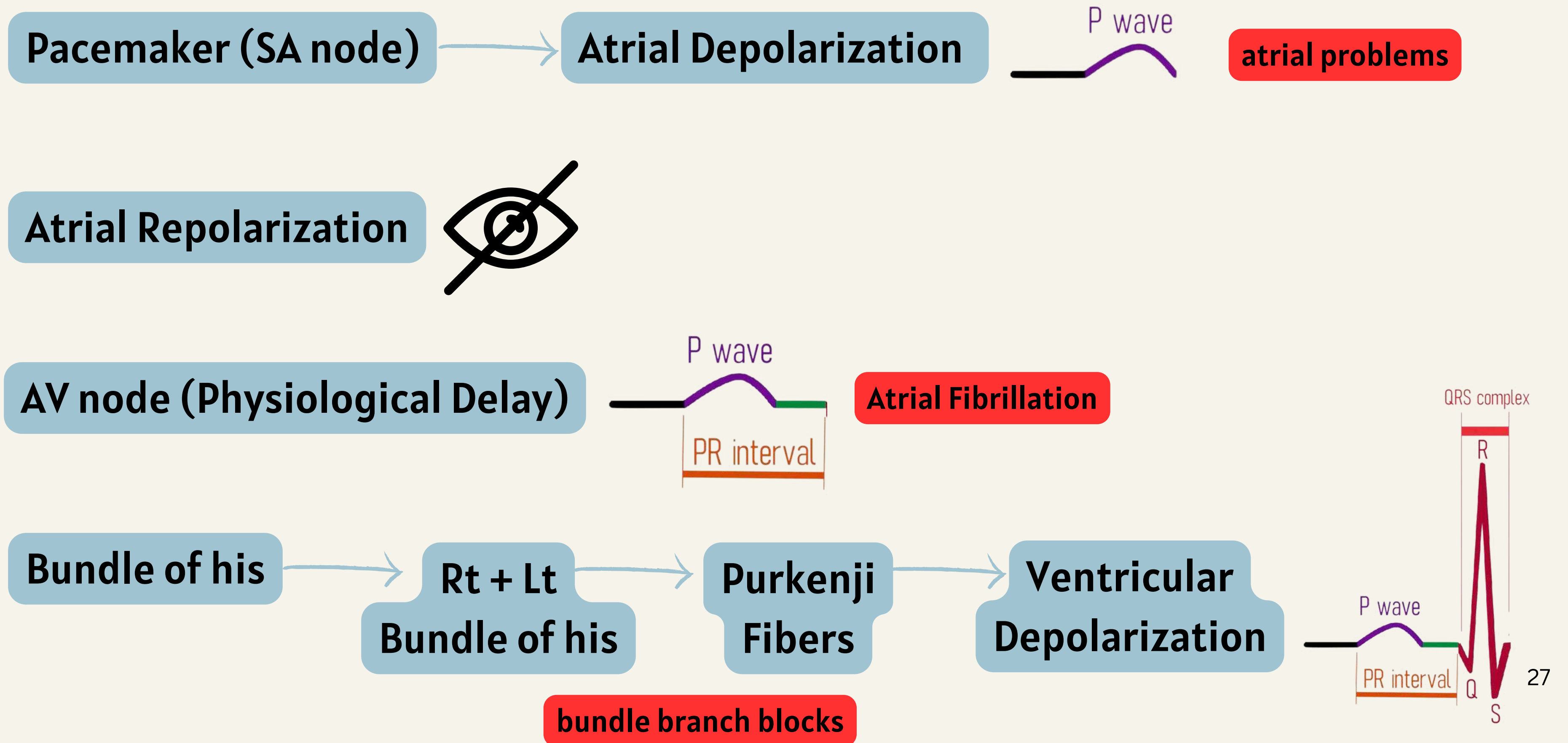
AV Node - Back-up pacemaker with an intrinsic rate of 40 - 60 beats/minute.

Ventricular cells - Back-up pacemaker with an intrinsic rate of 20 - 45 bpm.

CONDUCTIVE SYSTEM OF HEART

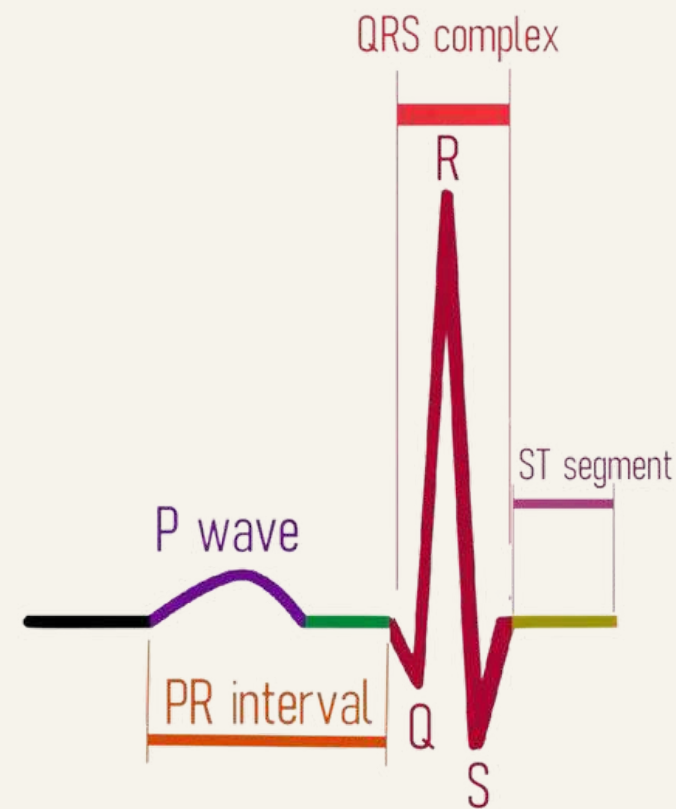


HOW IS EACH WAVE GENERATED IN THE ECG?



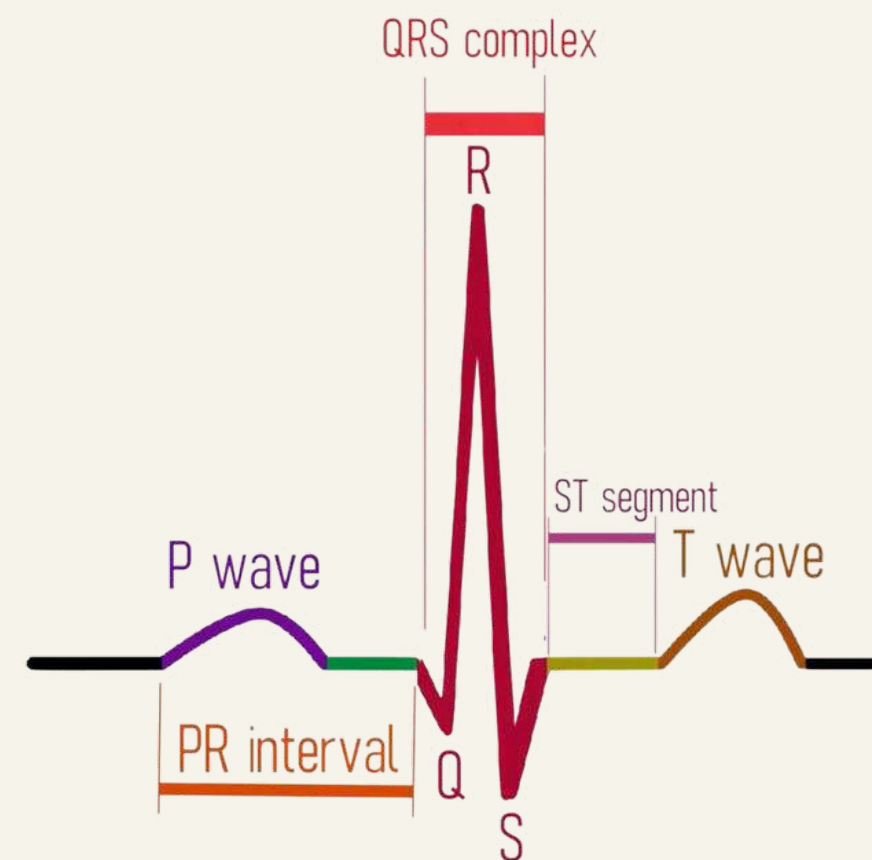
HOW IS EACH WAVE GENERATED IN THE ECG?

Isoelectric Period

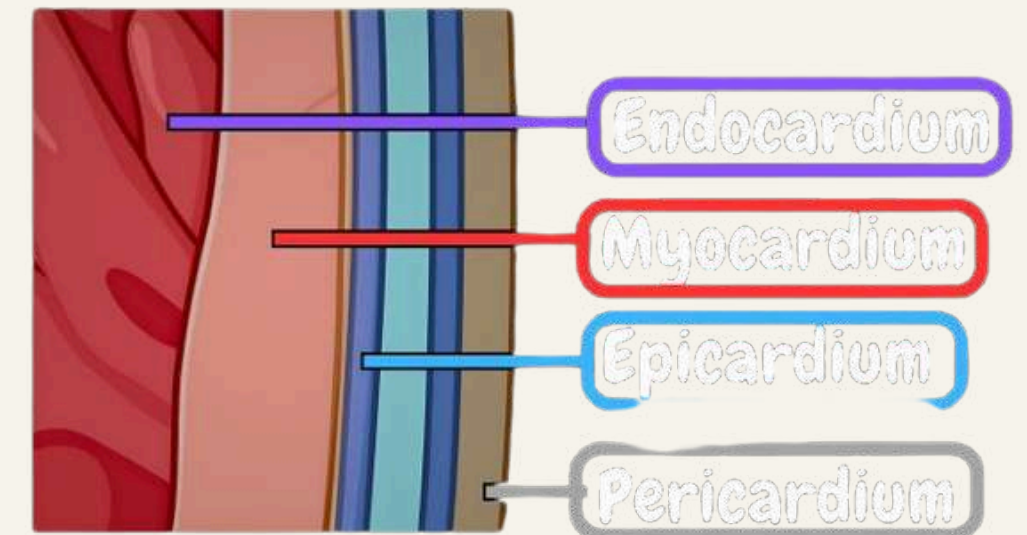


elevation or depression indicates ischemia

Ventricular Repolarization



inversion suggests ischemia



1. ST Depression (Subendocardial Ischemia)

- **Mechanism:** ST depression typically occurs when there's a partial thickness injury or reduced blood flow in the inner layer of the heart wall (subendocardium), which is more vulnerable to ischemia because it's furthest from the coronary arteries.
- **Why It Happens:**
 - The subendocardial cells, when deprived of oxygen, become unable to maintain normal ionic gradients (especially potassium) across their cell membranes.
 - This creates a **voltage gradient** between the ischemic (subendocardial) and non-ischemic (epicardial) areas, which alters the baseline electrical activity.
 - This baseline shift, seen on the ECG, creates an apparent **ST depression**.



• **Common Conditions:**

- Often seen in non-ST-elevation myocardial infarction (**NSTEMI**), unstable angina, or during exercise stress tests (when oxygen demand exceeds supply temporarily).

2. ST Elevation (Transmural Ischemia)

- **Mechanism:** ST elevation usually occurs with a full-thickness or transmural ischemia, where an entire segment of the heart wall (from the endocardium to the epicardium) becomes ischemic, typically due to a complete blockage of a coronary artery.
- **Why It Happens:**
 - In transmural ischemia, the outer heart layers (epicardium) become electrically "injured" and depolarize abnormally, creating a net voltage shift that appears as ST elevation.
 - This injured area generates what is known as an **injury current**, which causes the ECG baseline to shift.
 - As a result, the ST segment appears elevated in the leads "facing" the area of transmural injury.

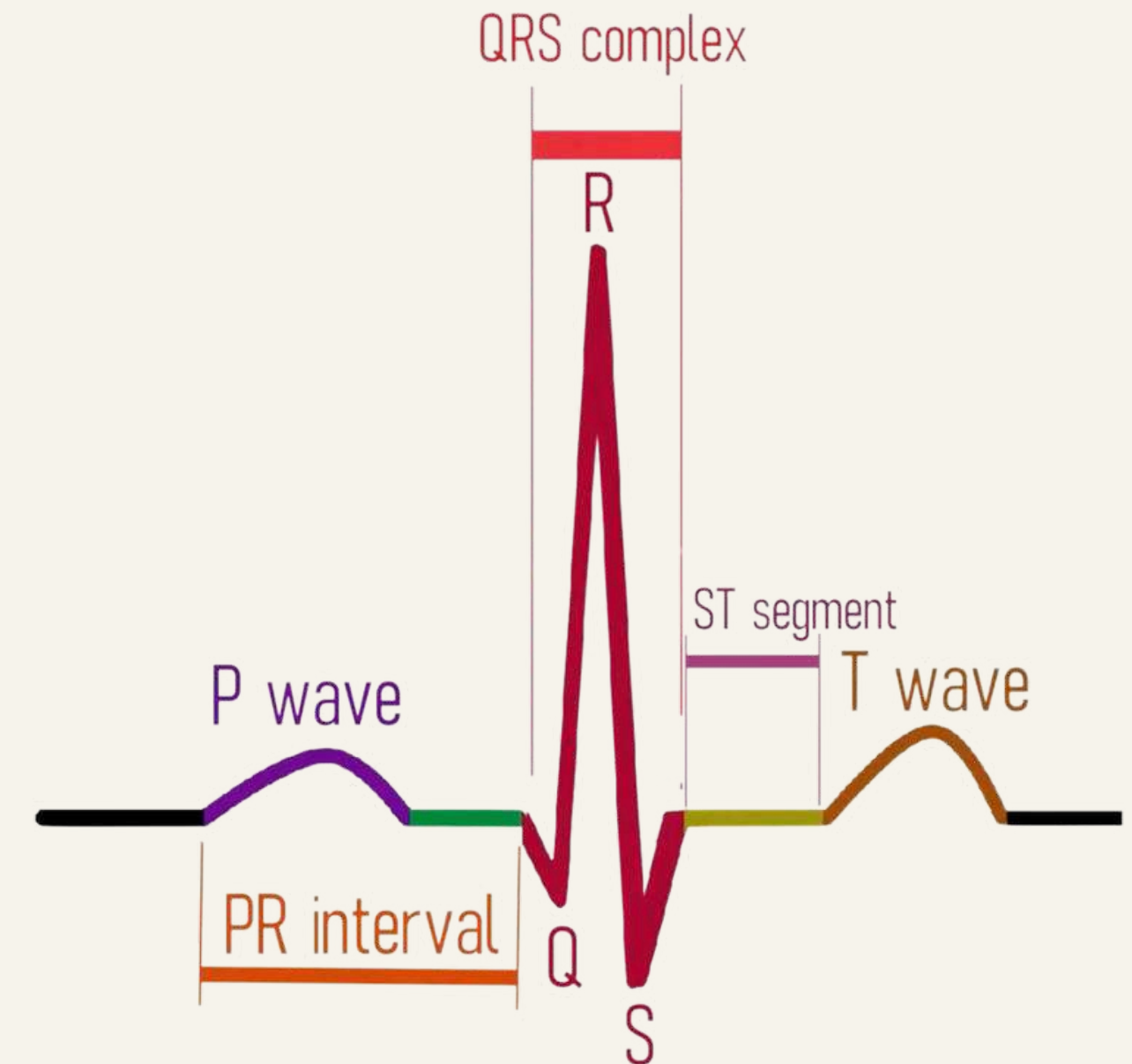
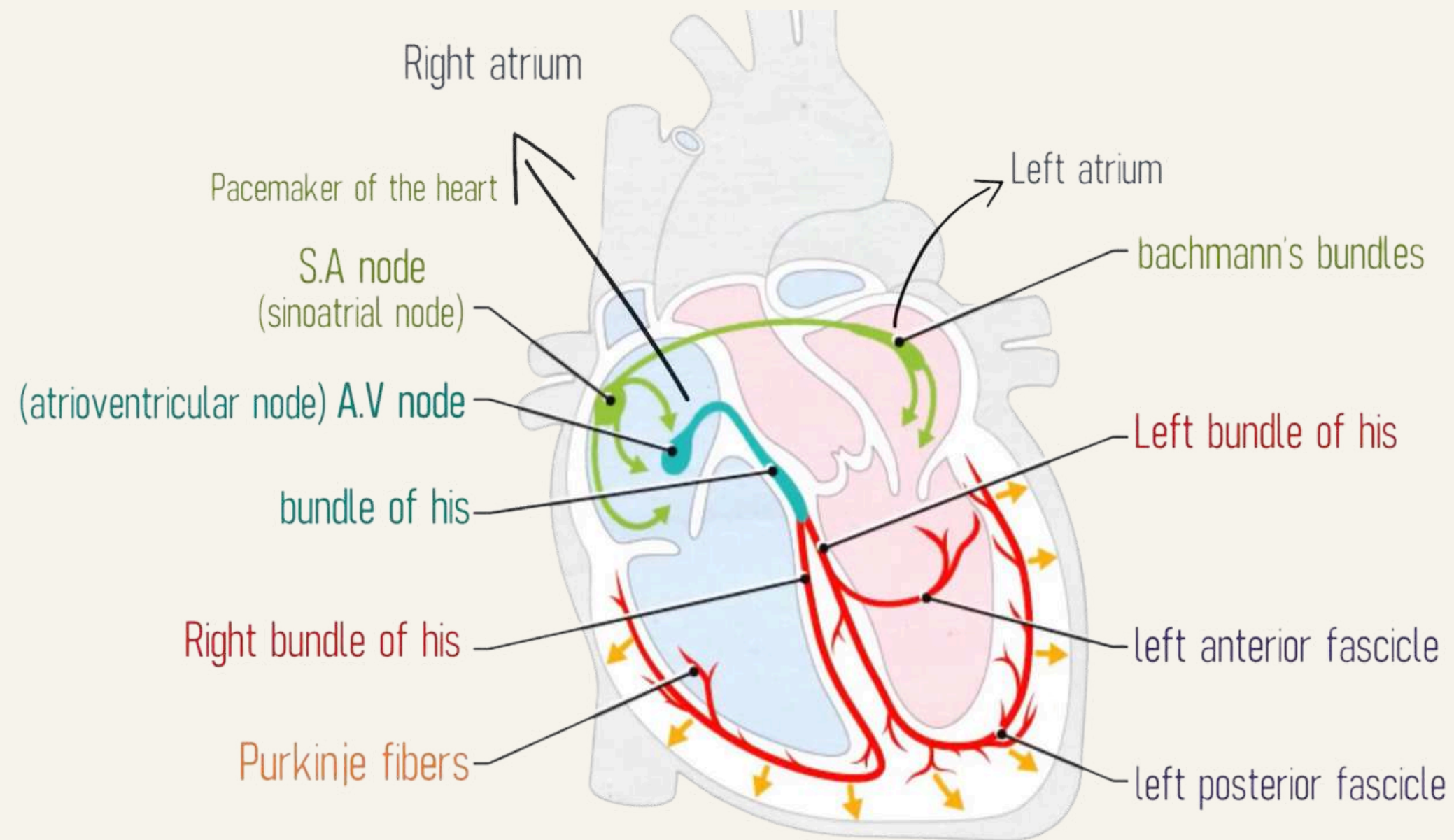
• **Common Conditions:**

- Most commonly seen in **ST-elevation myocardial infarction (STEMI)** due to a full occlusion in a coronary artery.

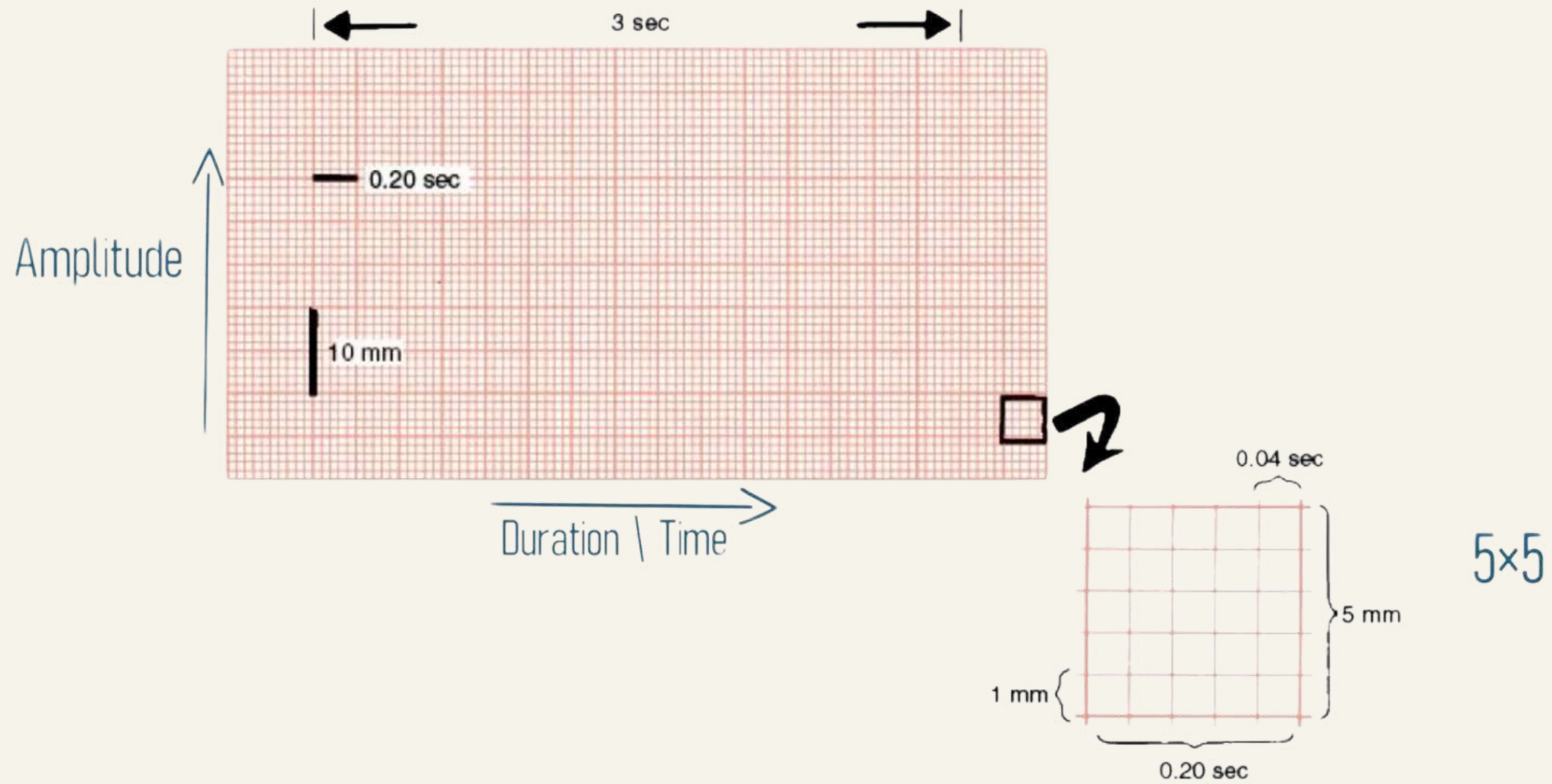
Summary: Why ST Depression or Elevation Occurs

- **ST Depression:** Subendocardial ischemia affects only the inner layer of the heart, creating an electrical gradient across the wall, which shifts the ST segment downward.

HOW IS EACH WAVE GENERATED IN THE ECG?



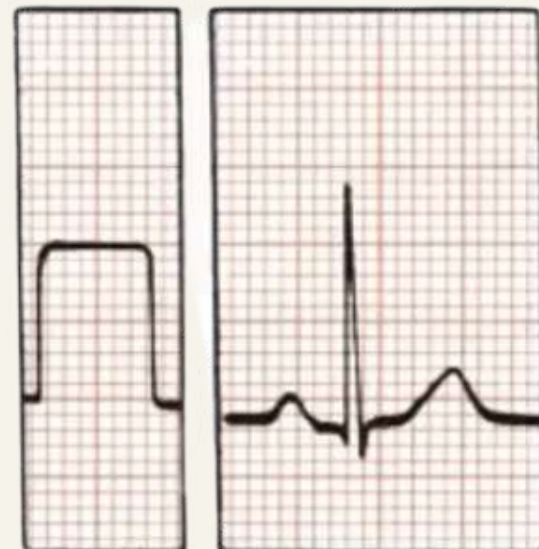
ECG PAPER



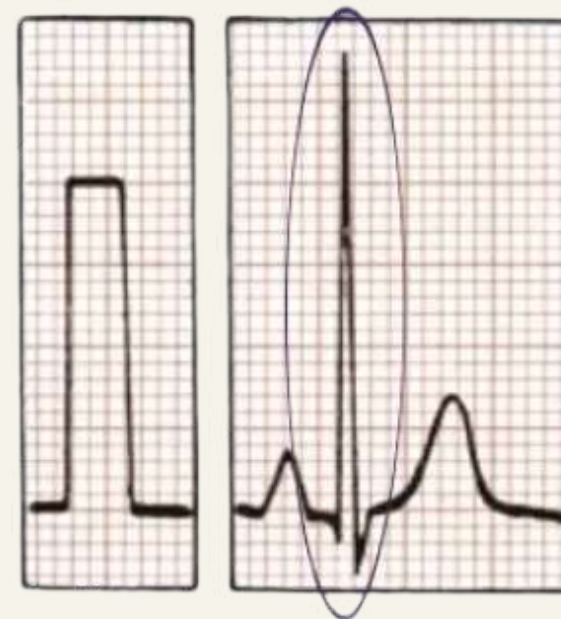
STANDARDIZATION MARK



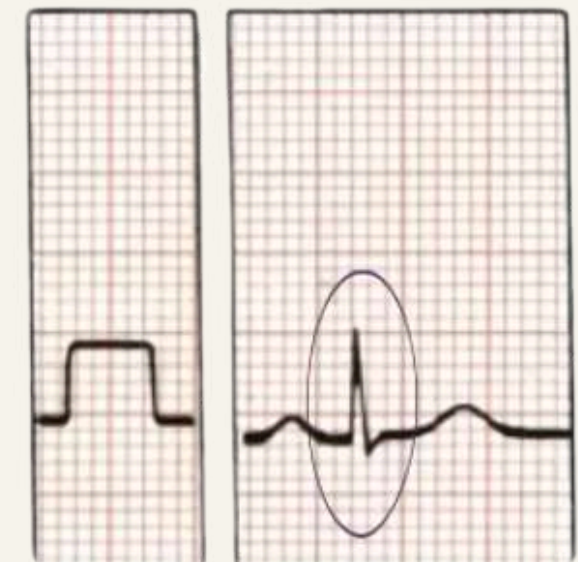
Normal



2 big squares tall
Indicates normal ventricular size and function.



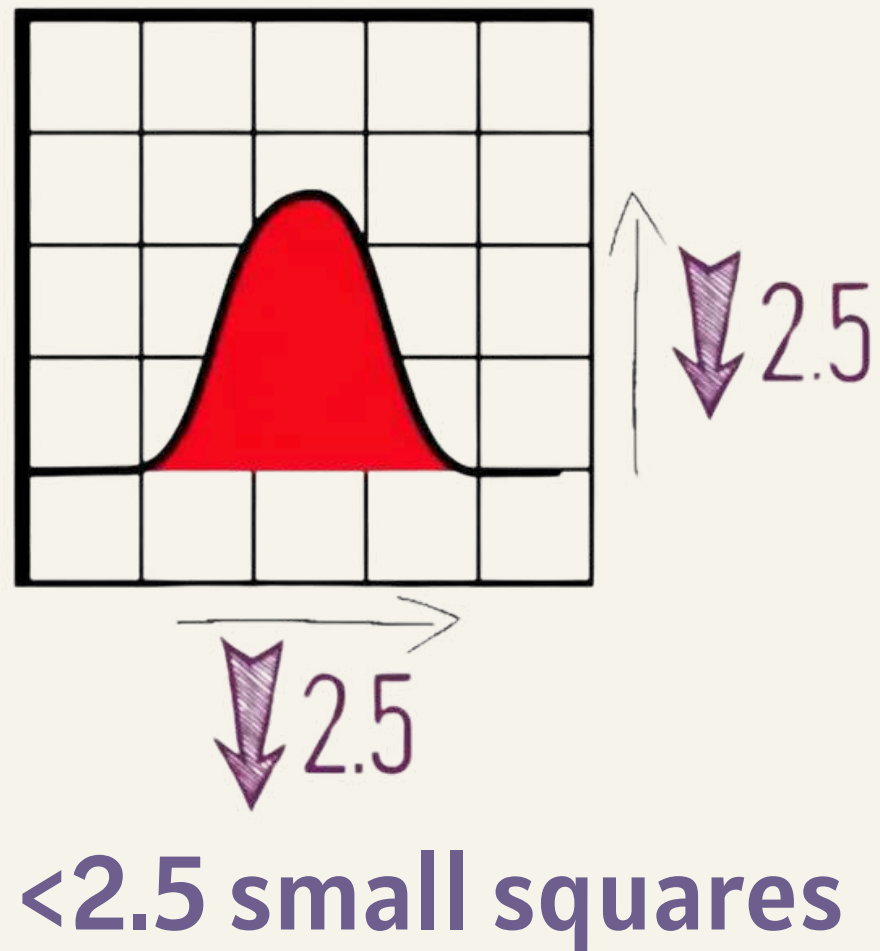
A smaller QRS complex -> obesity, pericardial effusion -> let make QRS taller to see it



A taller QRS complex -> ventricular hypertrophy -> let make QRS shorter to see it

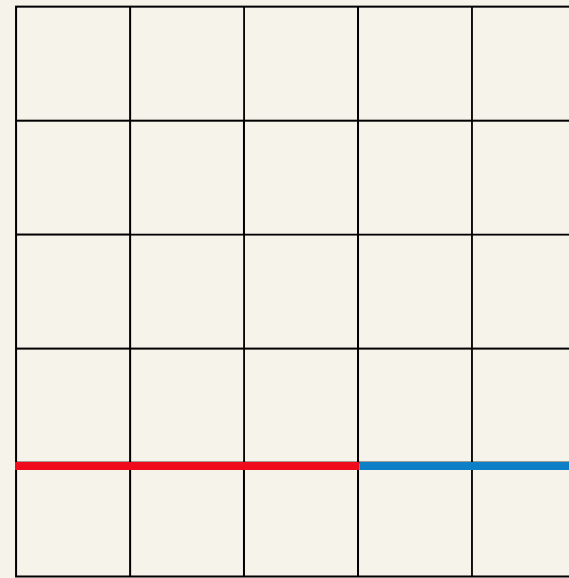
NORMAL WAVES

P wave



PR interval

P wave - QRS complex



QRS complex

Height : 1-5 big squares

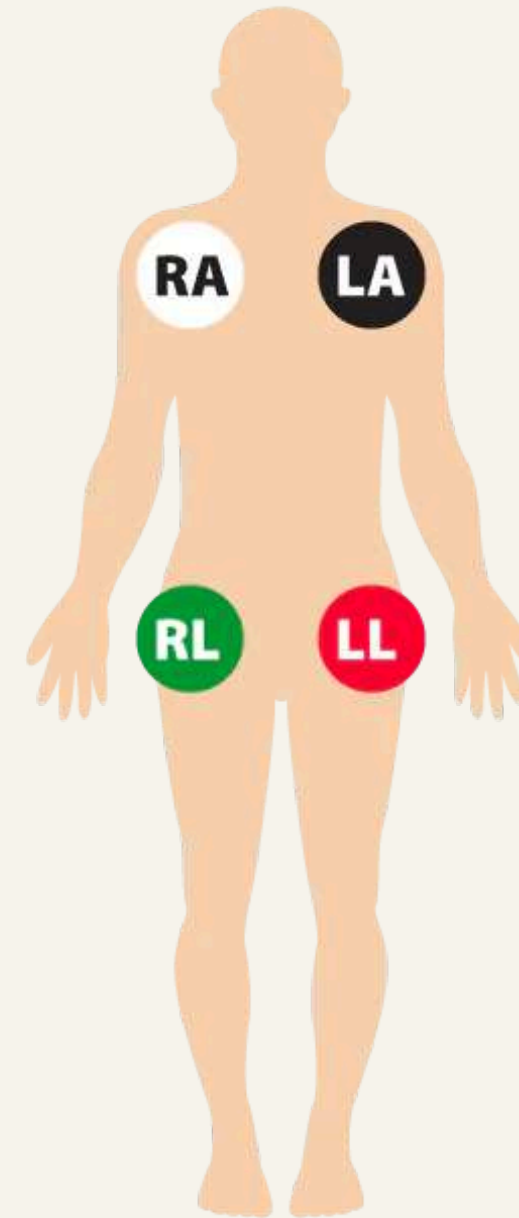
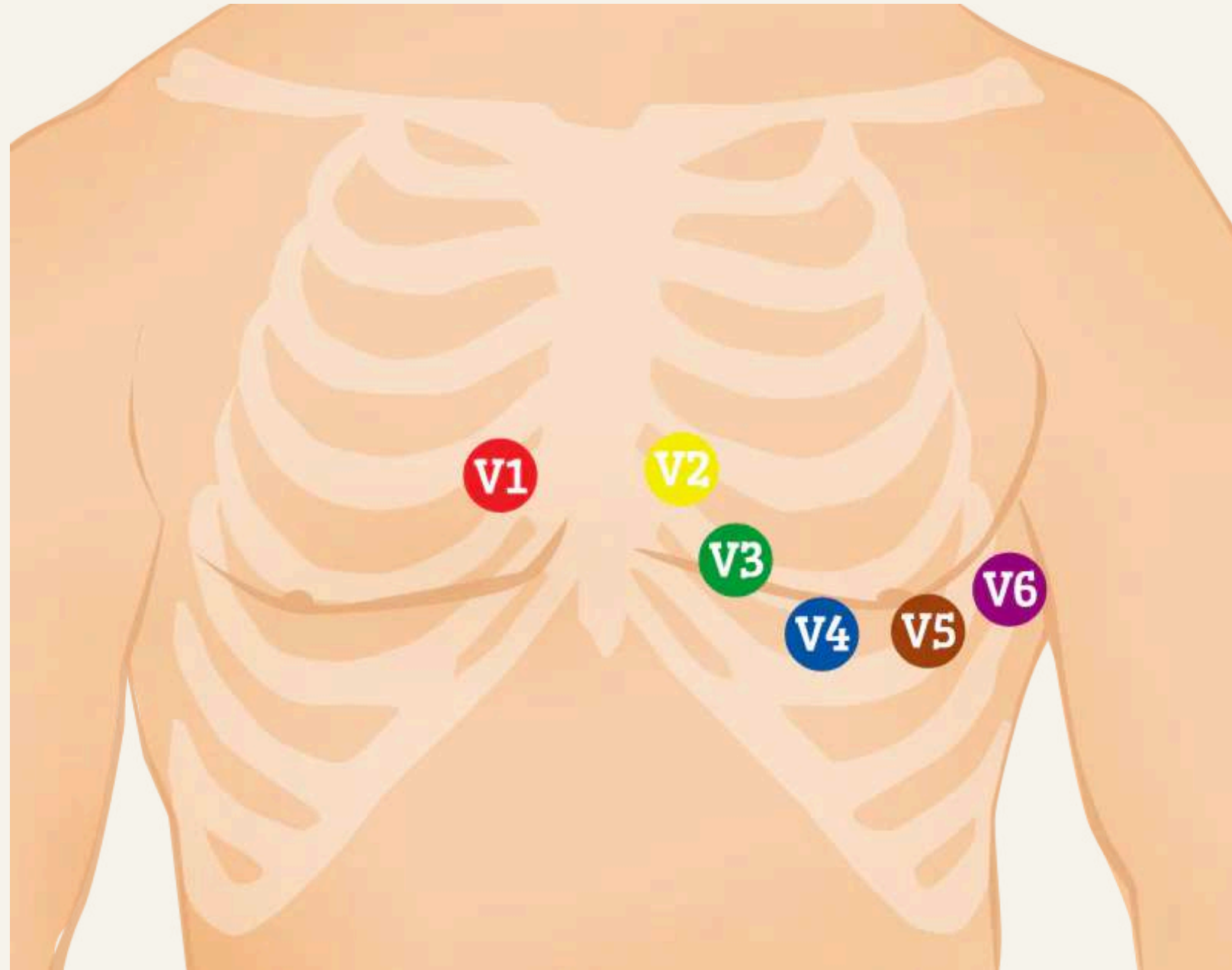
Width : <3 small squares

T wave

Height : <2 big squares

Width : <6 small squares

THE 12 LEAD ECG



Right Arm



Left Arm

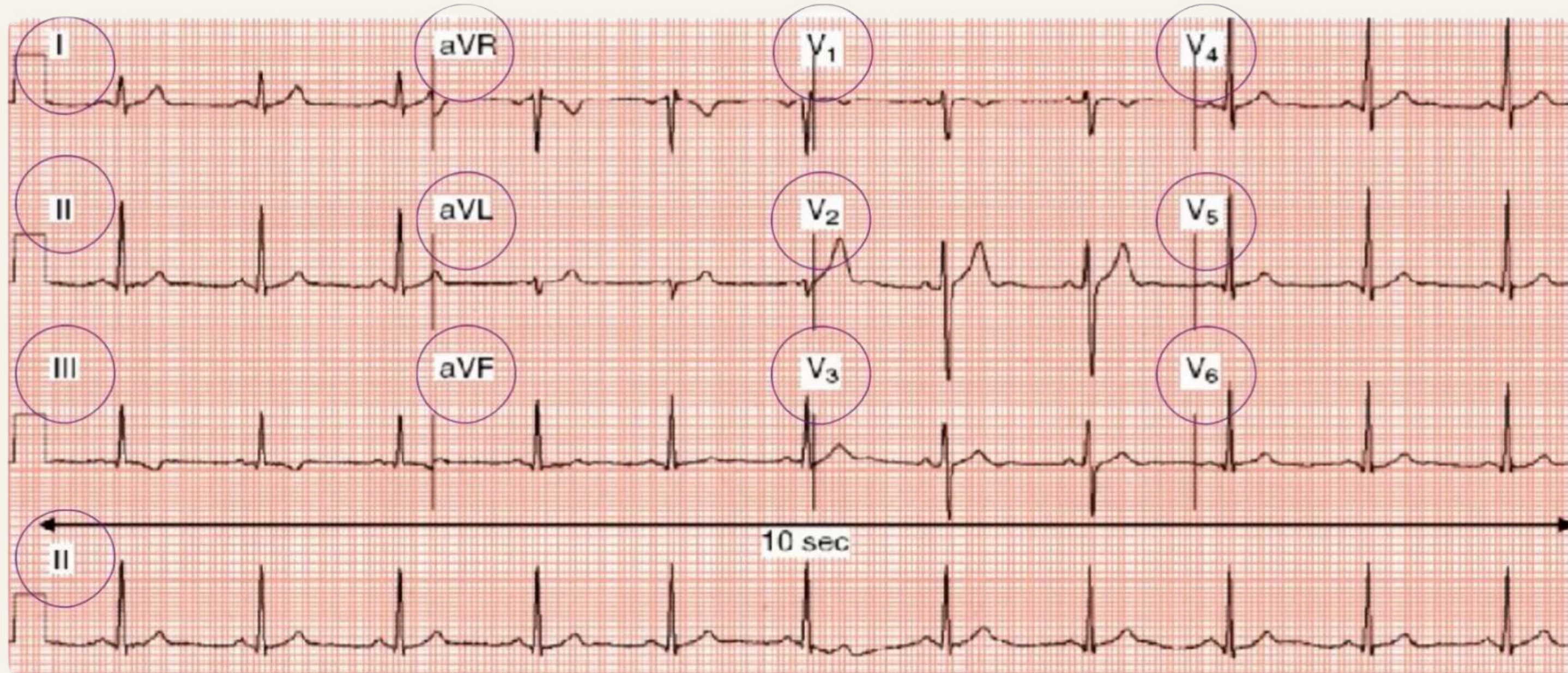


Left Leg



Right Leg

THE 12 LEAD ECG

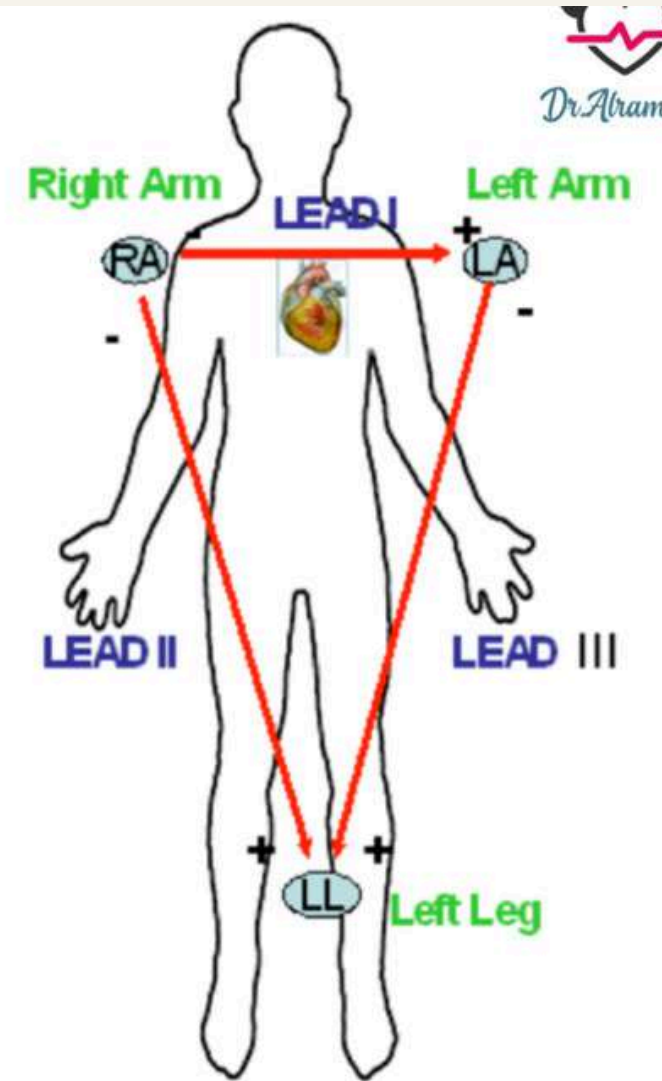


There are 12 ECG leads calculated using 10 electrodes.

THE 12 LEAD ECG

- Leads: 12 leads
 - 1- 6 chest leads (V1 to V6)
 - 2- 6 limb leads
- 3 unipolar: avR,avL,avF
3 bipolar: LI,LII,LIII

einthoven's triangle

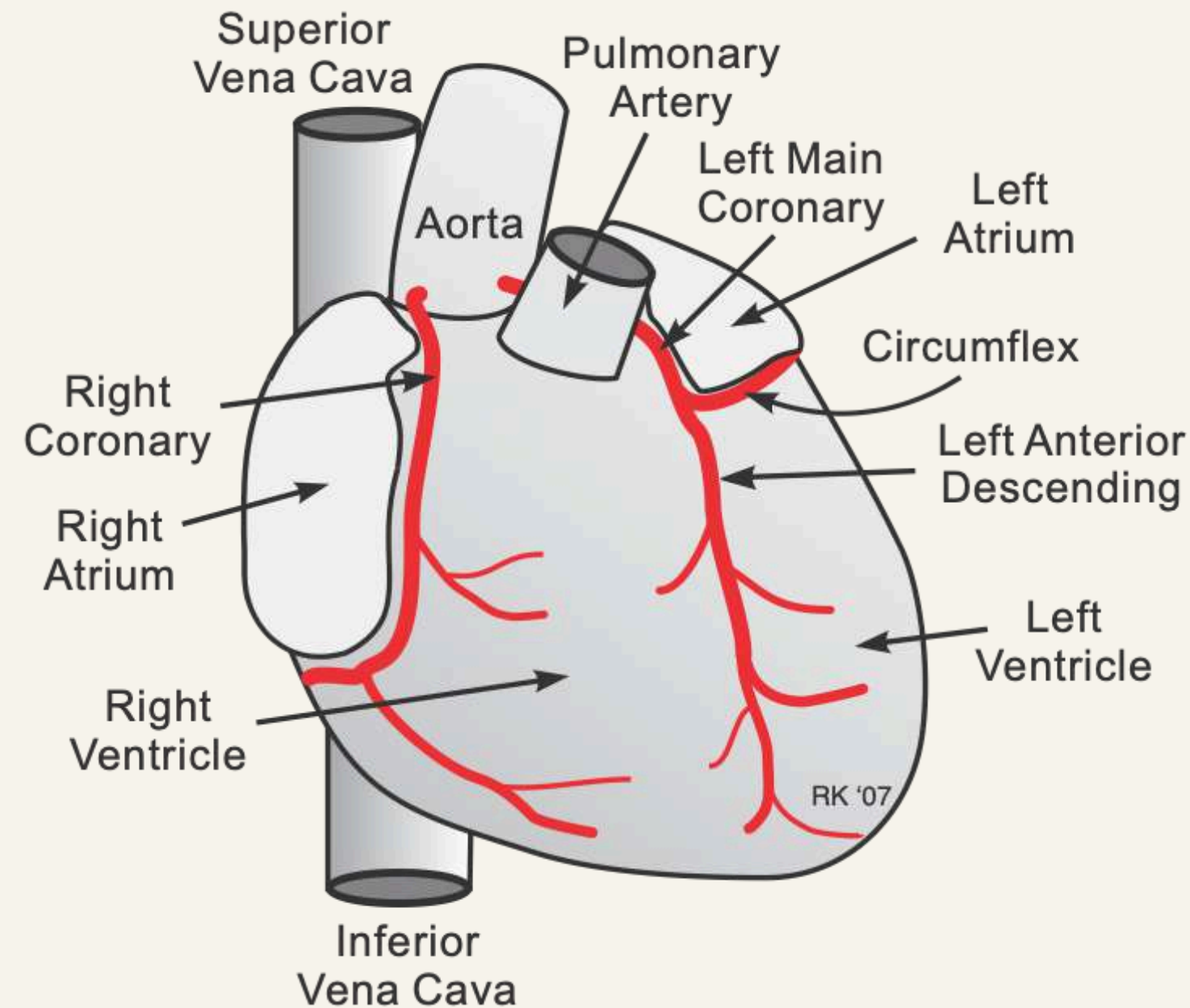


ECG LEADS AND THEIR HEART VIEWS

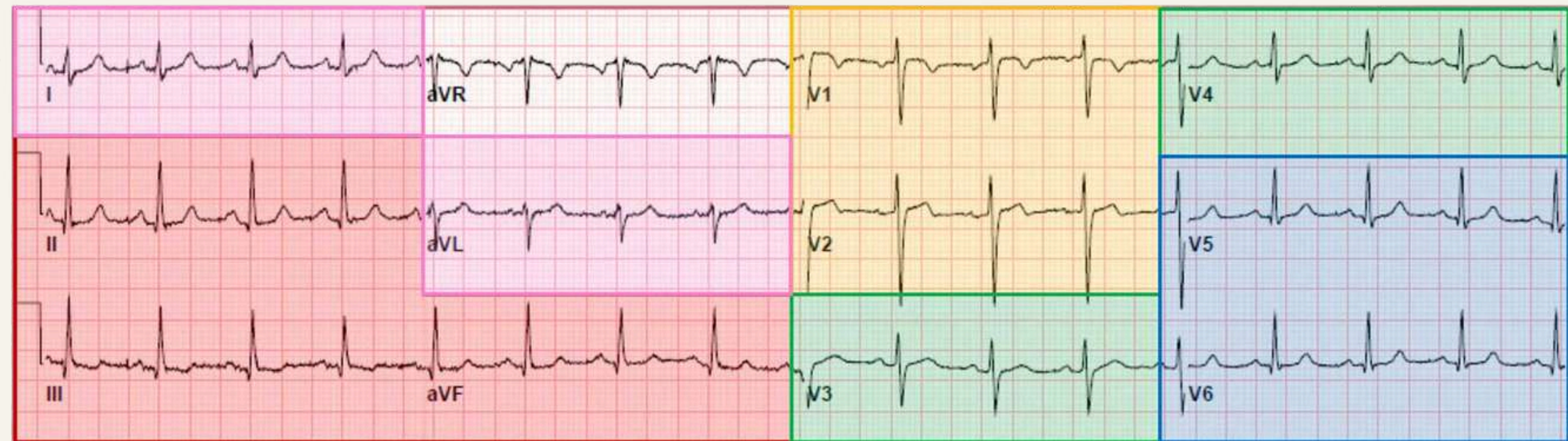
I Lateral	aVR	V1 Septal	V4 Anterior
II Inferior	aVL Lateral	V2 Septal	V5 Lateral
III Inferior	aVF Inferior	V3 Anterior	V6 Lateral

- Limb Leads (I, II, III, aVR, aVL, aVF)
Lateral, inferior, and right-side views of the heart.
- Precordial Leads (V1-V6)
Septal, anterior, and lateral views

DETAILED ECG FINDINGS BY LEAD GROUP



INFERIOR II, III, aVF RCA	ANTEROSEPTAL V1 – V2 LAD	ANTEROAPICAL V3 – V4 LAD	ANTEROLATERAL V5 – V6 Cx	LATERAL I, aVL Cx
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- **Inferior Leads (II, III, aVF):** Right coronary artery; associated with inferior wall MI.
- **Lateral Leads (I, aVL, V5, V6):** Circumflex artery; lateral wall MI.
- **Anterior Leads (V3, V4):** Left anterior descending artery; anterior wall MI.
- **Septal Leads (V1, V2):** Left anterior descending artery; septal MI

HOW TO READ ECG??

Heart rate

What is a normal adult heart rate?

- **Normal:** 60-100 bpm
- **Tachycardia:** > 100 bpm
- **Bradycardia:** < 60 bpm

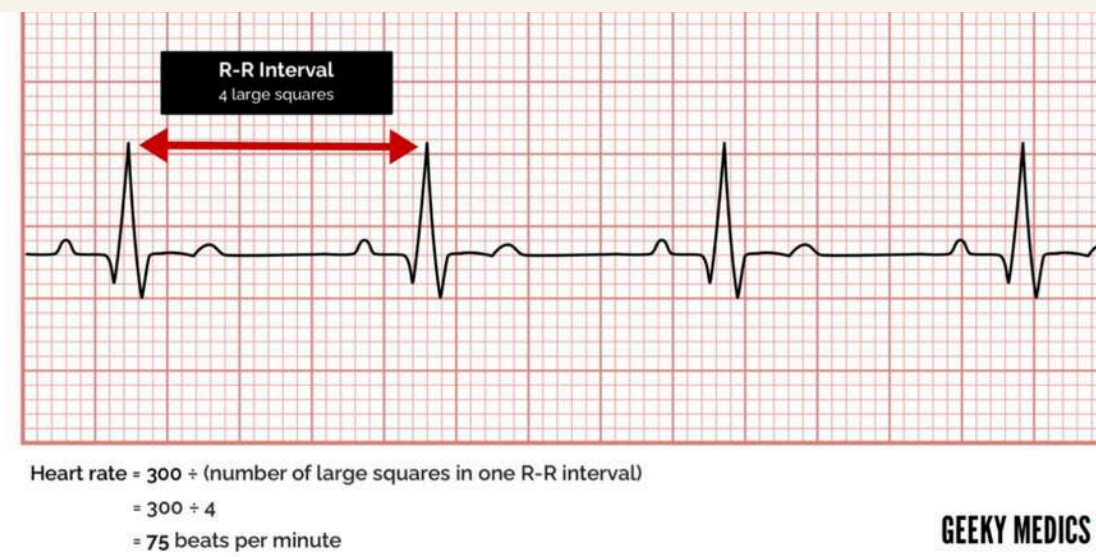
Regular heart rhythm

If a patient has a **regular heart rhythm**, their heart rate can be calculated using the following method:

- **Count** the number of **large squares** present within one **R-R interval**.
- **Divide 300** by **this number** to calculate **heart rate**.

Heart rate calculation example

- 4 large squares in an R-R interval
- $300/4 = 75$ beats per minute



Irregular heart rhythm

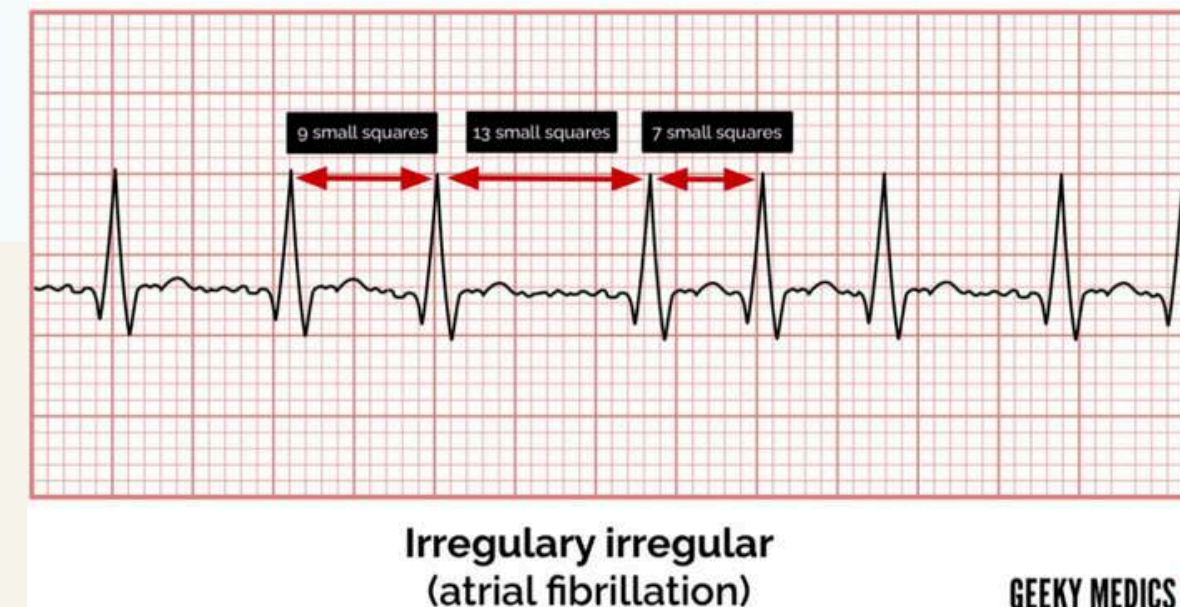
If a patient's heart rhythm is **irregular**, the first heart rate calculation method doesn't work (as the R-R interval differs significantly throughout the ECG). As a result, you need to apply a different method:

- Count the number of complexes on the rhythm strip (each rhythm strip is typically 10 seconds long).
- Multiply the number of complexes by 6 (giving you the average number of complexes in 1 minute).

Heart rate calculation example

- 10 complexes on a rhythm strip
- $10 \times 6 = 60$ beats per minute

Heart Rhythm



HOW TO READ ECG??

Cardiac axis

Cardiac axis describes the overall **direction of electrical spread** within the heart.

In a healthy individual, the axis should spread from **11 o'clock to 5 o'clock**.

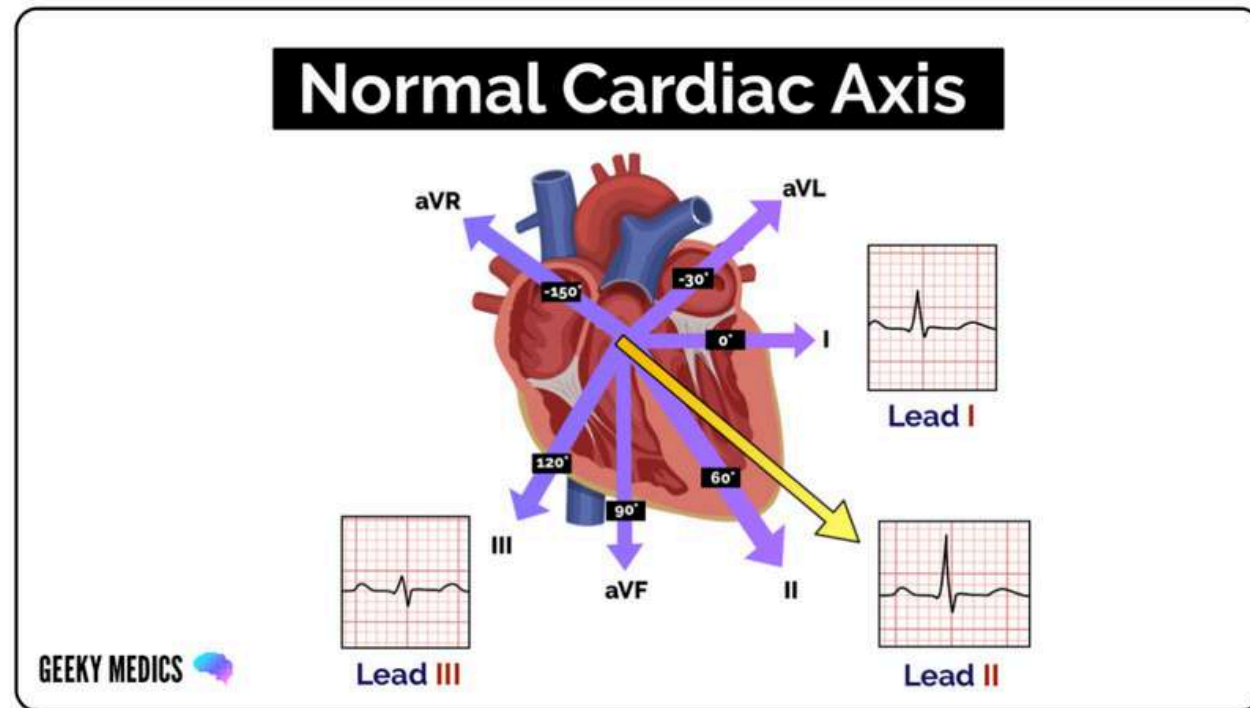
To determine the cardiac axis, you must look at **leads I, II and III**.

Read our [cardiac axis guide](#) to learn more.

Normal cardiac axis

Typical ECG findings for **normal cardiac axis**:

- **Lead II** has the **most positive deflection** compared to leads I and III.

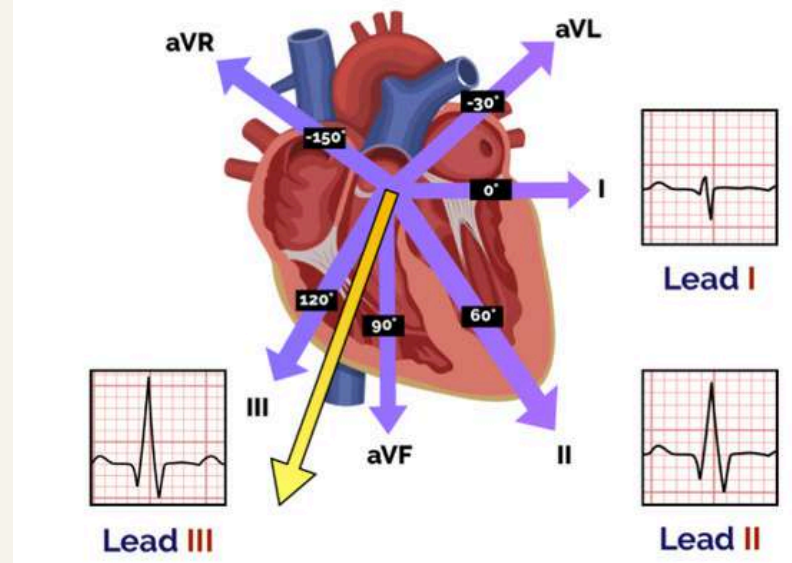


Right axis deviation

Typical ECG findings for **right axis deviation**:

- **Lead III** has the **most positive deflection**, and **lead I** should be **negative**.
- Right axis deviation is associated with right ventricular hypertrophy.

Right Axis Deviation

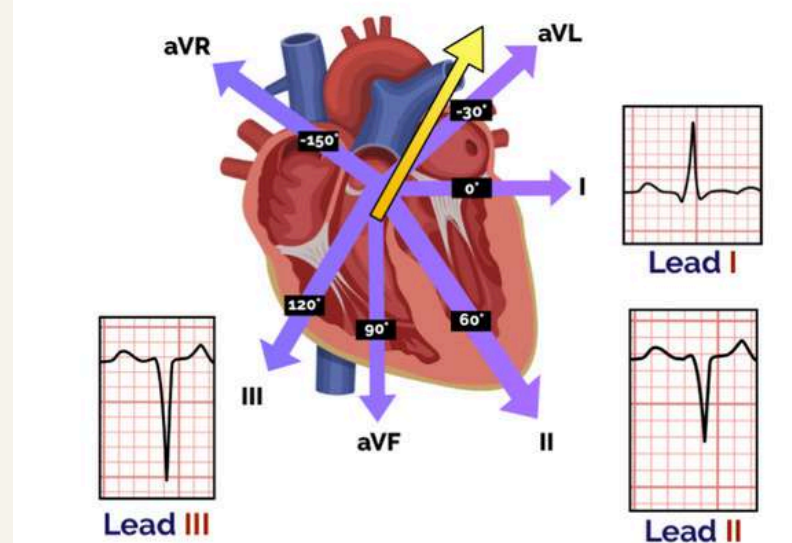


Left axis deviation

Typical ECG findings for **left axis deviation**:

- **Lead I** has the **most positive deflection**.
- **Leads II and III** are **negative**.
- Left axis deviation is associated with heart conduction abnormalities.

Left Axis Deviation



HOW TO READ ECG??

P waves

The next step is to **look at the P waves** and answer the following questions:

1. Are P waves present?
2. If so, is each P wave followed by a QRS complex?
3. Do the P waves look normal? – check duration, direction and shape
4. If P waves are absent, is there any atrial activity?
 - Sawtooth baseline → flutter waves
 - Chaotic baseline → fibrillation waves
 - Flat line → no atrial activity at all

Hint

If P waves are **absent** and there is an **irregular rhythm**, it may suggest a diagnosis of **atrial fibrillation**.

HOW TO READ ECG??

PR interval

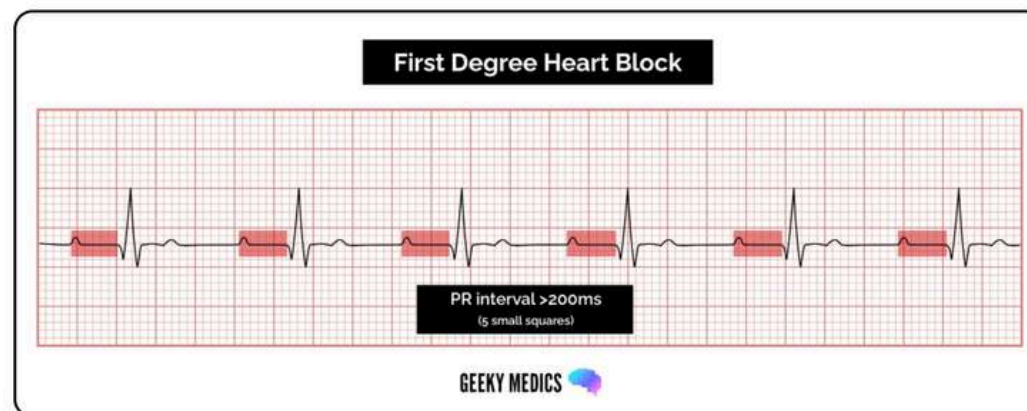
The **PR interval** should be between **120-200 ms** (3-5 small squares).

Prolonged PR interval (>0.2 seconds)

A prolonged PR interval suggests the presence of **atrioventricular delay (AV block)**.

First-degree heart block (AV block)

First-degree heart block involves a **fixed prolonged** PR interval (>200 ms).

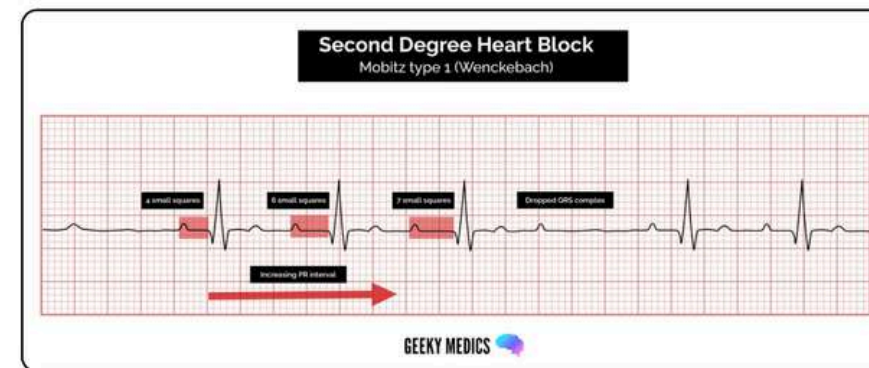


Second-degree heart block (type 1)

Second-degree AV block (type 1) is also known as **Mobitz type 1 AV block** or **Wenckebach phenomenon**.

Typical ECG findings in Mobitz type 1 AV block include **progressive prolongation of the PR interval** until eventually the atrial impulse is not conducted and the **QRS complex is dropped**.

AV nodal conduction **resumes** with the next beat, and the sequence of progressive PR interval prolongation and the eventual dropping of a QRS complex **repeats** itself.



Second-degree AV block (Mobitz Type 1 - Wenckebach)

Third-degree heart block (complete heart block)

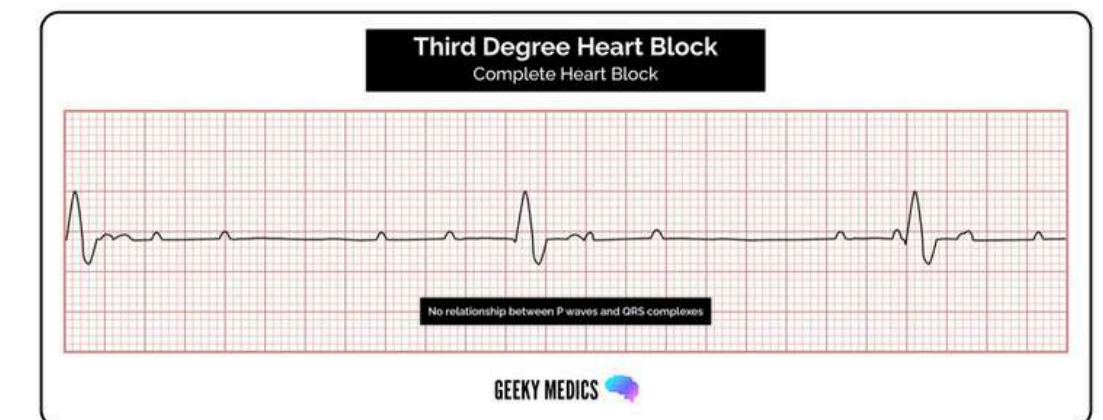
Third-degree (complete) AV block occurs when there is **no electrical communication between the atria and ventricles** due to a complete failure of conduction.

Typical ECG findings include the **presence of P waves** and **QRS complexes** that have **no association with each other**, due to the atria and ventricles functioning independently.

Cardiac function is maintained by a **junctional** or **ventricular pacemaker**.

Narrow-complex escape rhythms (QRS complexes of <0.12 seconds duration) originate **above the bifurcation of the bundle of His**.

Broad-complex escape rhythms (QRS complexes >0.12 seconds duration) originate from **below the bifurcation of the bundle of His**.



Complete heart block (3rd degree)

HOW TO READ ECG??

Tips for remembering types of heart block

To help remember the various types of AV block, it is useful to know the anatomical location of the block within the conducting system.

First-degree AV block:

- Occurs between the SA node and the AV node (i.e. within the atrium).

Second-degree AV block:

- Mobitz I AV block (Wenckebach) occurs IN the AV node (this is the only piece of conductive tissue in the heart which exhibits the ability to conduct at different speeds).
- Mobitz II AV block occurs AFTER the AV node in the bundle of His or Purkinje fibres.

Third-degree AV block:

- Occurs at or after the AV node resulting in a complete blockade of distal conduction.

Shortened PR interval

If the **PR interval** is **shortened**, this can mean one of two things:

- Simply, the P wave originates from somewhere closer to the AV node, so the conduction takes less time (the SA node is not in a fixed place, and some people's atria are smaller than others).
- The atrial impulse is getting to the ventricle by a **faster shortcut** instead of conducting slowly across the atrial wall. This **accessory pathway** can be associated with a **delta wave** (see below).

Delta Wave

Associated with Wolff-Parkinson-White Syndrome



HOW TO READ ECG??

Bundle branch block

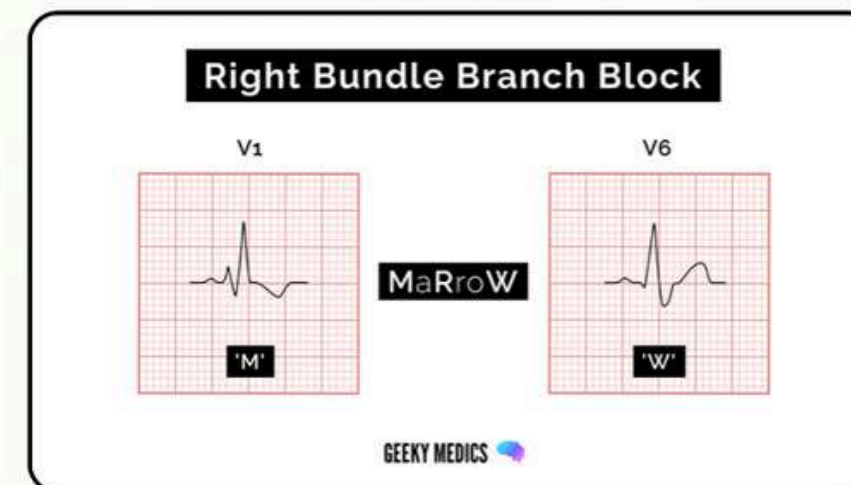
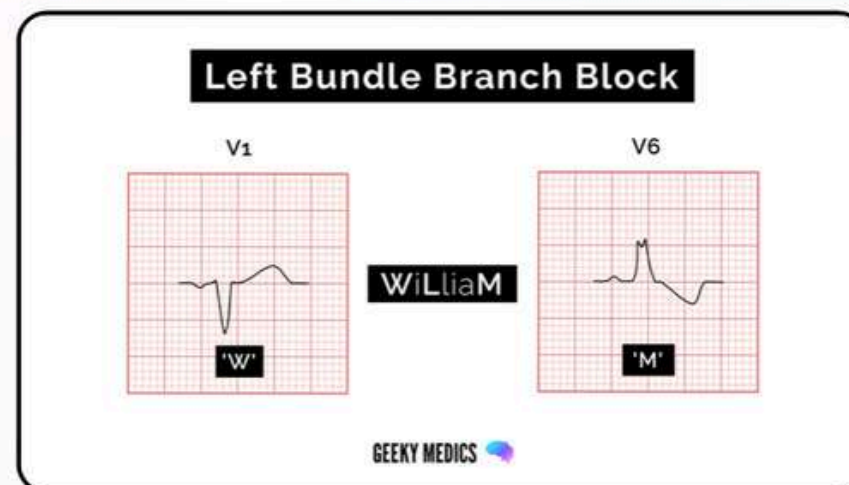
Broad QRS complexes are a hallmark feature of **bundle branch block**, which includes **left bundle branch block** (LBBB) and **right bundle branch block** (RBBB).

The **WiLLiaM MaRRoW** mnemonic can be used to quickly recognise left and right bundle branch blocks by looking at **V1** and **V6**.

The **middle letters** of the names help you remember which bundle branch block each name is referring to (two Ls in Wi**LL**iaM = left bundle branch block, two Rs in Ma**RR**oW = right bundle branch block).

Each name's **first** and **last letter** helps you recognise the ECG features of the associated bundle branch block.

- **LBBB**: deep S wave in V1 which may be notched ("W") and broad "M" shaped R wave in V6
- **RBBB**: RSR' pattern in V1 ("M") and broad S wave in V6 ("W")



HOW TO READ ECG??

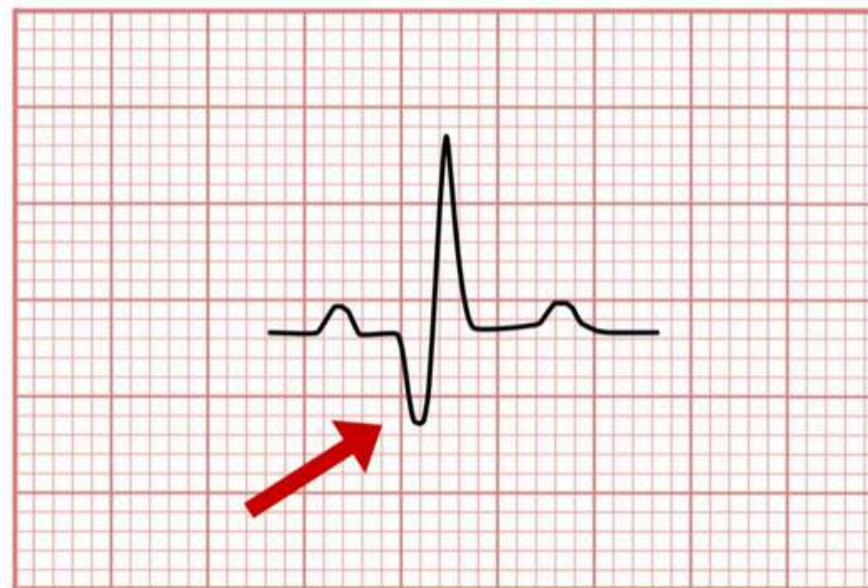
Q-waves

Isolated Q waves can be **normal**.

A **pathological Q wave** is **> 25% the size of the R wave that follows it** or **> 2mm in height and > 40ms in width**.

A single Q wave is not a cause for concern – look for Q waves in an entire territory (e.g. anterior/inferior) for evidence of previous myocardial infarction.

Pathological Q Wave



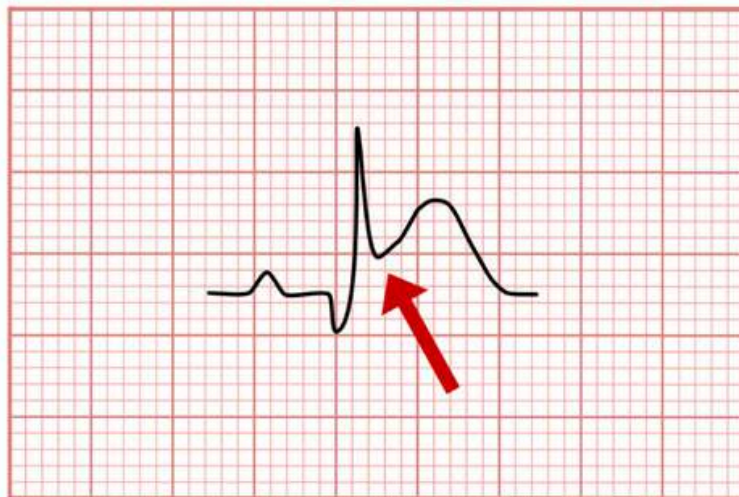
HOW TO READ ECG??

ST-elevation

ST-elevation is significant when it is **greater than 1 mm** (1 small square) in **2 or more contiguous limb leads** or **>2mm** in **2 or more chest leads**.

It is most commonly caused by **acute full-thickness myocardial infarction**.

ST Elevation



ST depression

ST depression ≥ 0.5 mm in **≥ 2 contiguous leads** indicates **myocardial ischaemia**.

ST Depression



GEEKY MEDICS 

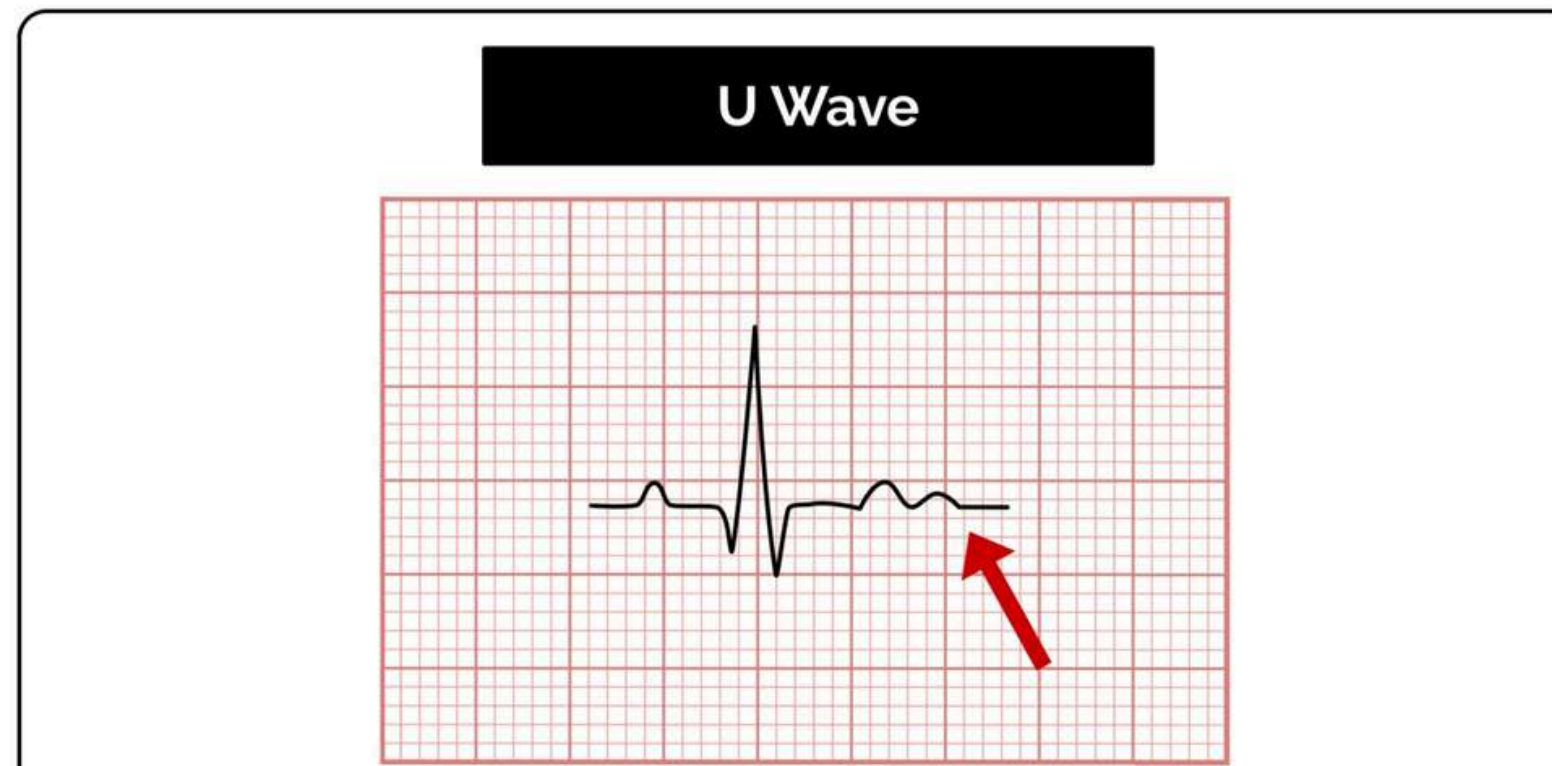
HOW TO READ ECG??

U waves

U waves are **not** a **common** finding.

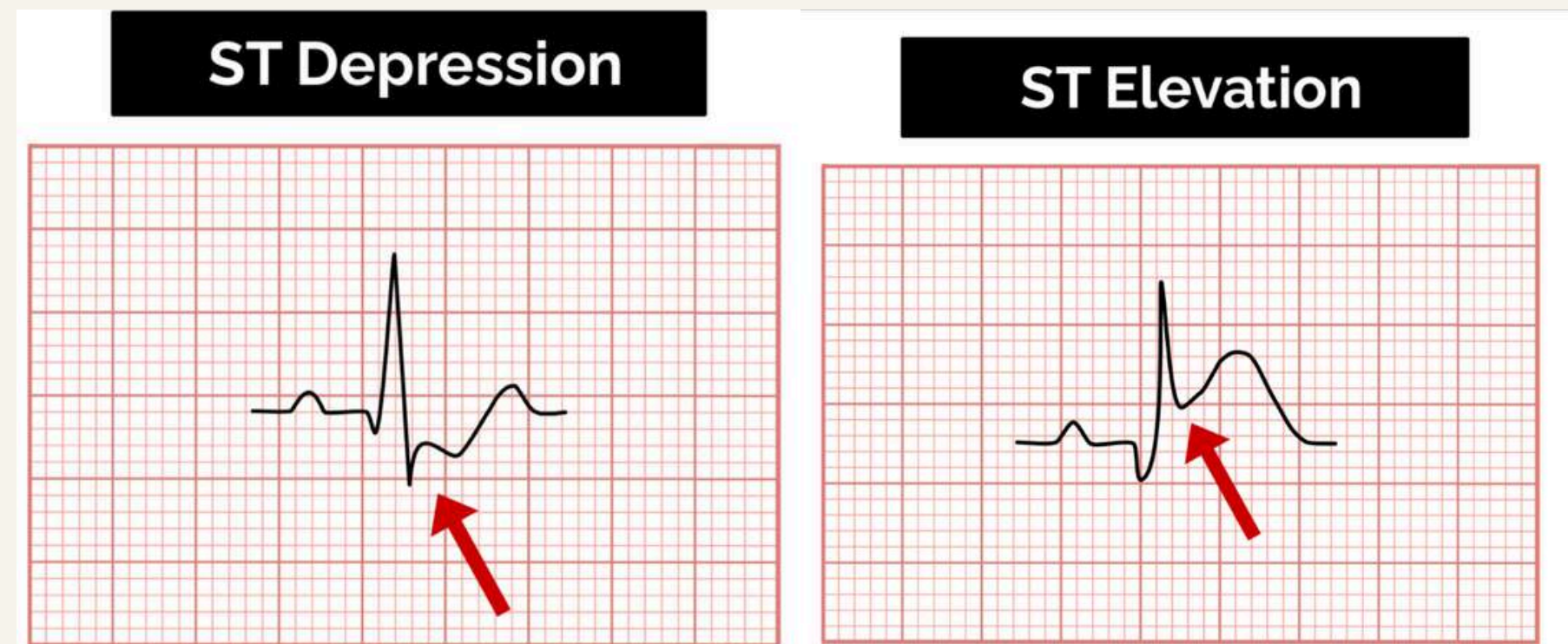
The U wave is a **> 0.5mm deflection after the T wave** best seen in **V2** or **V3**.

These become larger the slower the bradycardia – classically U waves are seen in various **electrolyte imbalances**, **hypothermia** and secondary to **antiarrhythmic therapy** (such as digoxin, procainamide or amiodarone).



ECG PATTERNS IN ACS

- **STEMI:** ST Elevation in specific leads. Q Waves: Develop over time, indicating full-thickness infarction.
- **NSTEMI:** ST Depression or T Wave Inversion; no ST elevation.
- **Stable and Unstable Angina:** May show normal ECG at rest; stress may reveal ST depression



Phase 0



Peaking-T: T positive, high, wide

Phase 1



Q small, R small, monophasic ST-elevation,
T positive

Phase 2



Q large, R small, ST-elevation regressing,
T peaked, negative

Phase 3



Q large, R higher as in Phase 2,
ST-elevation vanished

Phase 4



Q still large, R normal dimension again,
no ST-elevation, no ST-decline, T positive again

ASSESSMENT OF ACUTE CORONARY SYNDROME

