ECG – BASICS
HOW TO INTERPRET NORMAL ECG

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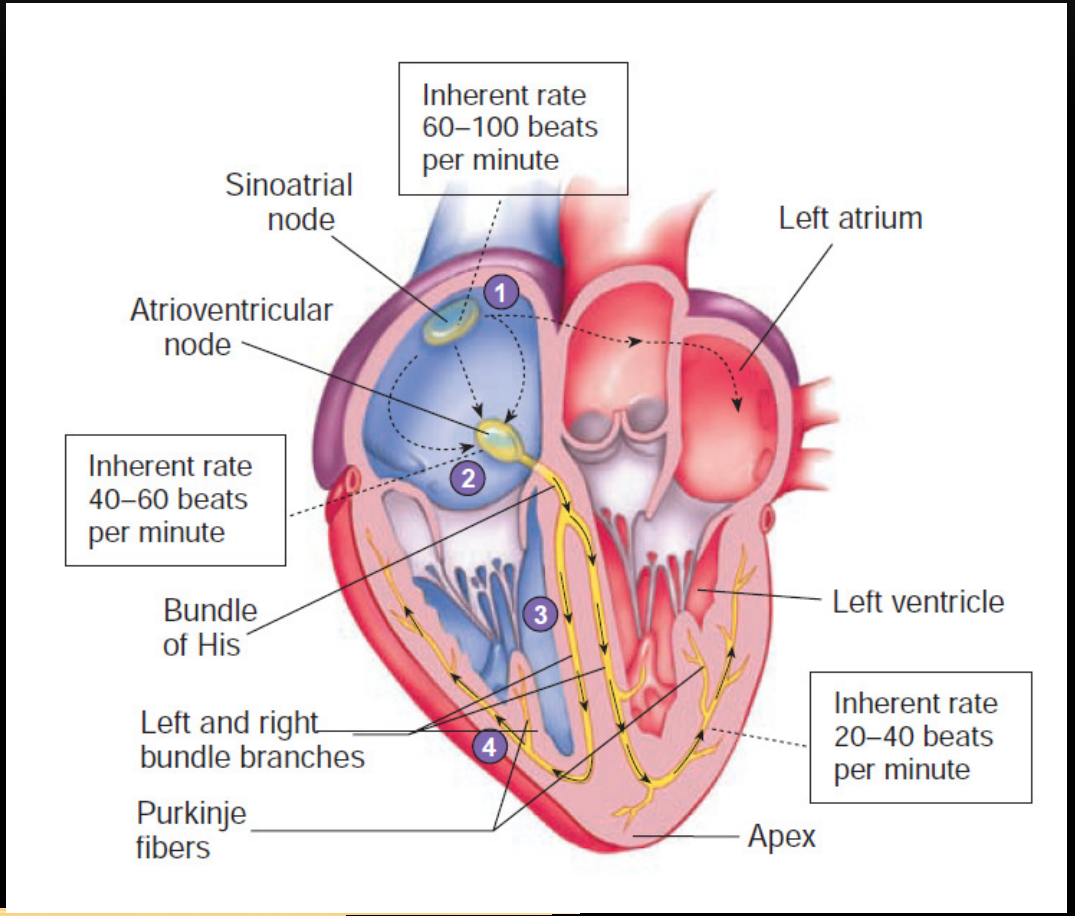
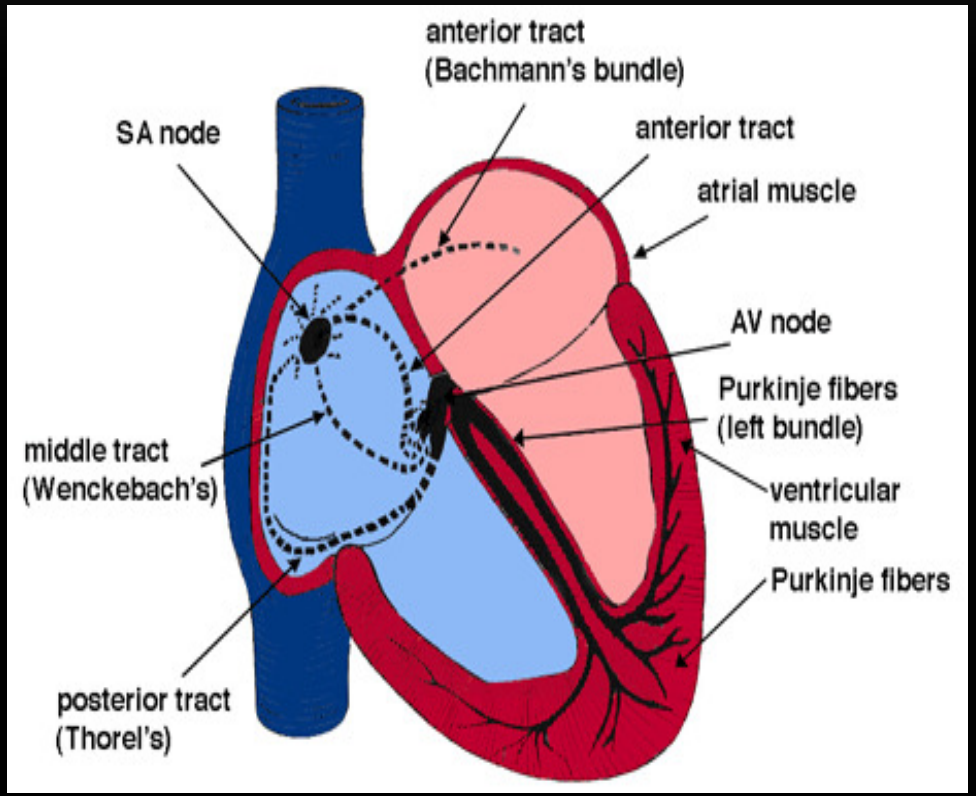
CONDUCTION SYSTEM

- **Sinoatrial Node (SA)**
  - **Primary pacemaker**
  - **Intrinsic rate 60-100/min**
  - **Located in Rt. Atrium**
  - **Supplied by sympathetic and para-sympathetic nerve fibers**
  - **Blood from RCA-60% of people**



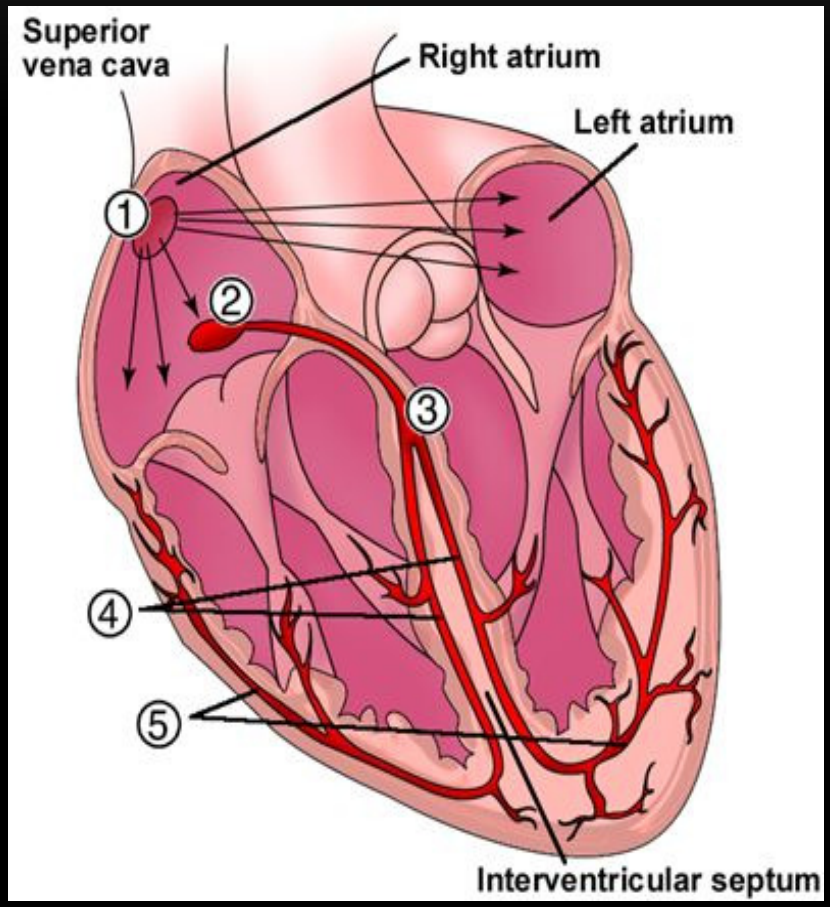
CONDUCTION SYSTEM

- Atrioventricular Junction
  - Internodal pathways merge
  - AV Node
  - Non-branching portion of the Bundle of His



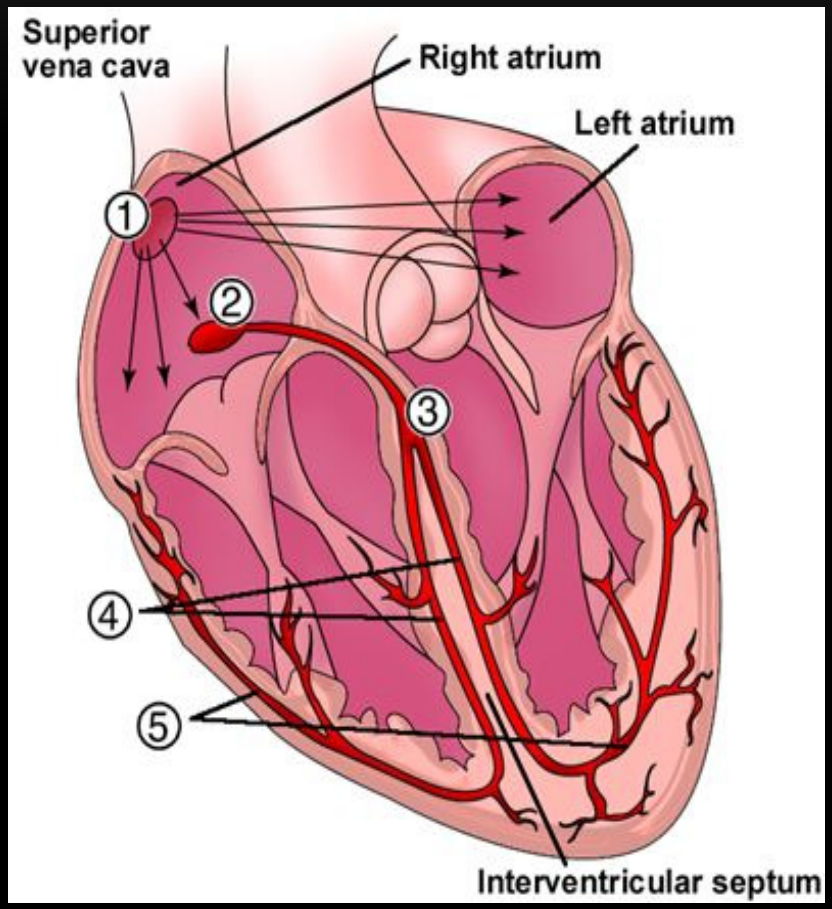
CONDUCTION SYSTEM

- AV Node
  - Supplied by RCA – 85%-90% of people
    - Left circumflex artery in rest of people
  - Delay in conduction due to smaller fibers



CONDUCTION SYSTEM

- Bundle of His
  - Located in upper portion of interventricular septum
  - Intrinsic rate 40-60/min
  - Blood from LAD and Posterior Descending
    - Less vulnerable to ischemia

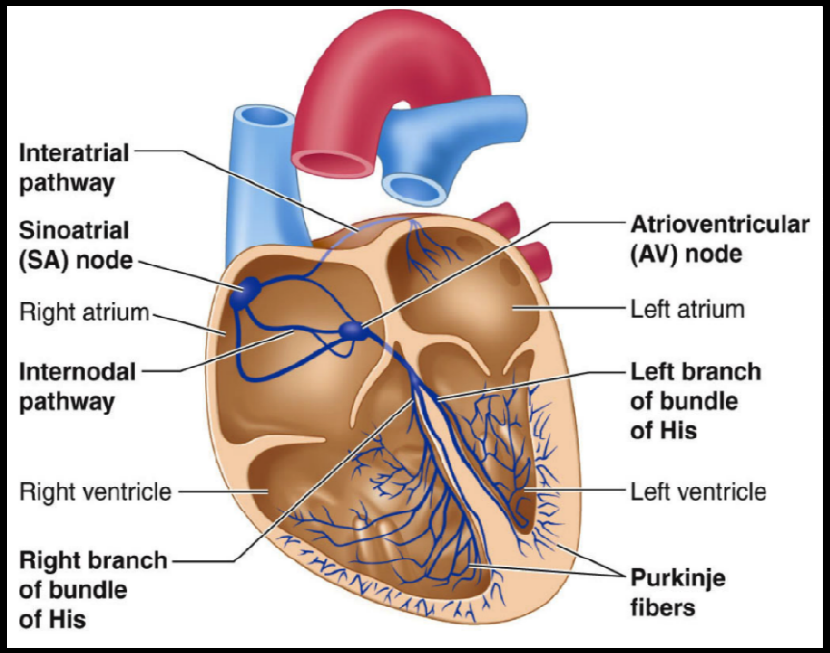


CONDUCTION SYSTEM

- Right & Left Bundle Branches

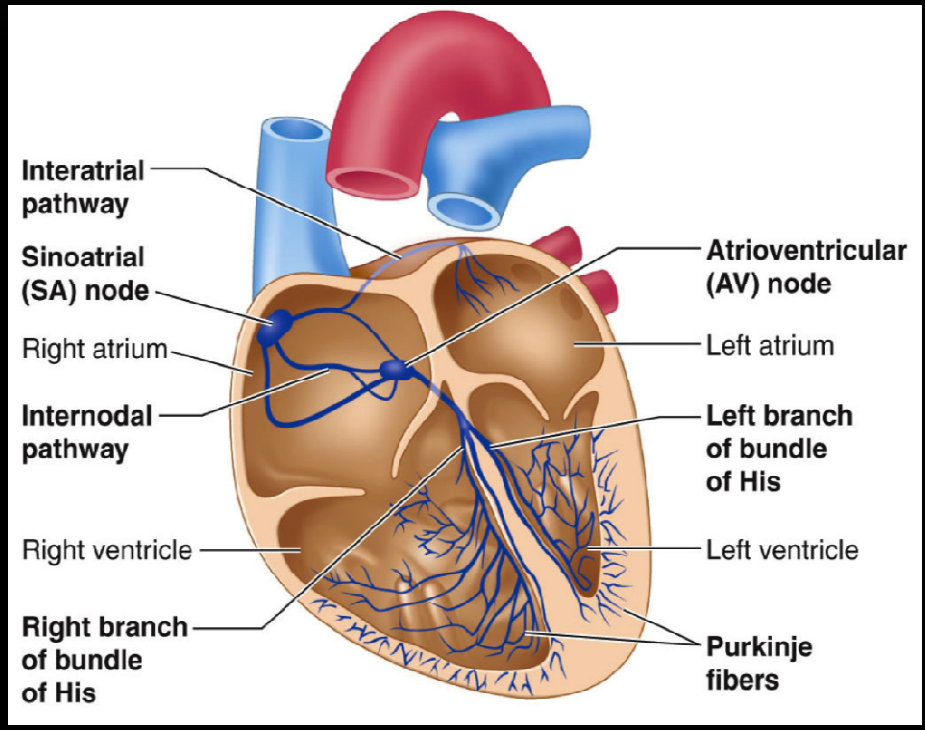
- LBB – Left Bundle Branch
  - Anterior Fascicle
    - Anterior portion left ventricle
  - Posterior Fascicle
    - Posterior portions of left ventricle

- RBB – Right Bundle Branch
    - Right Ventricle



CONDUCTION SYSTEM

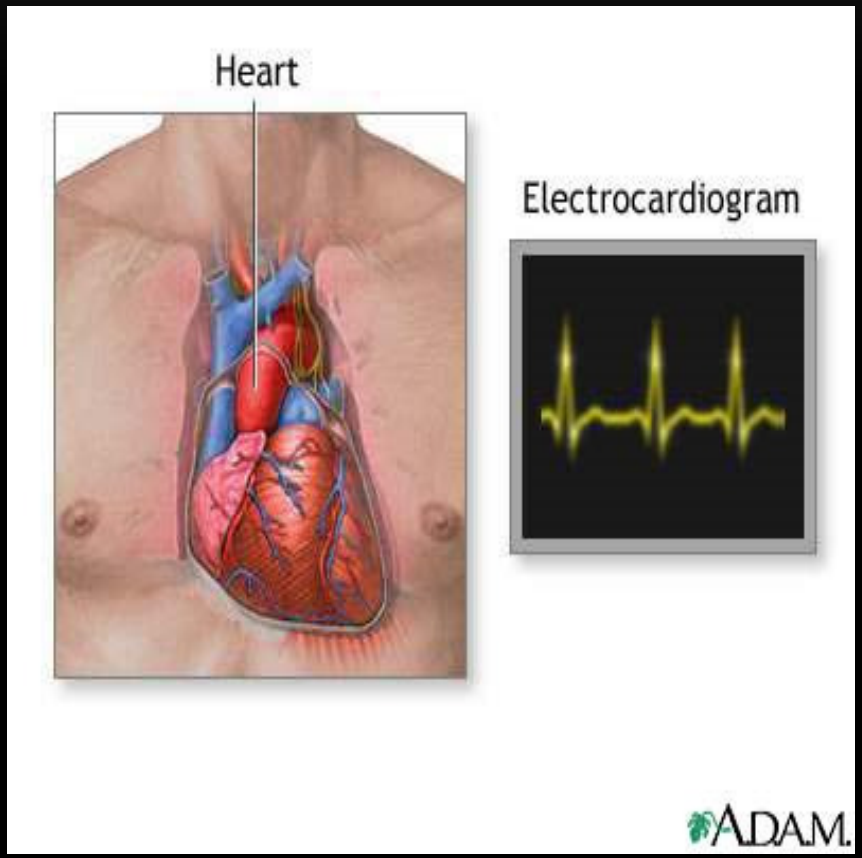
- **Purkinje Fibers**
  - **Intrinsic pacemaker rate 20-40/min**
  - **Impulse spreads from endocardium to epicardium**



THE ECG

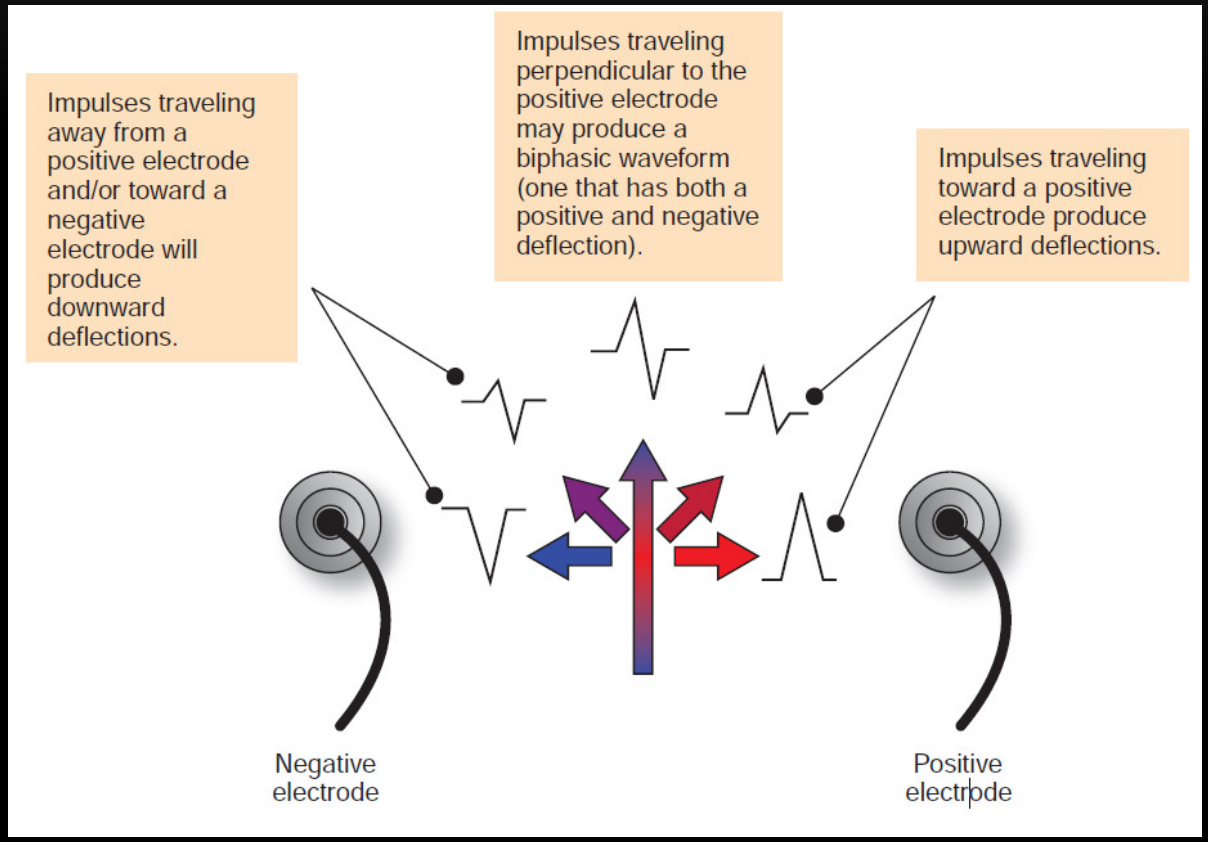
ECG

- Records electrical voltage of heart cells
  - Orientation of heart
  - Conduction disturbances
  - Electrical effects of medications and electrolytes
  - Cardiac muscle mass
  - Ischemia / Infarction

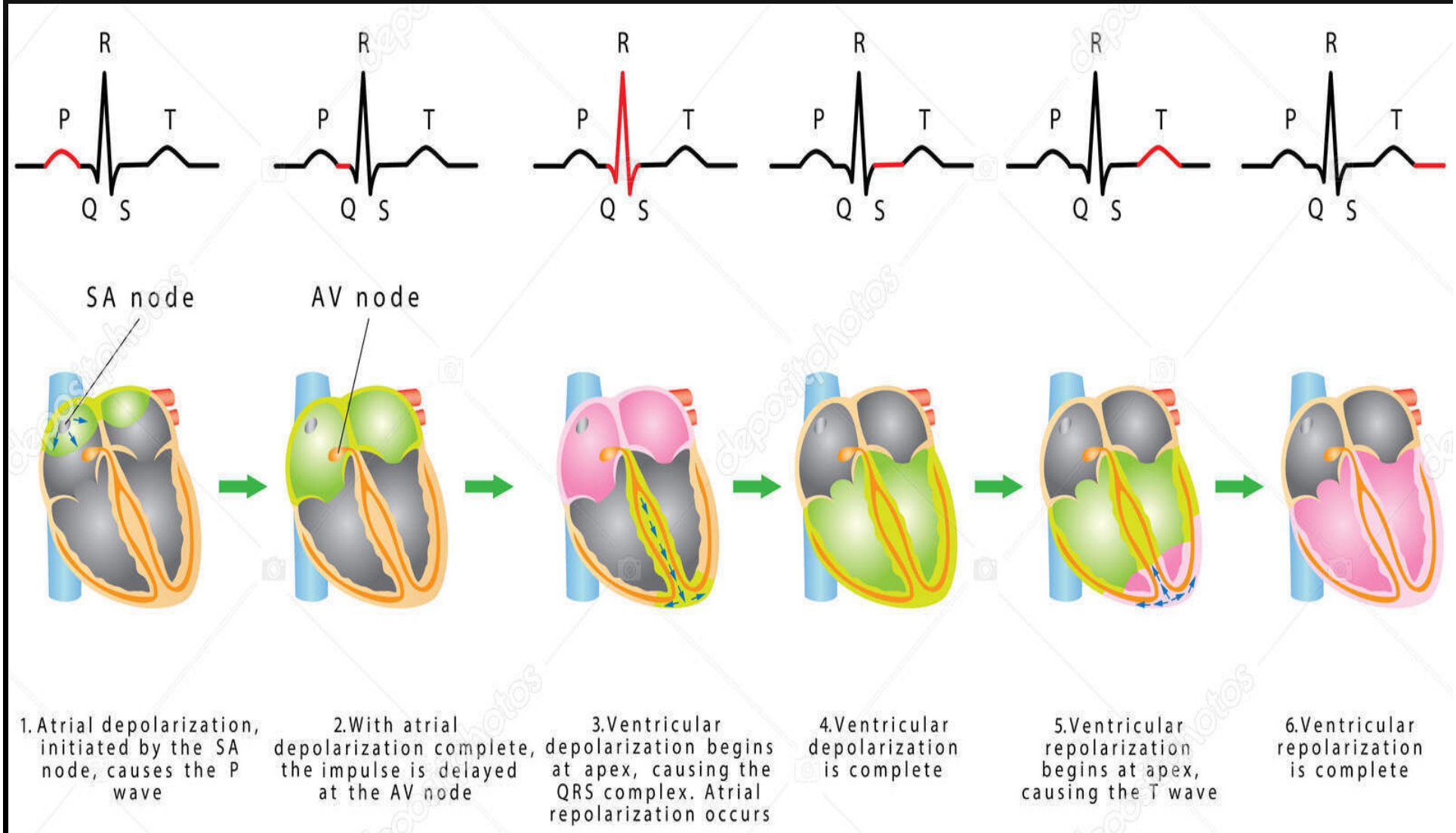


ECG

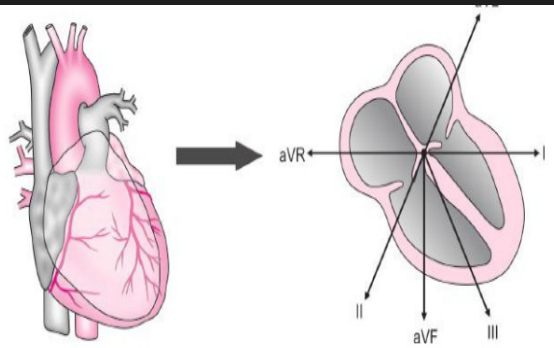
- Leads
  - Tracing of electrical activity between 2 electrodes
  - Records the ***Average*** current flow at any specific time in any specific portion of time

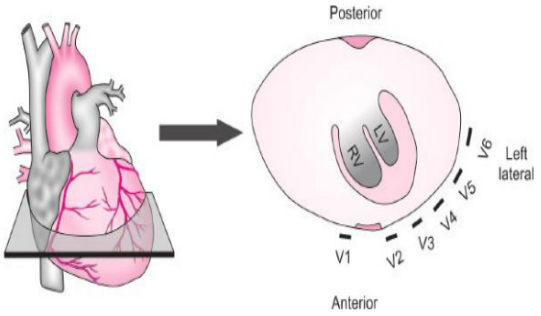


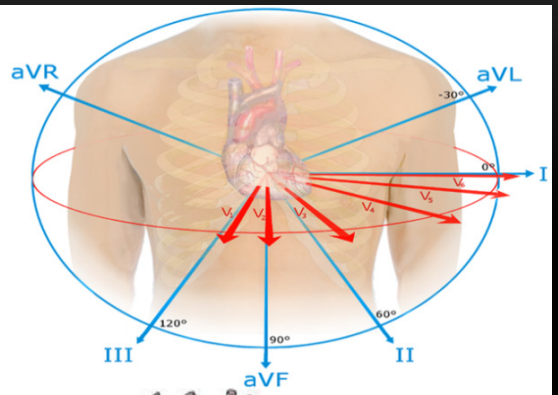
CARDIAC CYCLE - ECG

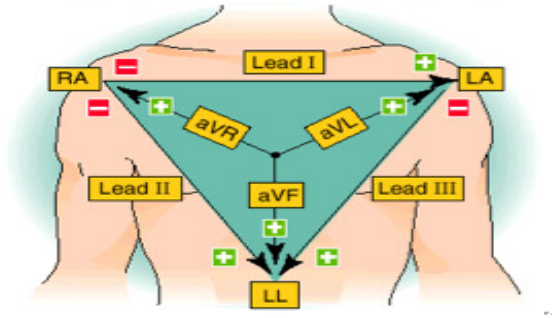


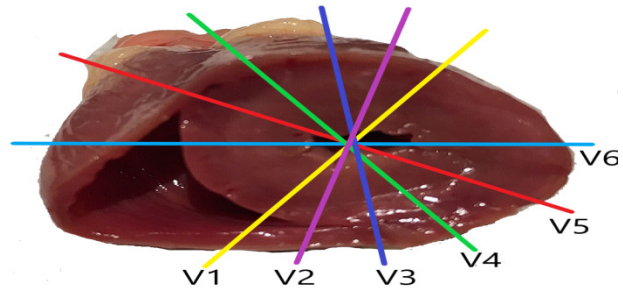
12 LEADS – 12 CAMERAS



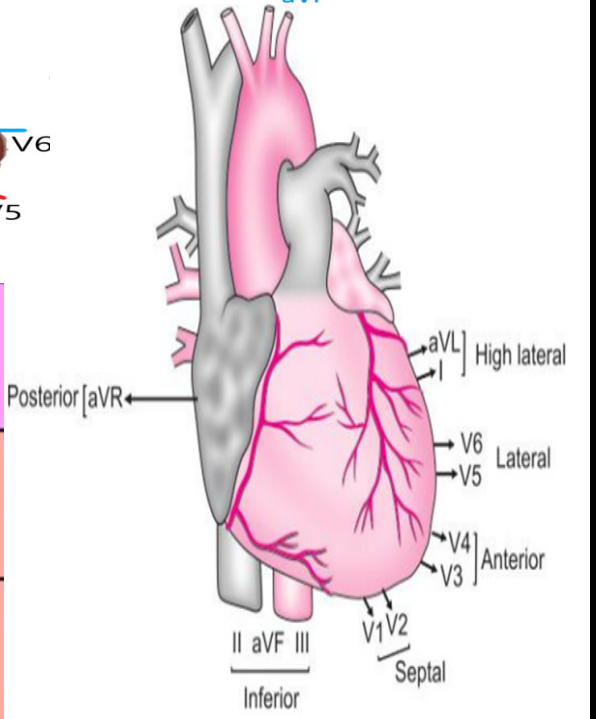




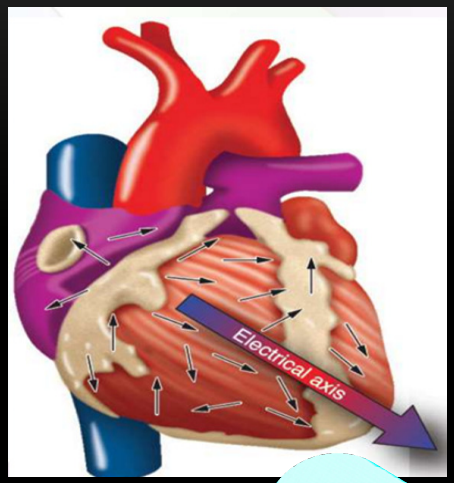


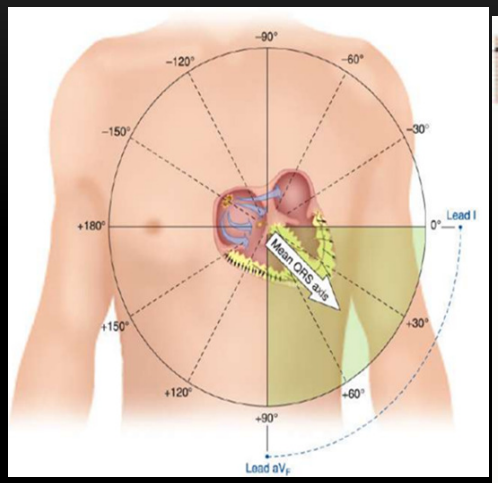


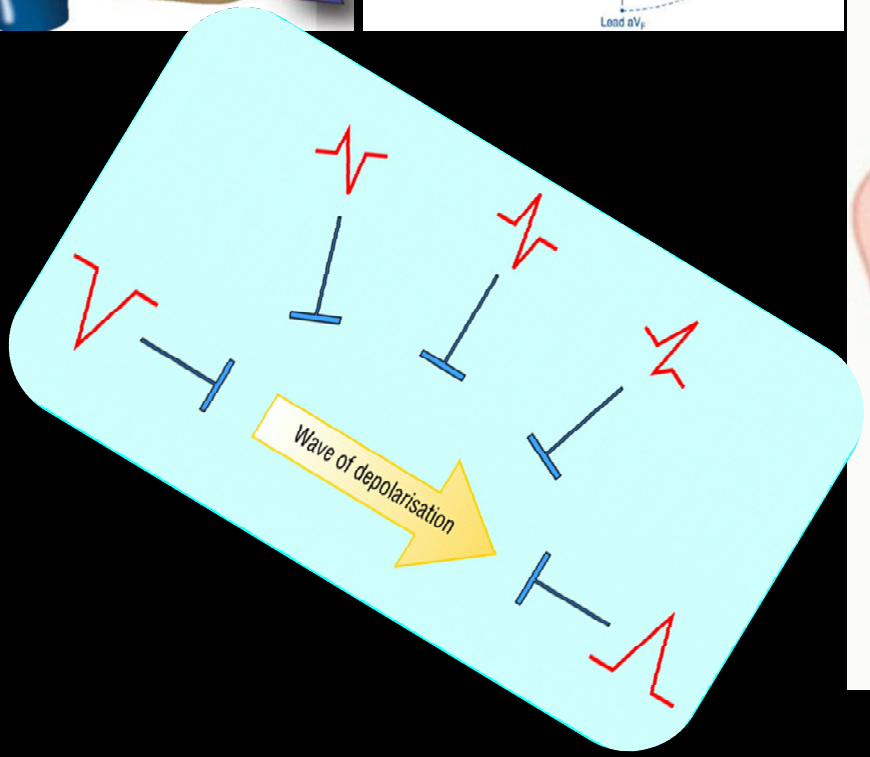
I Lateral	aVR None	V_1 Septal	V_4 Anterior
II Inferior	aVL Lateral	V_2 Septal	V_5 Lateral
III Inferior	aVF Inferior	V_3 Anterior	V_6 Lateral

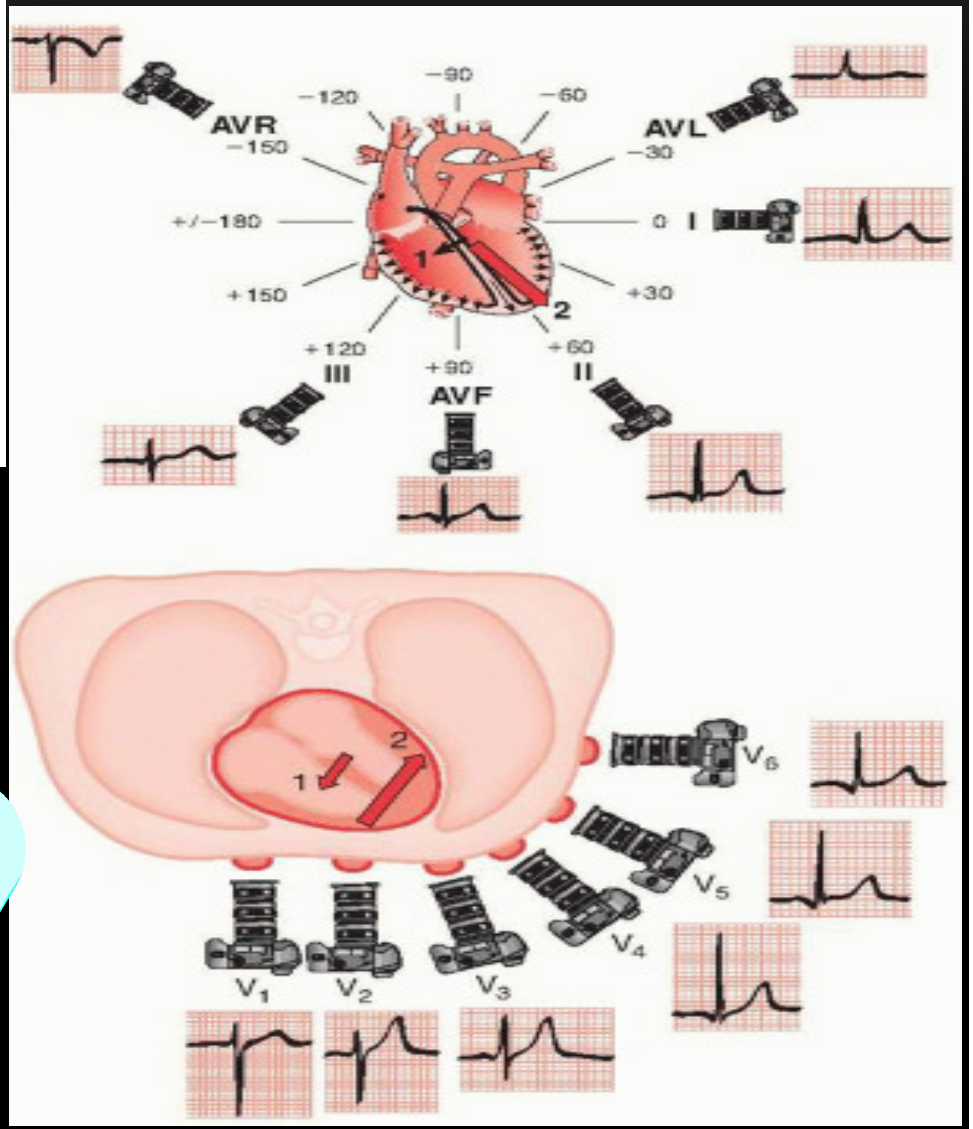


12 CAMERAS – IN ACTION



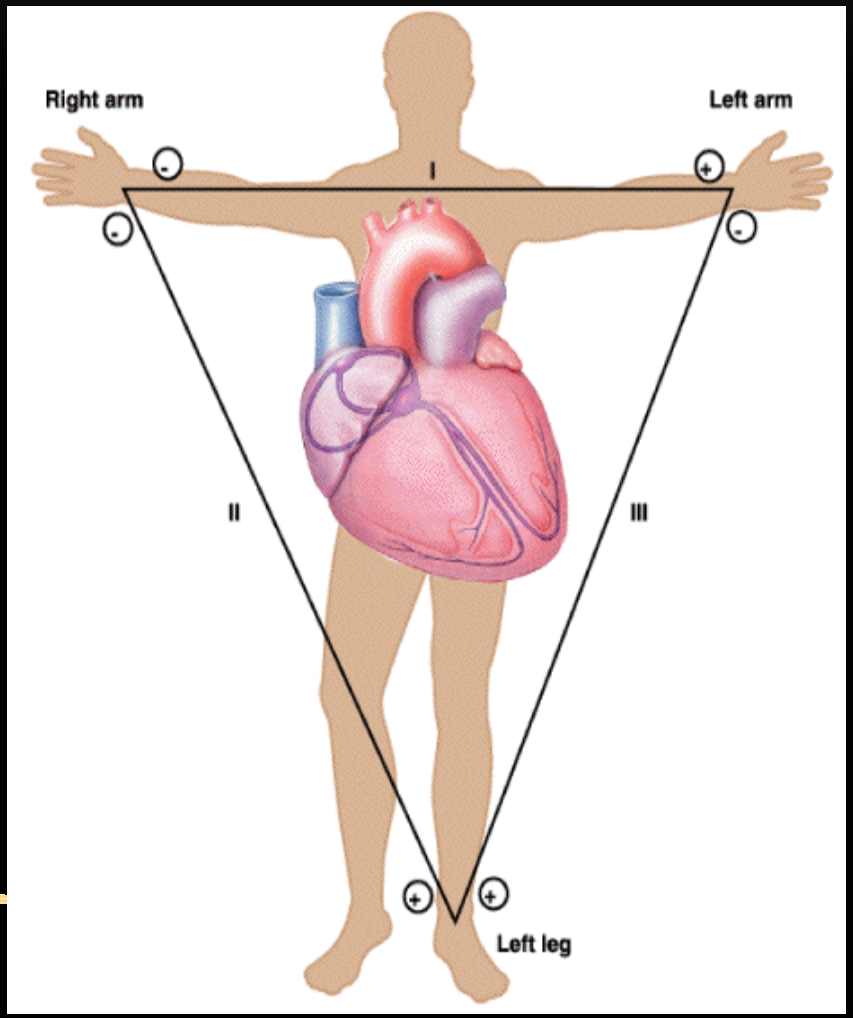






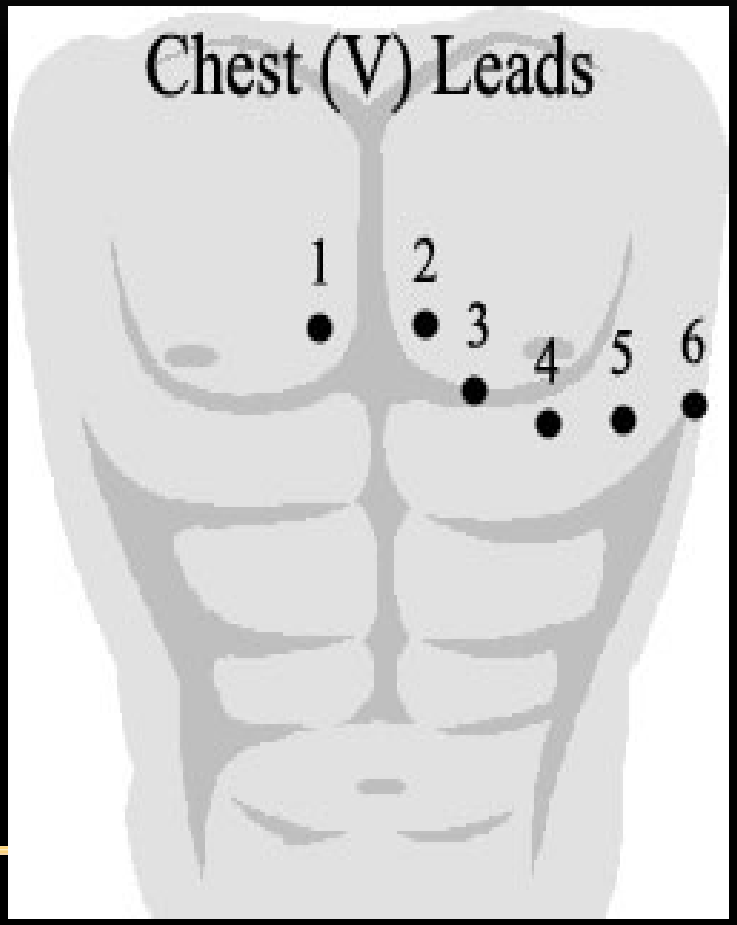
ECG

- **Types of leads**
  - Limb Lead (I, II, III)
  - Augmented (magnified) Limb Leads (aVR, aVL, aVF)
  - Chest (Precordial) Leads (V1,V2,V3,V4,V5,V6)
  - Each lead has Positive electrode



ECG

- Each lead ‘sees’ heart as determined by 2 factors
  - 1. Dominance of left ventricle
  - 2. Position of Positive electrode on body

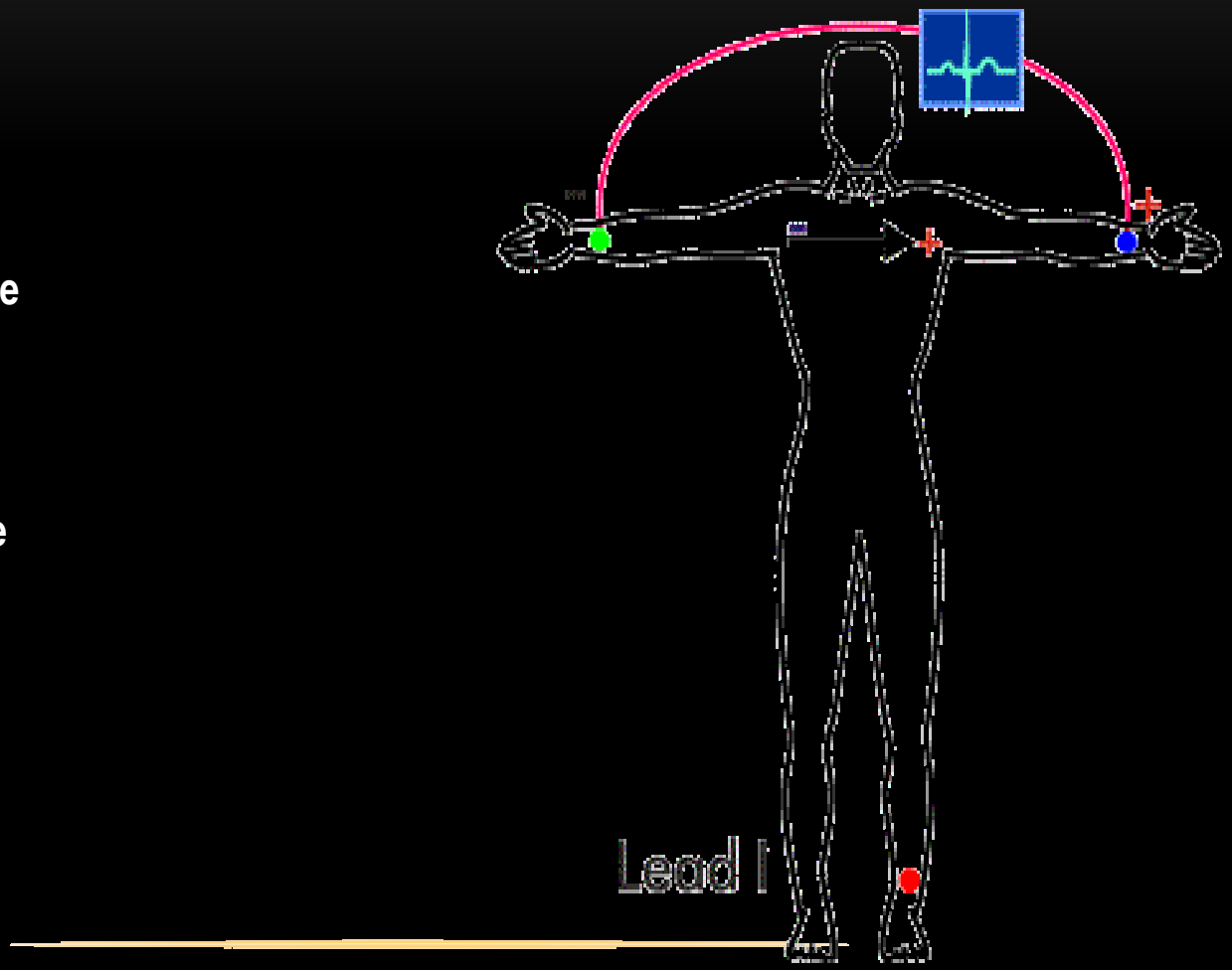


ECG

- **Lead I**

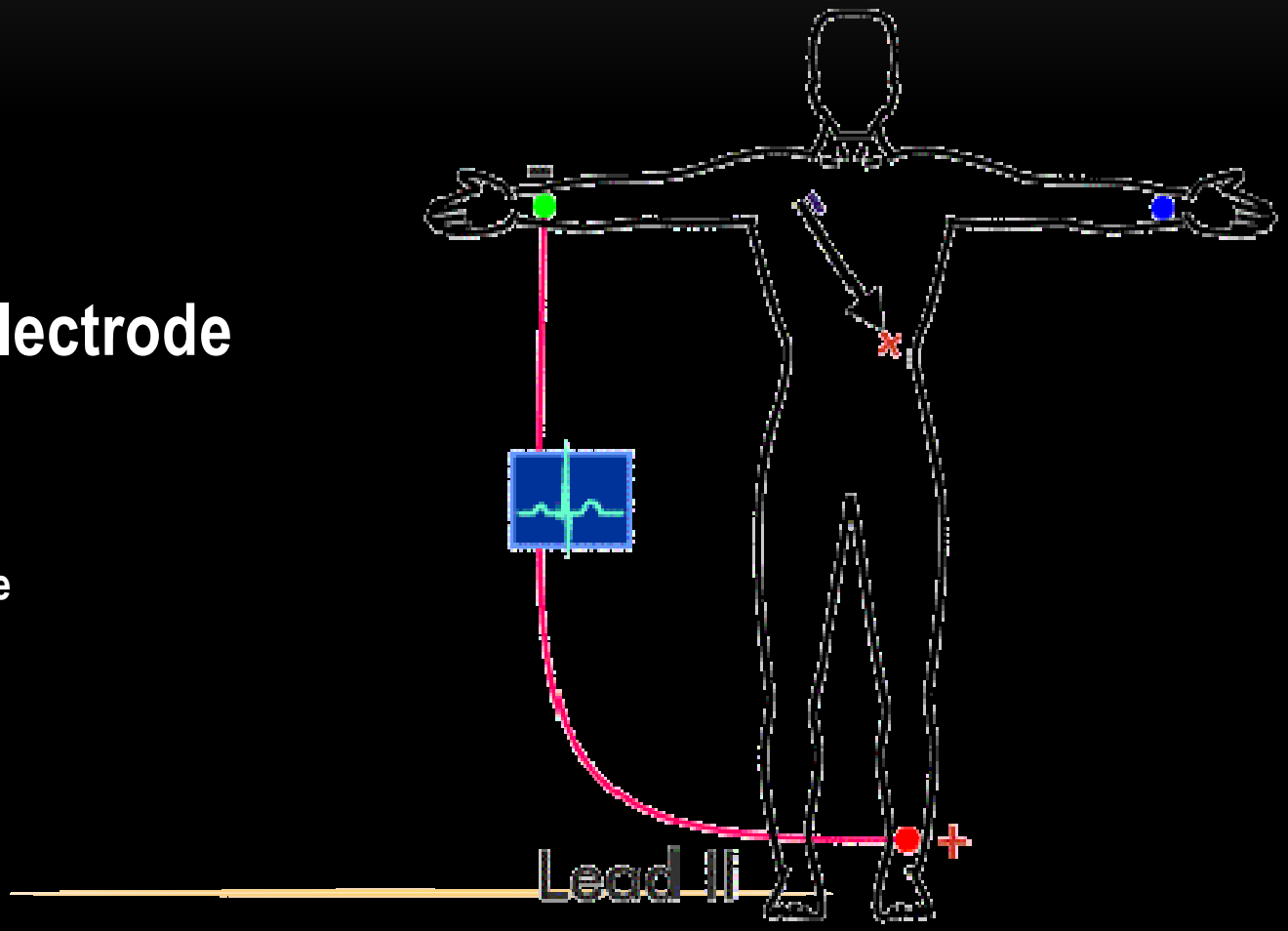
- Negative electrode
  - Right arm

- Positive electrode
  - Left arm



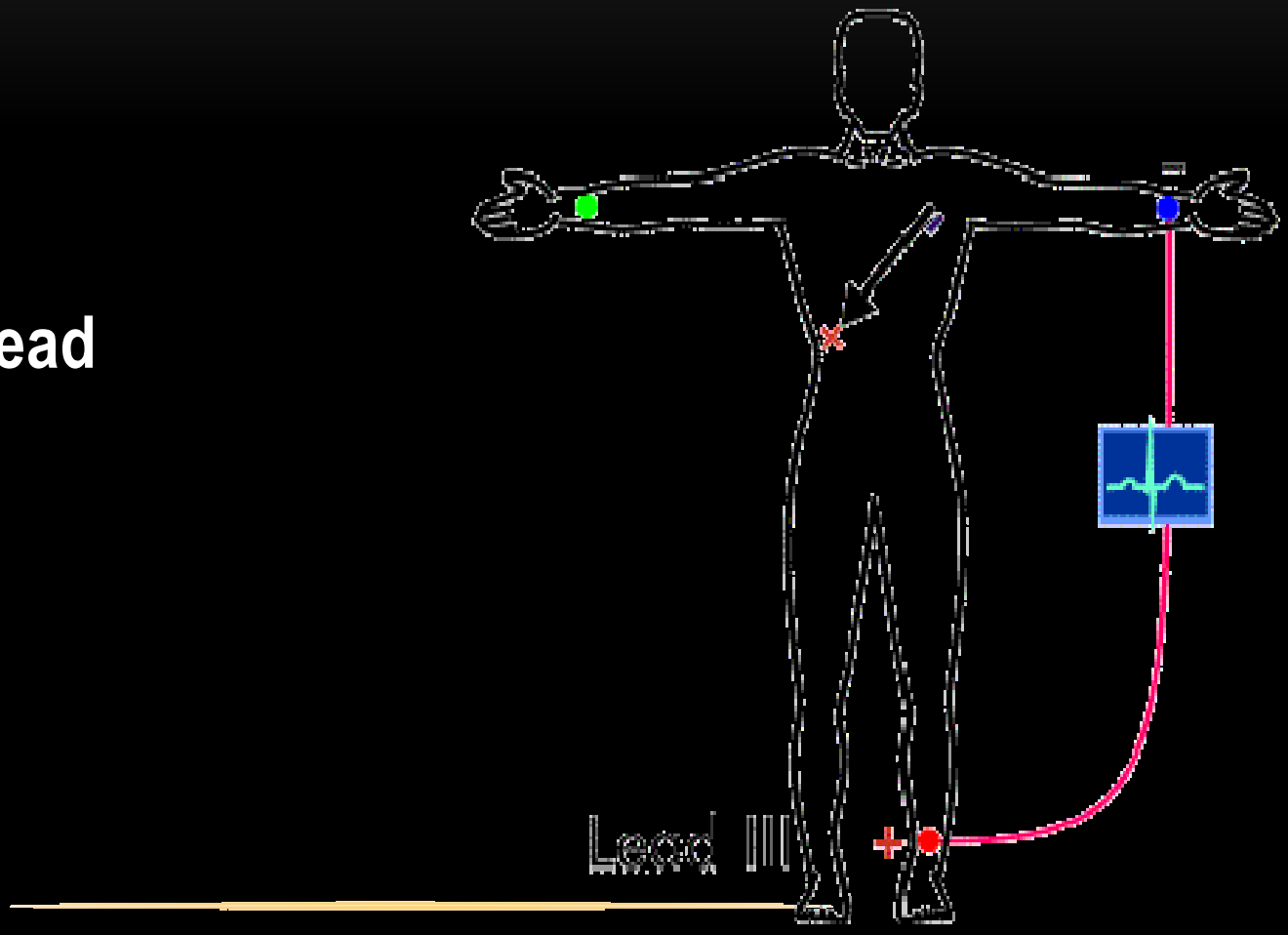
ECG

- Lead II
- Negative Electrode
  - Right Arm
- Positive Electrode
  - Left Leg

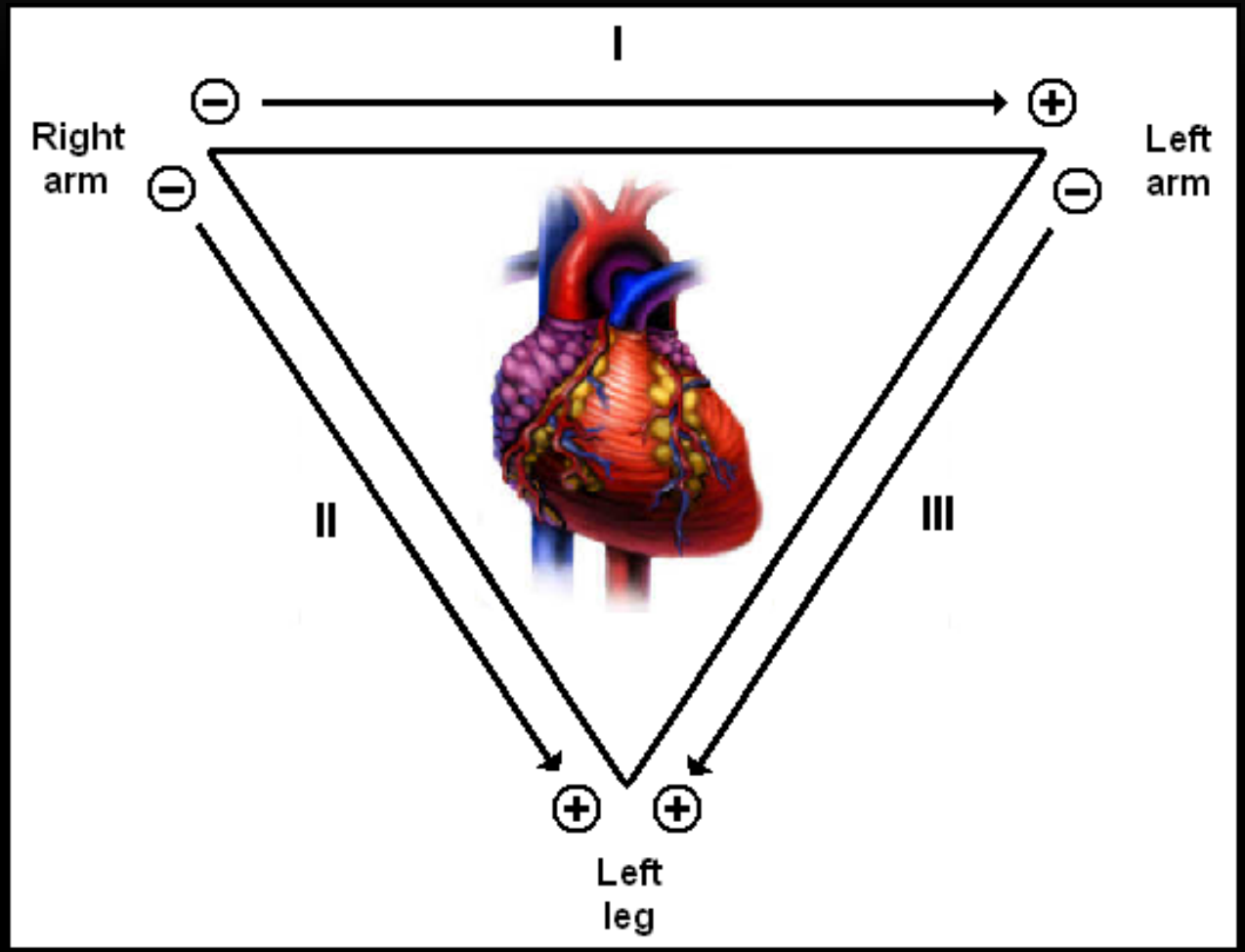


ECG

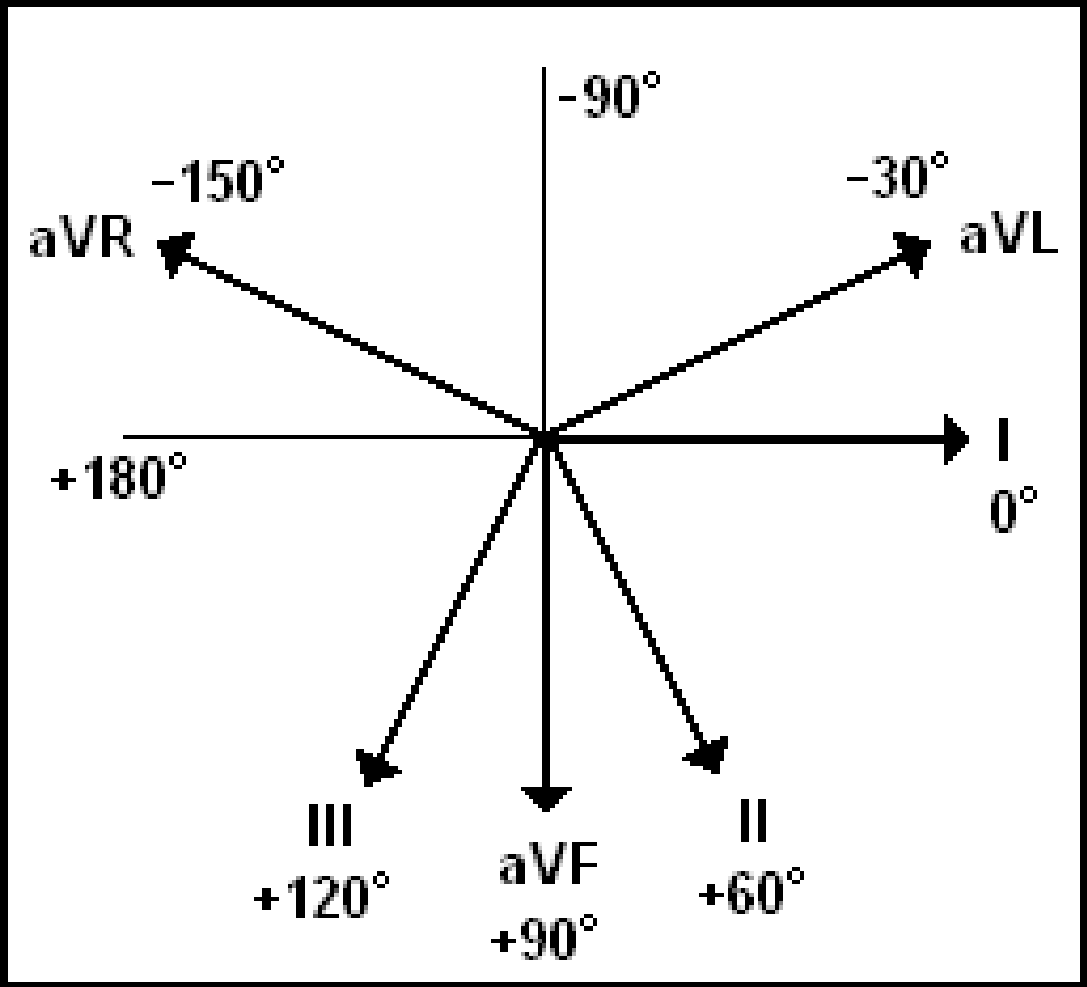
- Lead III
- Negative Lead
  - Left Arm
- Positive Lead
  - Left Leg



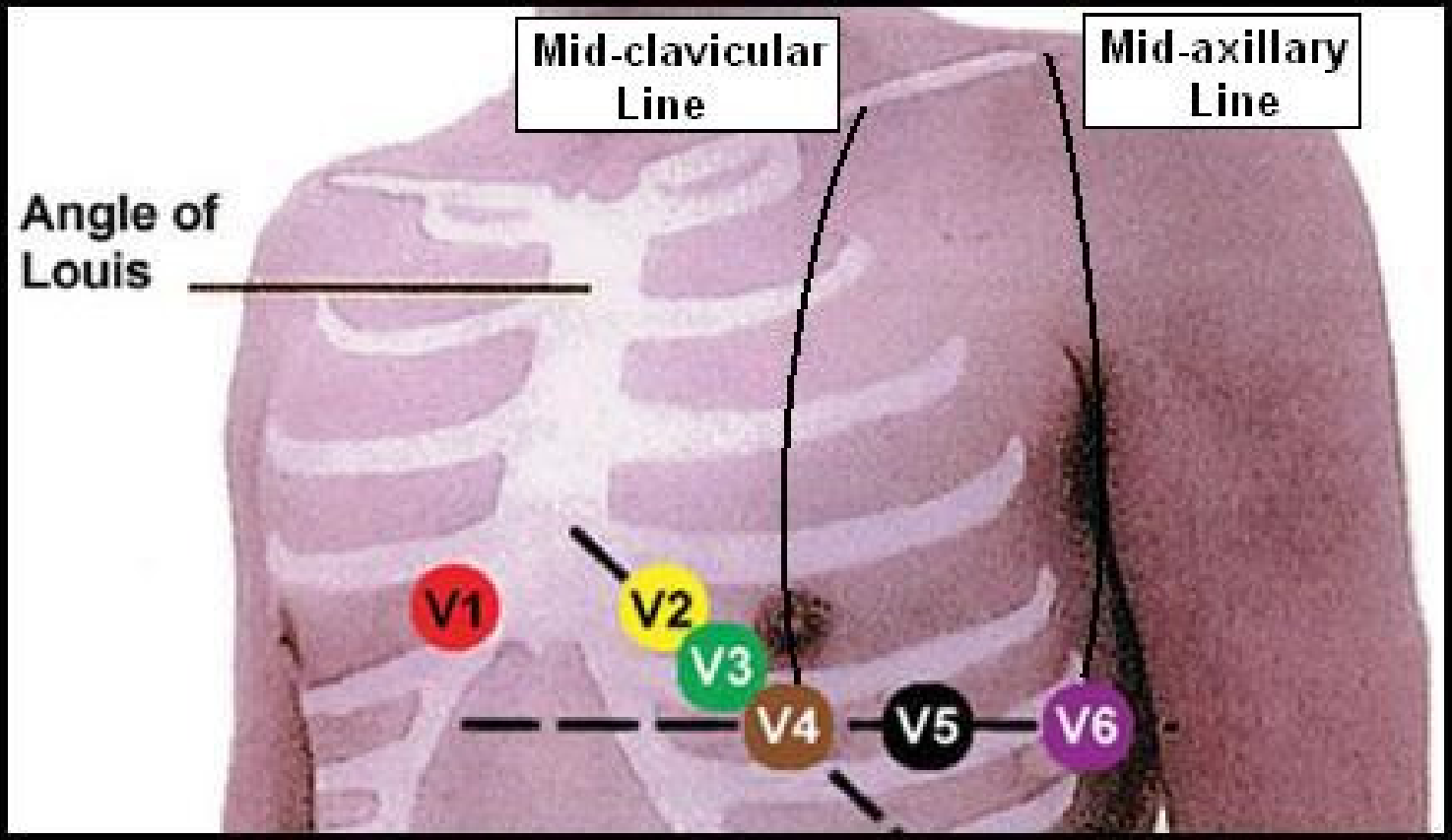
STANDARD LIMB LEADS



ALL LIMB LEADS

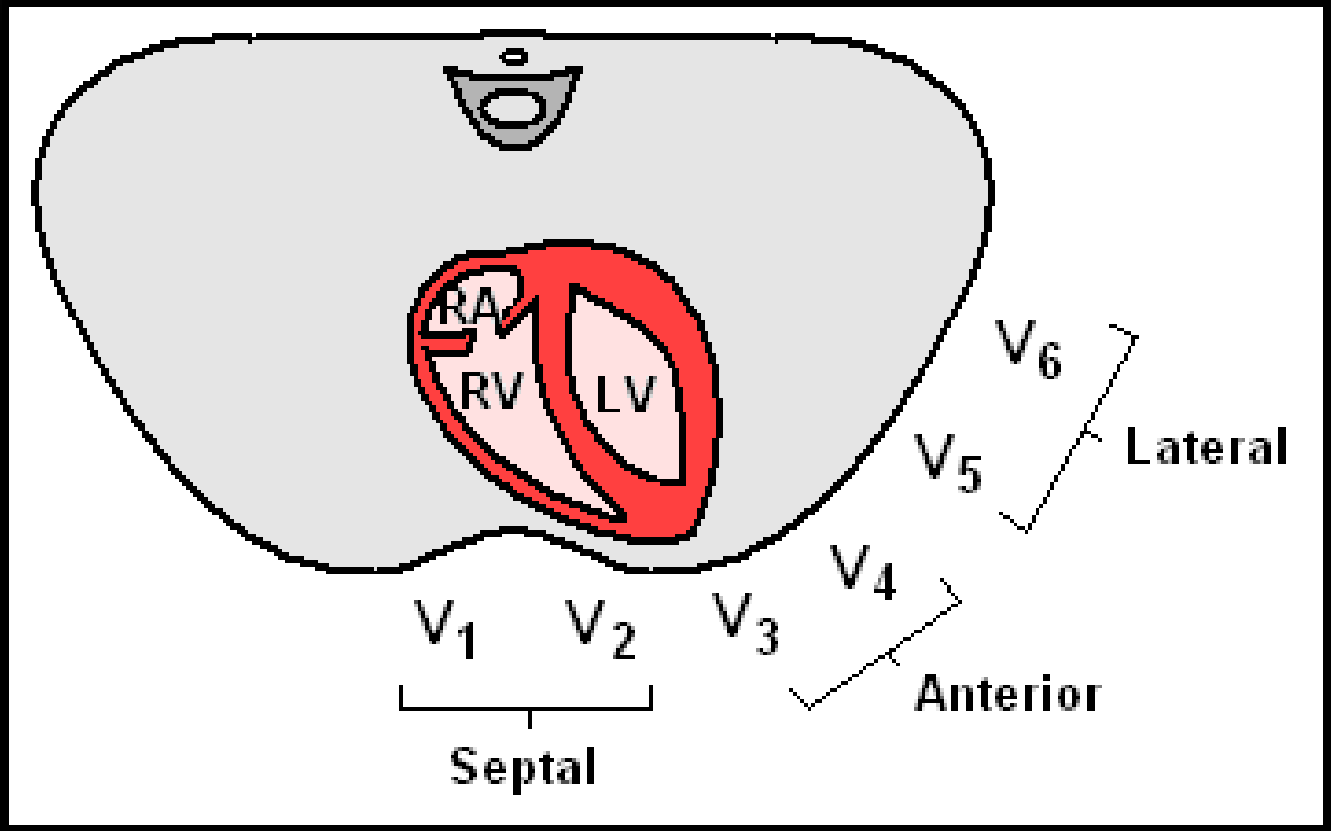


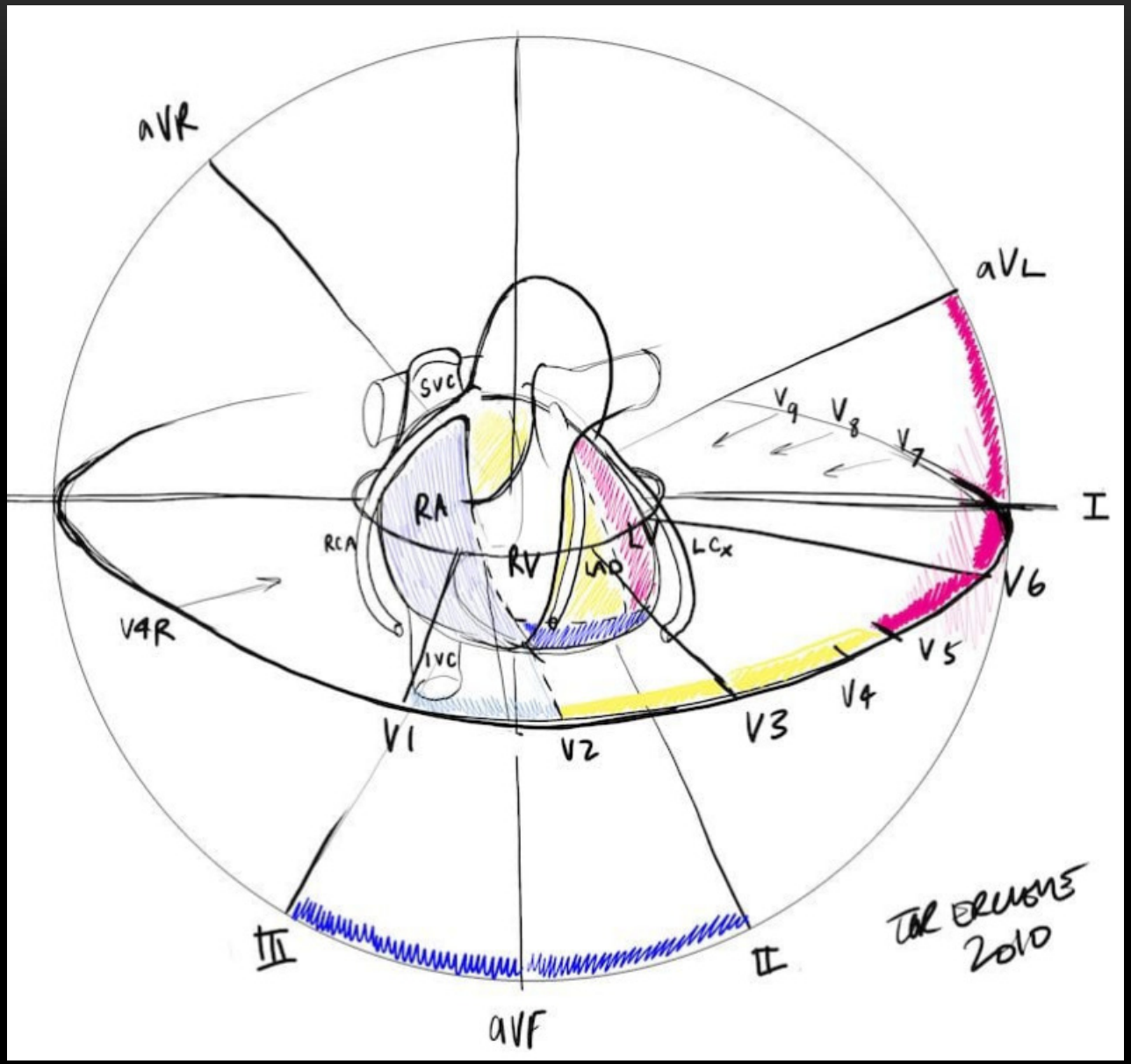
PRECORDIAL LEADS



Adapted from: www.numed.co.uk/electrodepl.html

PRECORDIAL LEADS




aVR
aVL
I
II
III
aVF
SVC
RA
RV
LV
RCA
LAD
LCx
IVC
V1
V2
V3
V4
V5
V6
V4R
V7
V8
V9
TOM ERNSTE
2010

ANATOMIC GROUPS
(SUMMARY)

I Lateral	aVR None	V_1 Septal	V_4 Anterior
II Inferior	aVL Lateral	V_2 Septal	V_5 Lateral
III Inferior	aVF Inferior	V_3 Anterior	V_6 Lateral

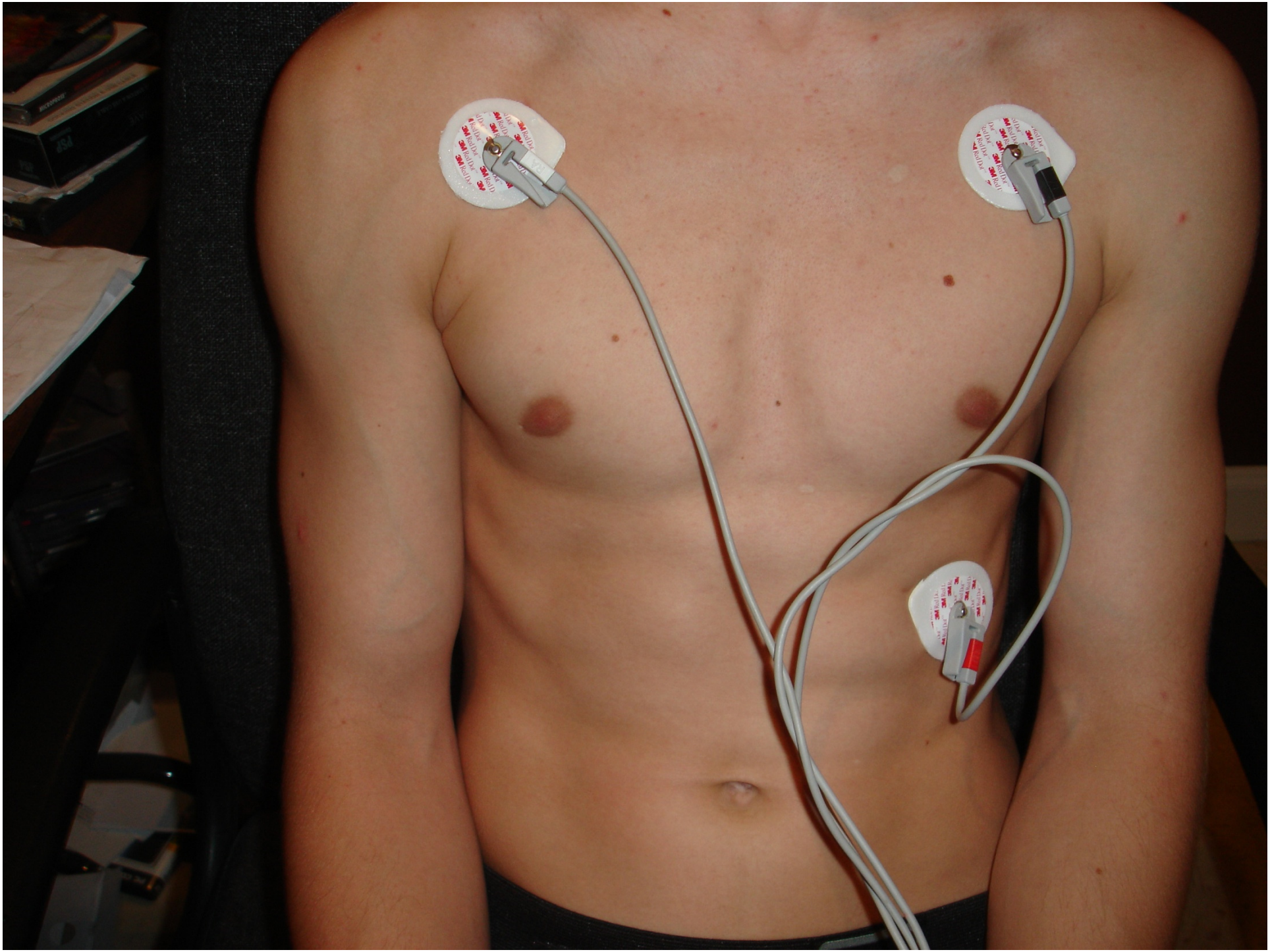
LEAD PLACEMENT FOR A 3 LEAD ECG

- **Remember the pneumonic**

  WHITE RIGHT

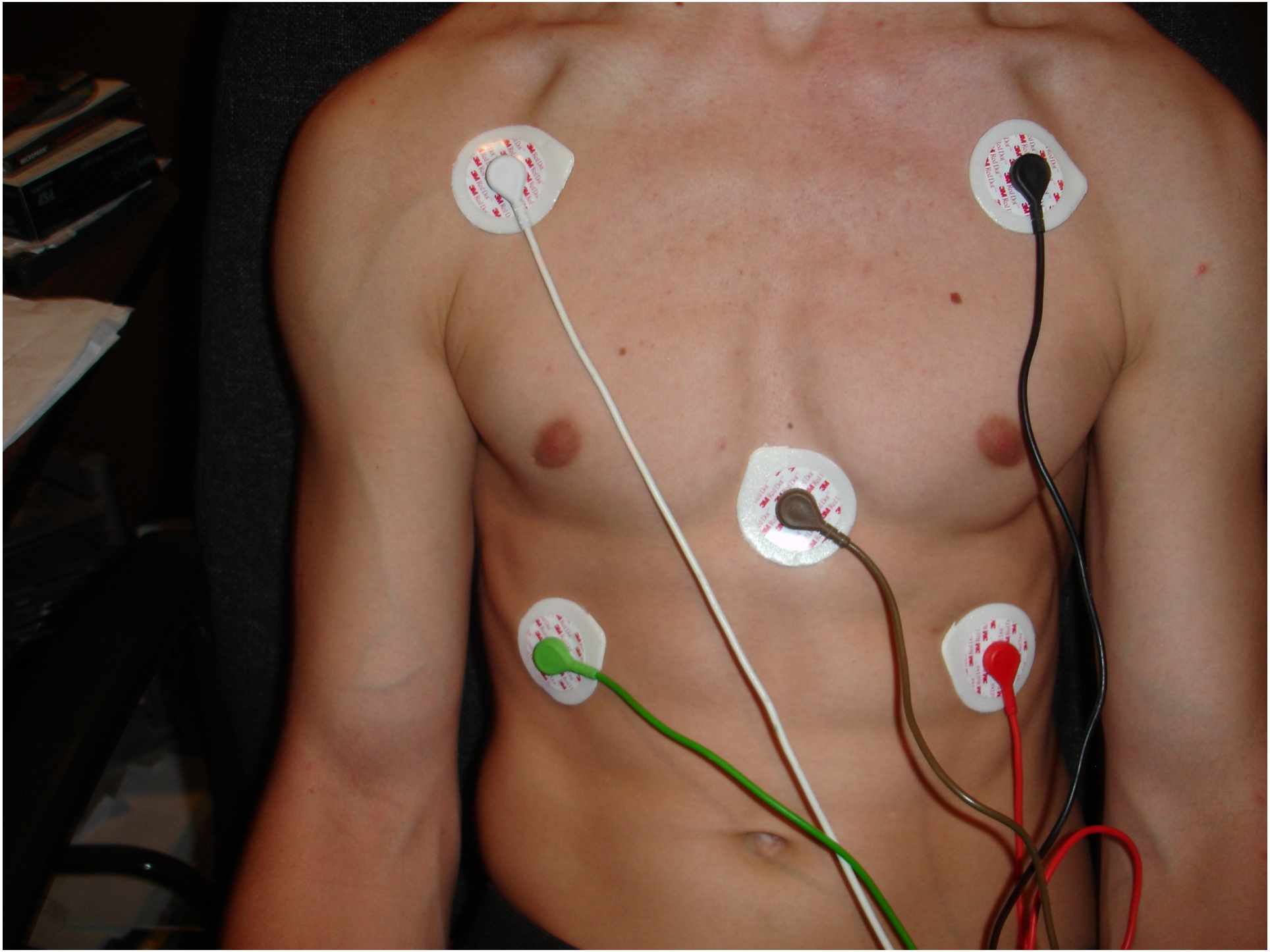
  RED RIBS

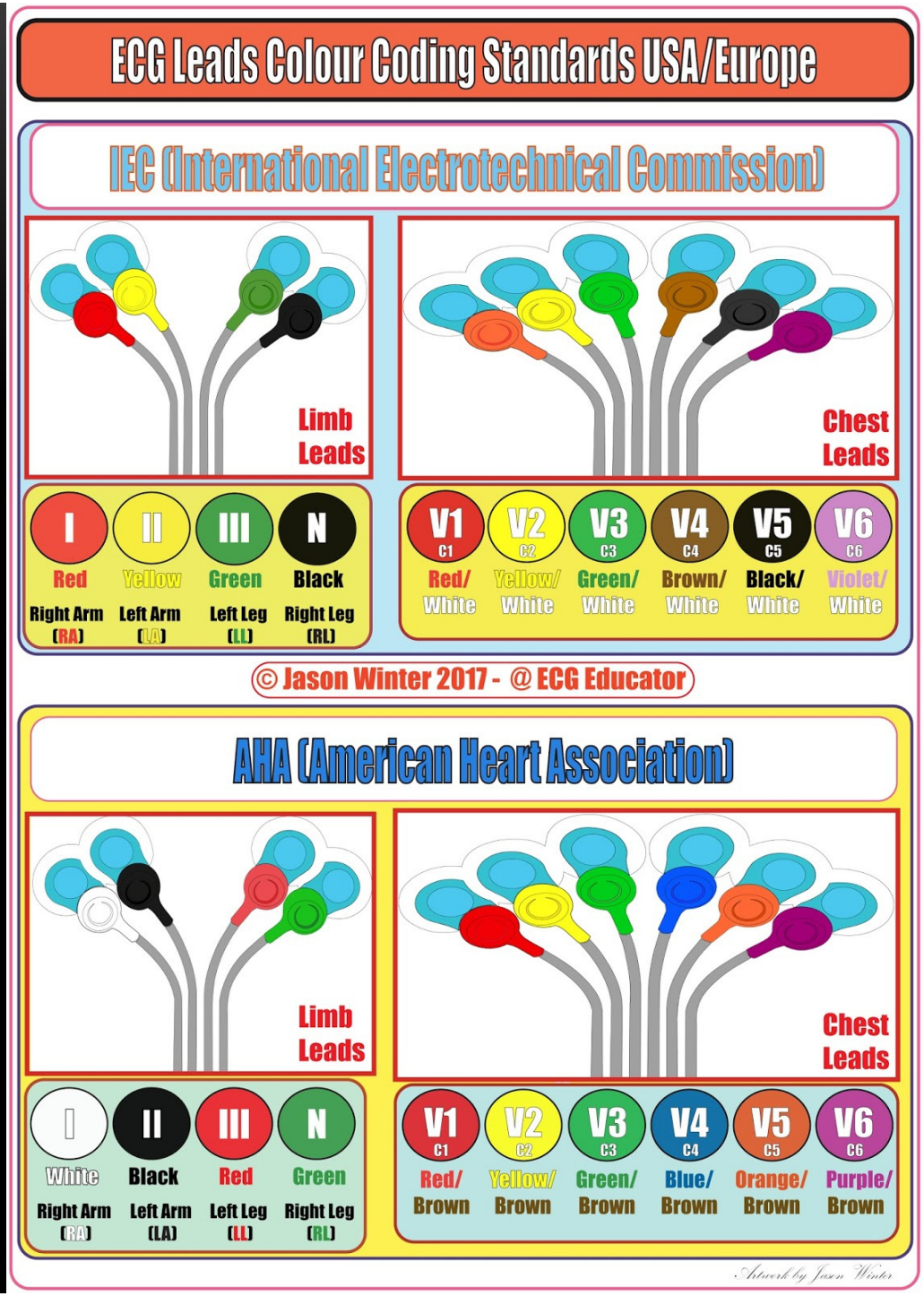
  BLACK LEFT OVER



LEAD PLACEMENT FOR FIVE LEAD

- **WHITE RIGHT, RED RIBS, BLACK LEFTOVER, PLUS GREEN RIGHT RIB AND BROWN MID CHEST**




ECG Leads Colour Coding Standards USA/Europe
IEC (International Electrotechnical Commission)
Limb Leads
Chest Leads
I
II
III
N
Red
Yellow
Green
Black
Right Arm (RA)
Left Arm (LA)
Left Leg (LL)
Right Leg (RL)
V1 C1
V2 C2
V3 C3
V4 C4
V5 C5
V6 C6
Red/ White
Yellow/ White
Green/ White
Brown/ White
Black/ White
Violet/ White
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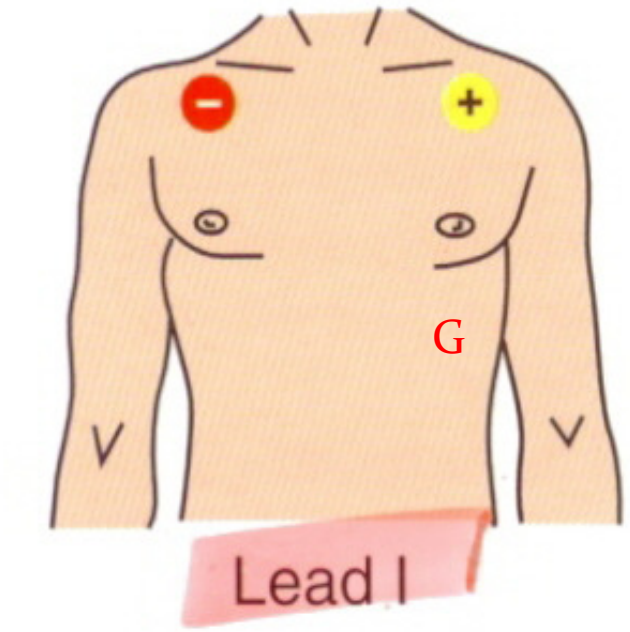
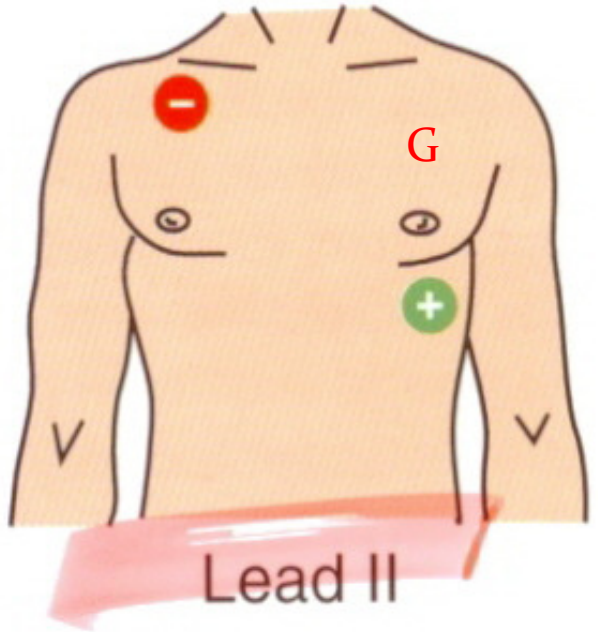
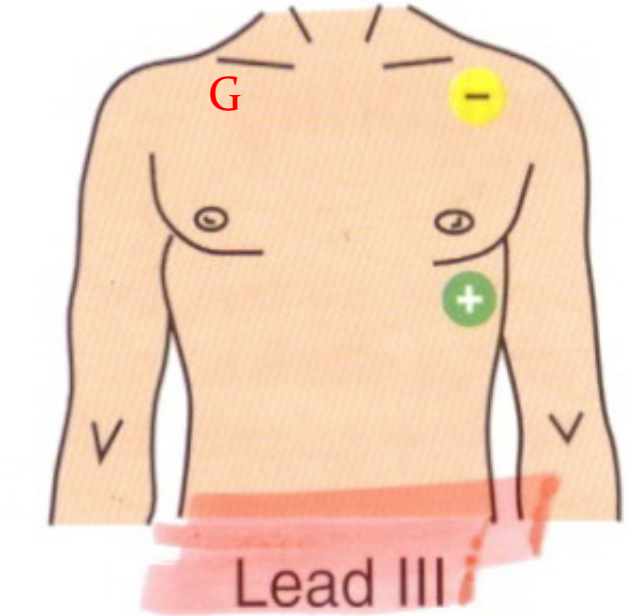
AHA (American Heart Association)
Limb Leads
Chest Leads
I
II
III
N
White
Black
Red
Green
Right Arm (RA)
Left Arm (LA)
Left Leg (LL)
Right Leg (RL)
V1 C1
V2 C2
V3 C3
V4 C4
V5 C5
V6 C6
Red/ Brown
Yellow/ Brown
Green/ Brown
Blue/ Brown
Orange/ Brown
Purple/ Brown
Artwork by Jason Winter

The lead you are looking at depends on the charge of the leads in relationship to their position in the triangle. The following picture shows how the ECG machine changes the charges to show different leads. But the physical position of the white red and black leads does not change.



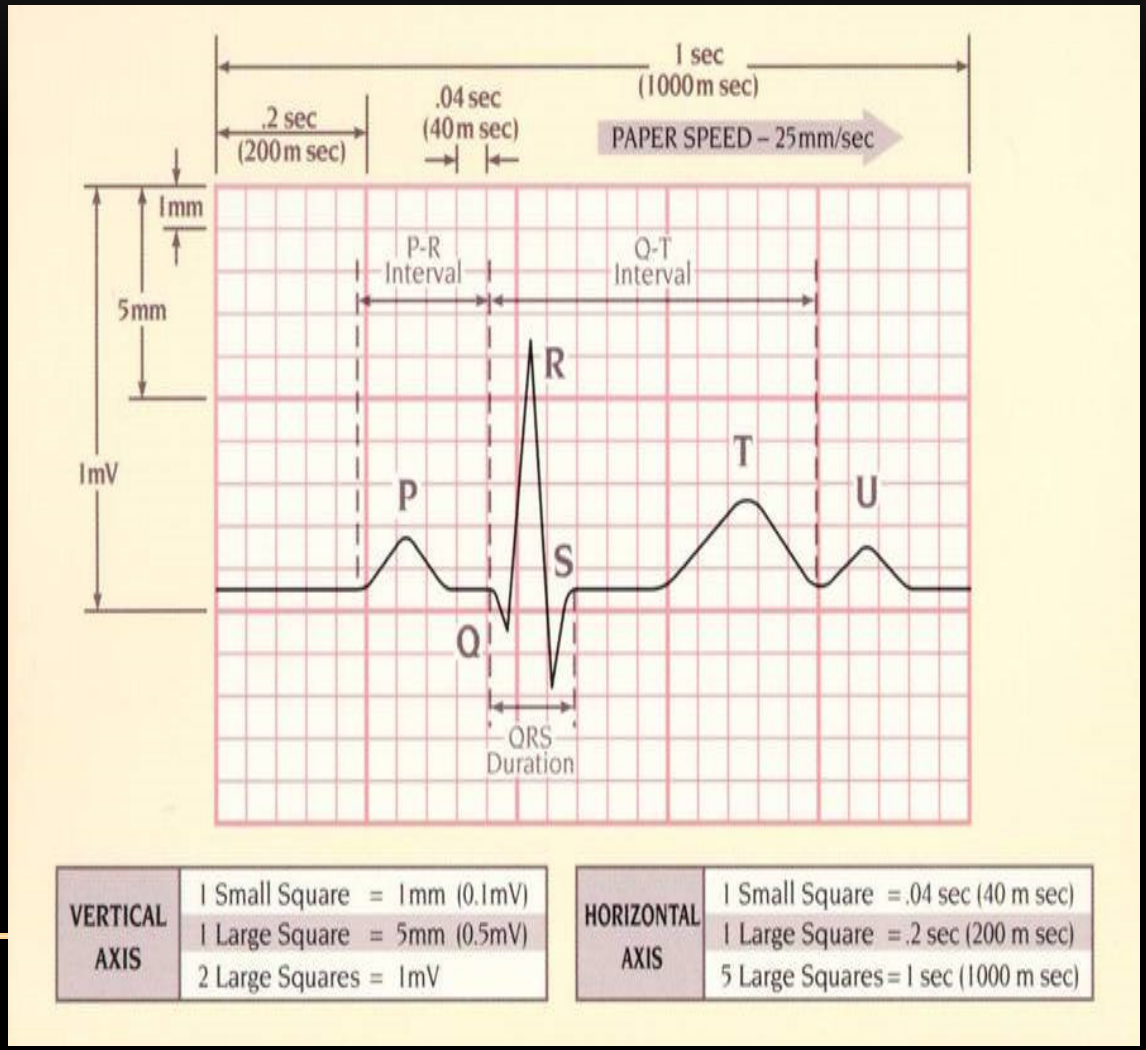


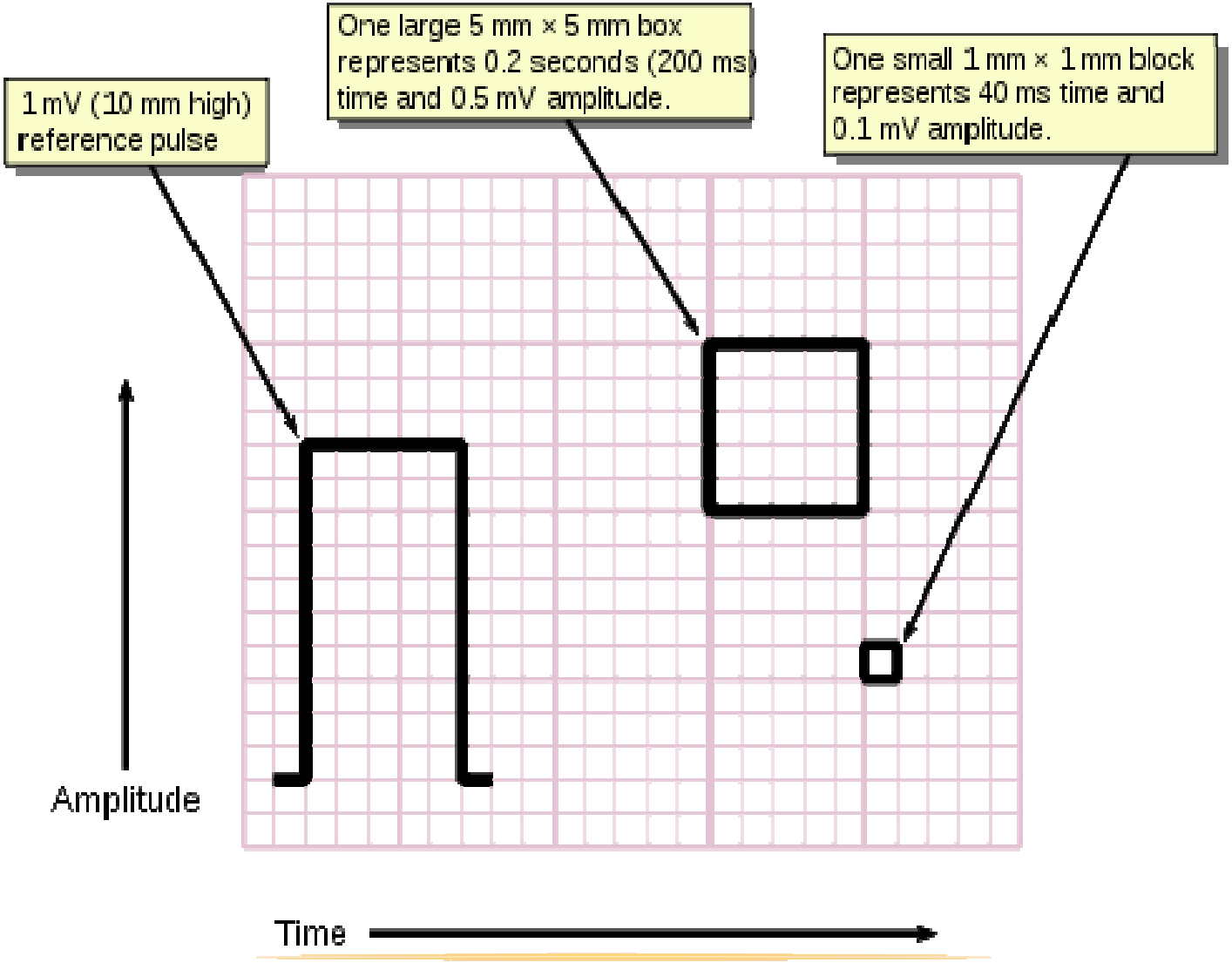


Note the ground lead is in the 3rd position of the triangle (G)

KNOW THY PAPER

- Graph Paper
  - Small boxes
    - 1mm wide; 1 mm high
  - <u>Horizontal axis</u>
    - Time in seconds
    - 1 mm box represents 0.04 seconds
    - ECG paper speed is 25 mm/second
  - One large box is 5 small boxes and =.20 seconds (.04sec x5)



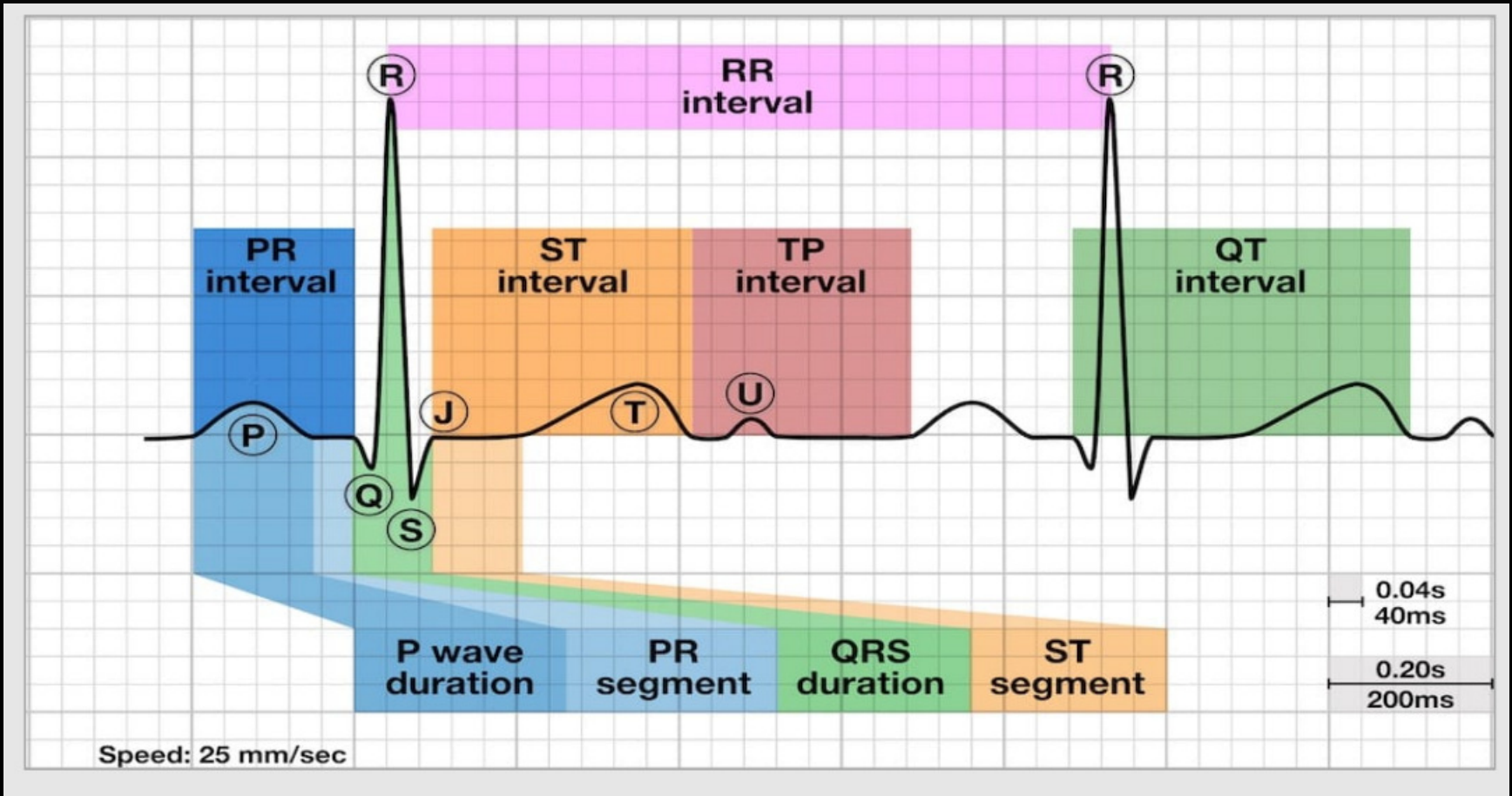

1 mV (10 mm high) reference pulse
One large 5 mm × 5 mm box represents 0.2 seconds (200 ms) time and 0.5 mV amplitude.
One small 1 mm × 1 mm block represents 40 ms time and 0.1 mV amplitude.
Amplitude
Time

ECG

- Waveforms
  - Movement from baseline
  - Positive (upward)
  - Negative (downward)

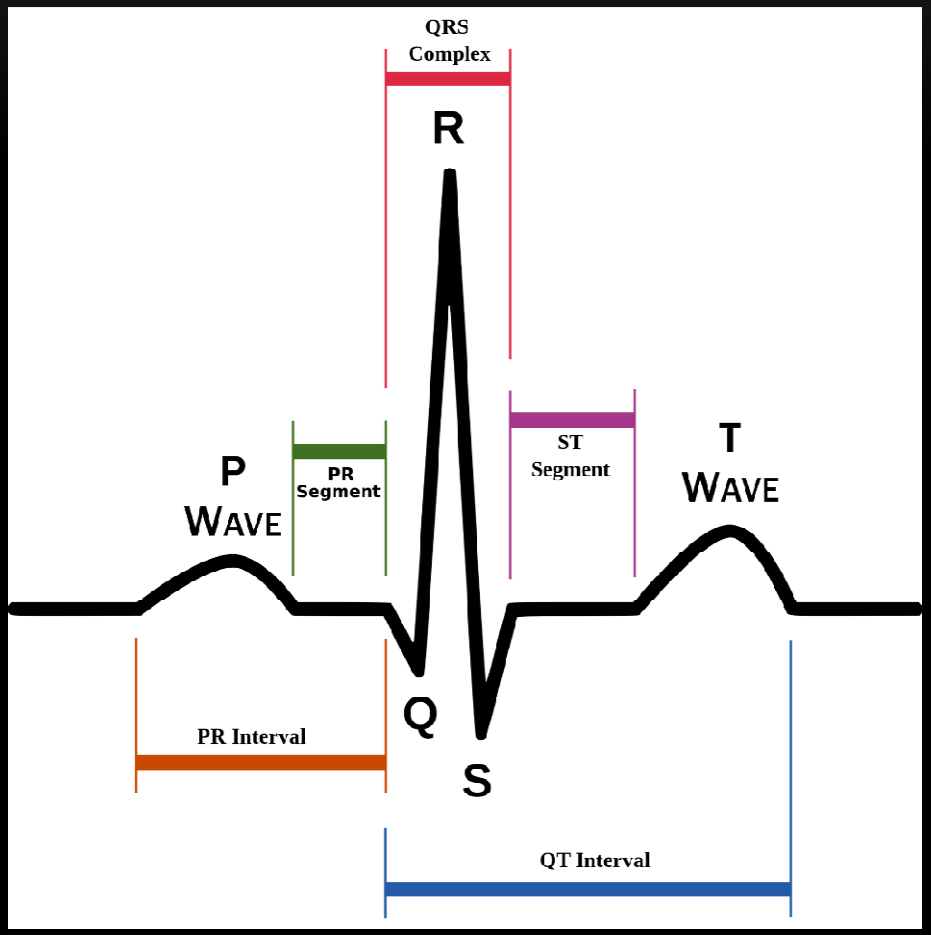
  - Isoelectric –along baseline
  - Biphasic - Both upward and downward

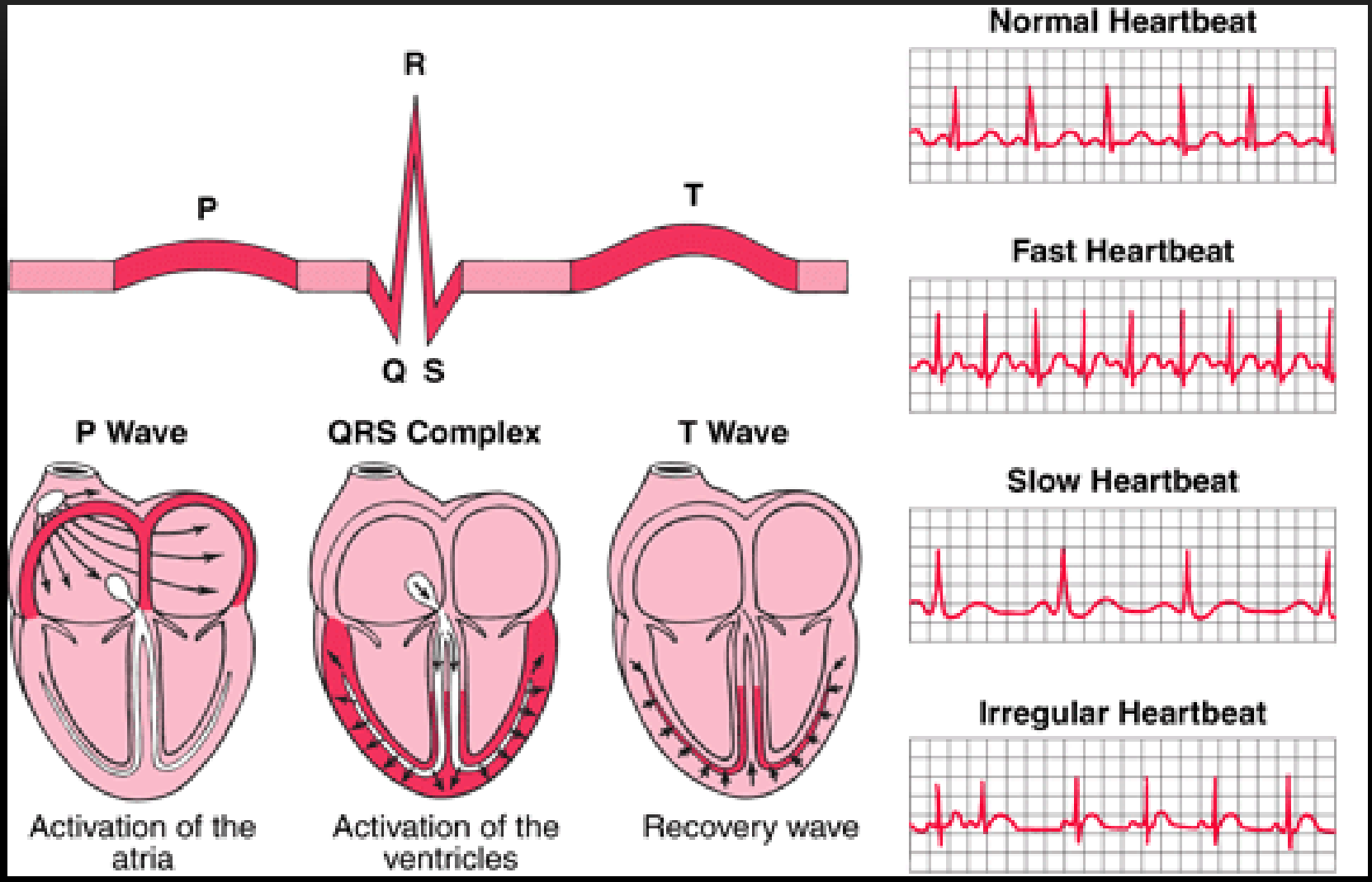
ECG – WAVES AND INTERVALS



ECG

- **P Wave**
  - First waveform
  - Impulse begins in SA Node in Right Atrium
  - Downslope of P wave –is stimulation of left atrium
  - 2.5 mm in height (max)
  - O.11 sec. duration (max)
  - Positive in Lead II

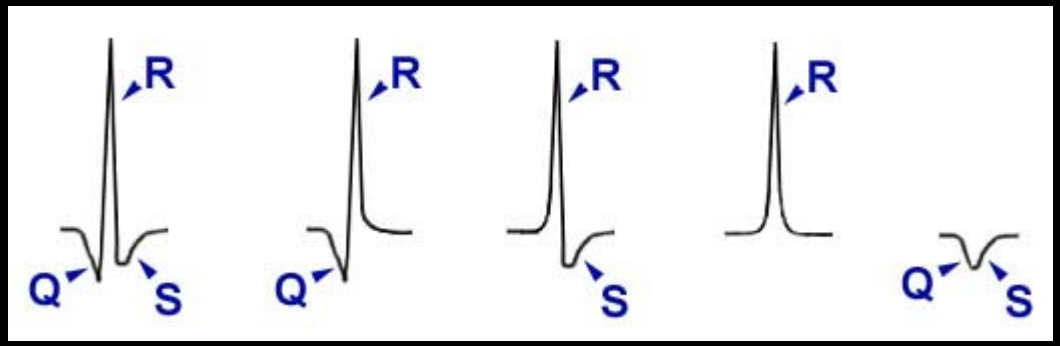



R
P
T
Q S
P Wave
QRS Complex
T Wave
Activation of the atria
Activation of the ventricles
Recovery wave
Normal Heartbeat
Fast Heartbeat
Slow Heartbeat
Irregular Heartbeat

A normal ECG waveform

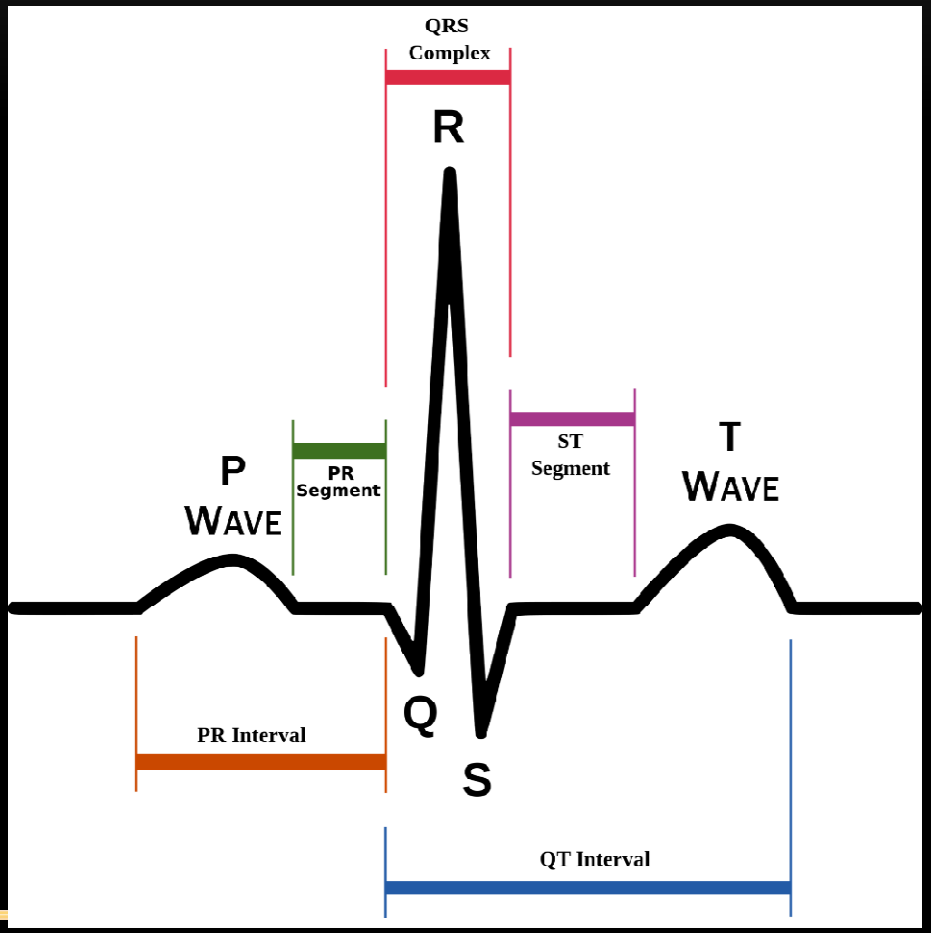
ECG

- <u>QRS Complex</u>
  - Electrical impulse through ventricules
  - Larger than P wave due to larger muscle mass of ventricles
  - Follows P wave
  - Made up of a
    - Q wave
    - R wave
    - S wave



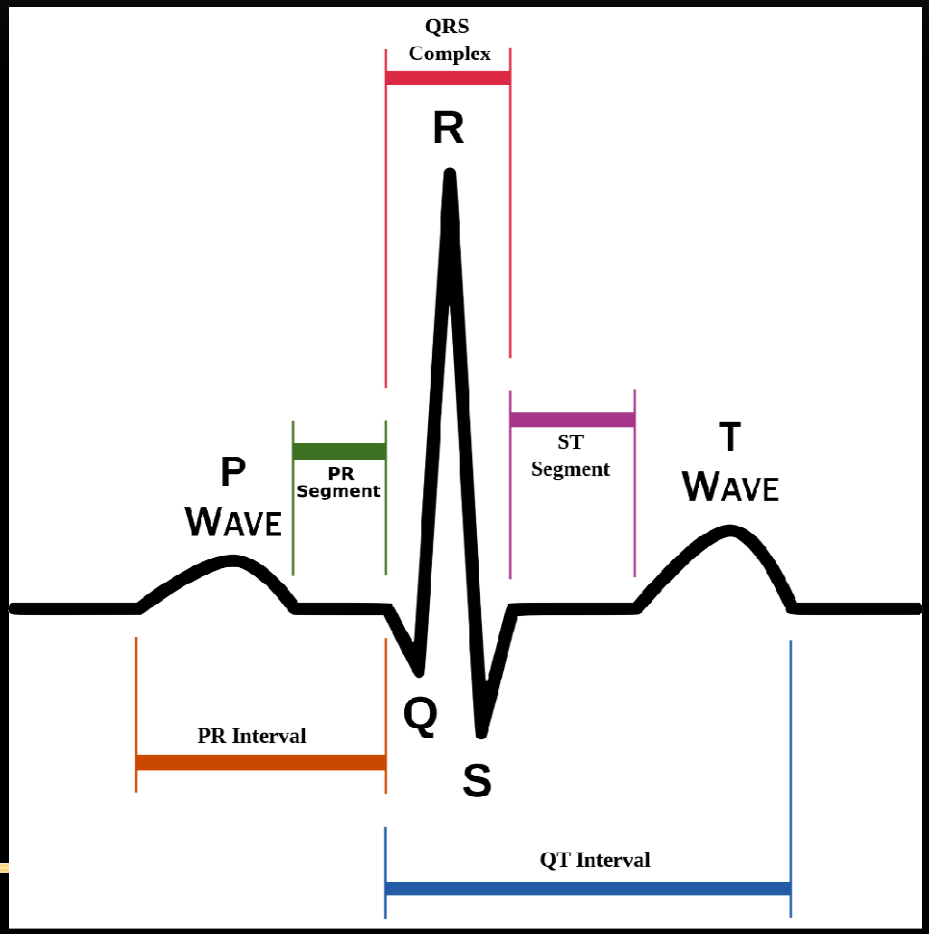
ECG

- **Q wave**
  - First **negative** deflection following P wave
  - Represents depolarization of the interventricular septum activated from left to right



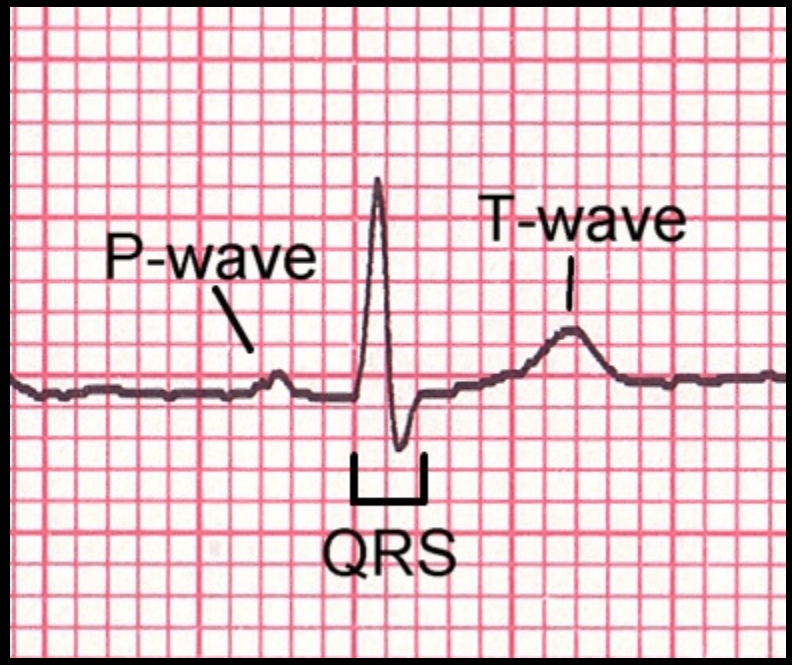
ECG

- S wave
  - Negative waveform following the R wave
- Normal duration of QRS
  - 0.06 mm – 0.10 mm
- Not all QRS Complexes have a Q, R and S



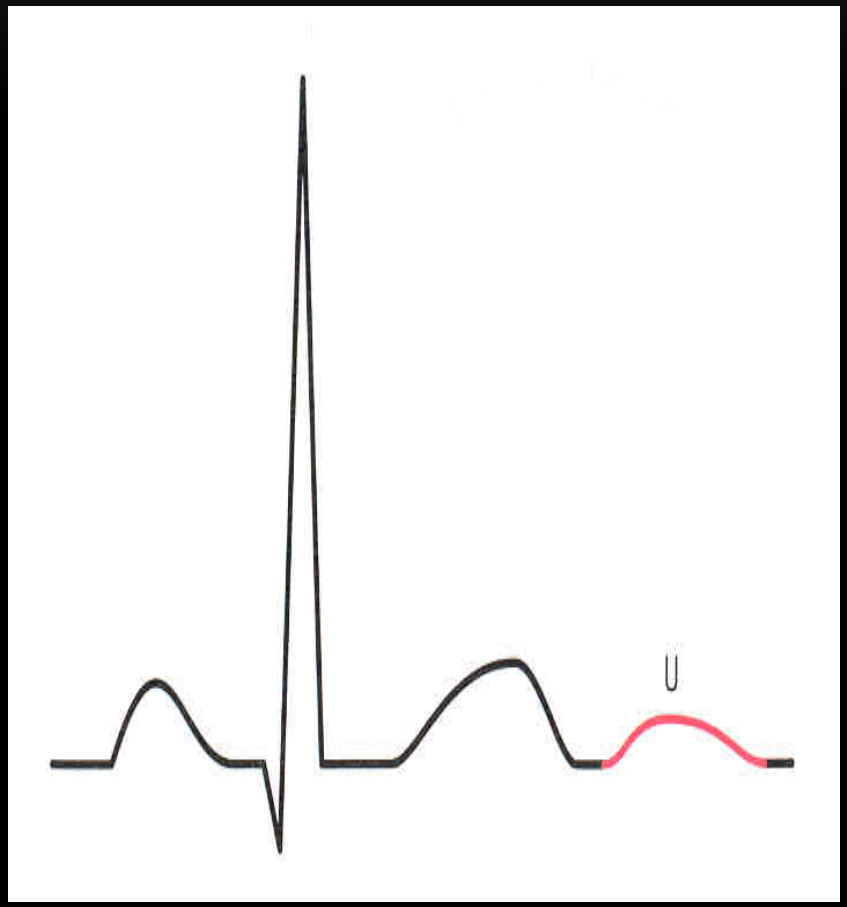
ECG

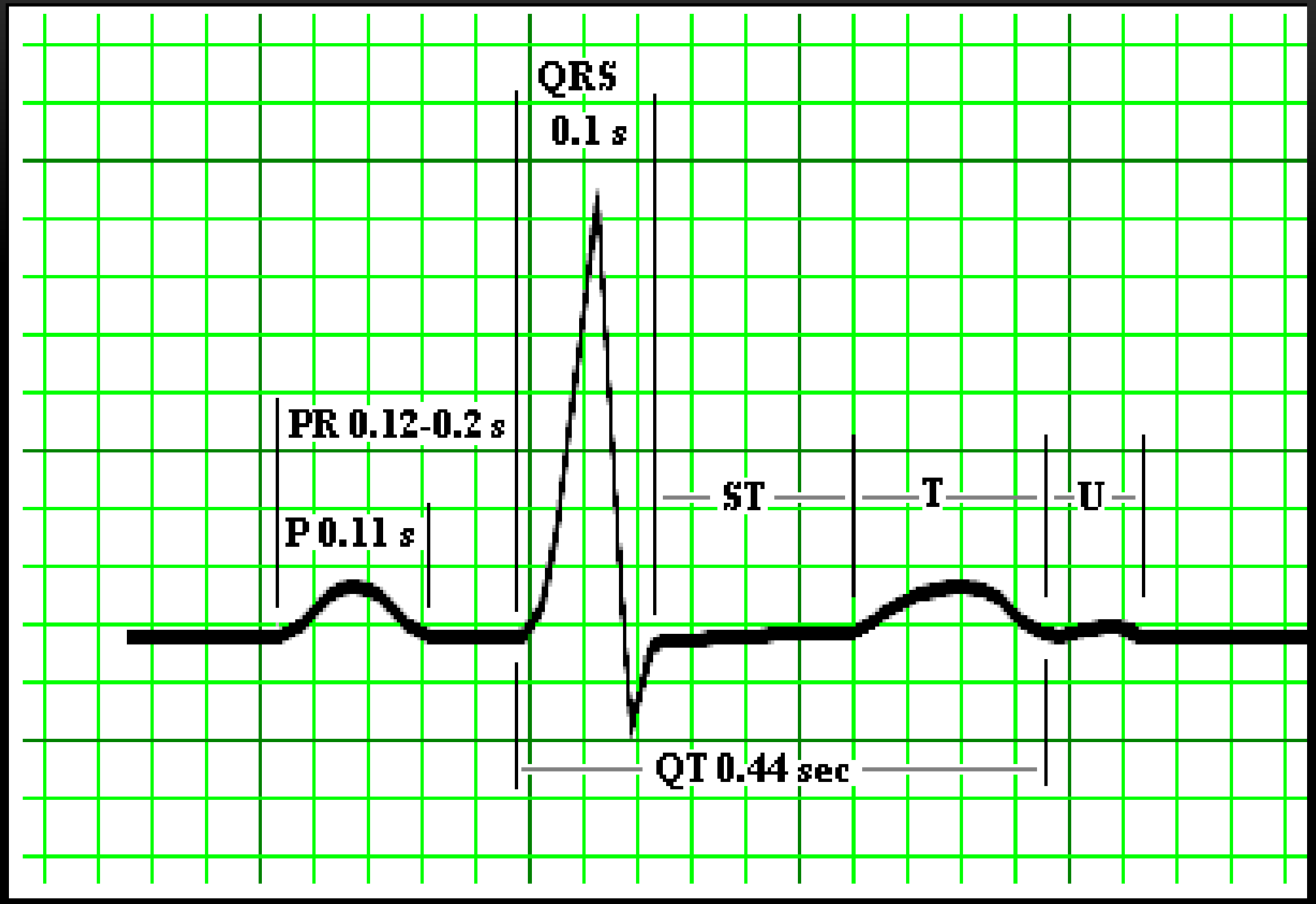
- T wave
  - Represents ventricular repolarization
  - Absolute refractory period present during beginning of T wave
  - Relative refractory period at peak
  - Usually 0.5 mm or more in height
  - Slightly rounded



ECG

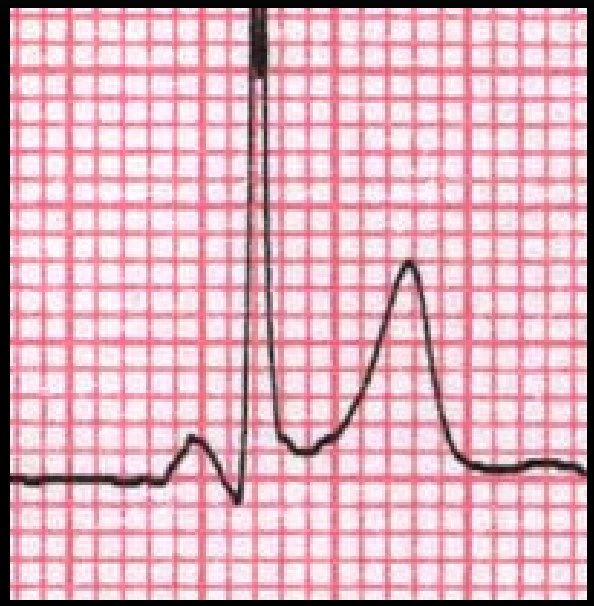
- U wave
  - Small waveform
  - Follows T wave
  - Less than 1.5 mm in amplitude




QRS
0.1 s
PR 0.12-0.2 s
P 0.11 s
ST
T
U
QT 0.44 sec

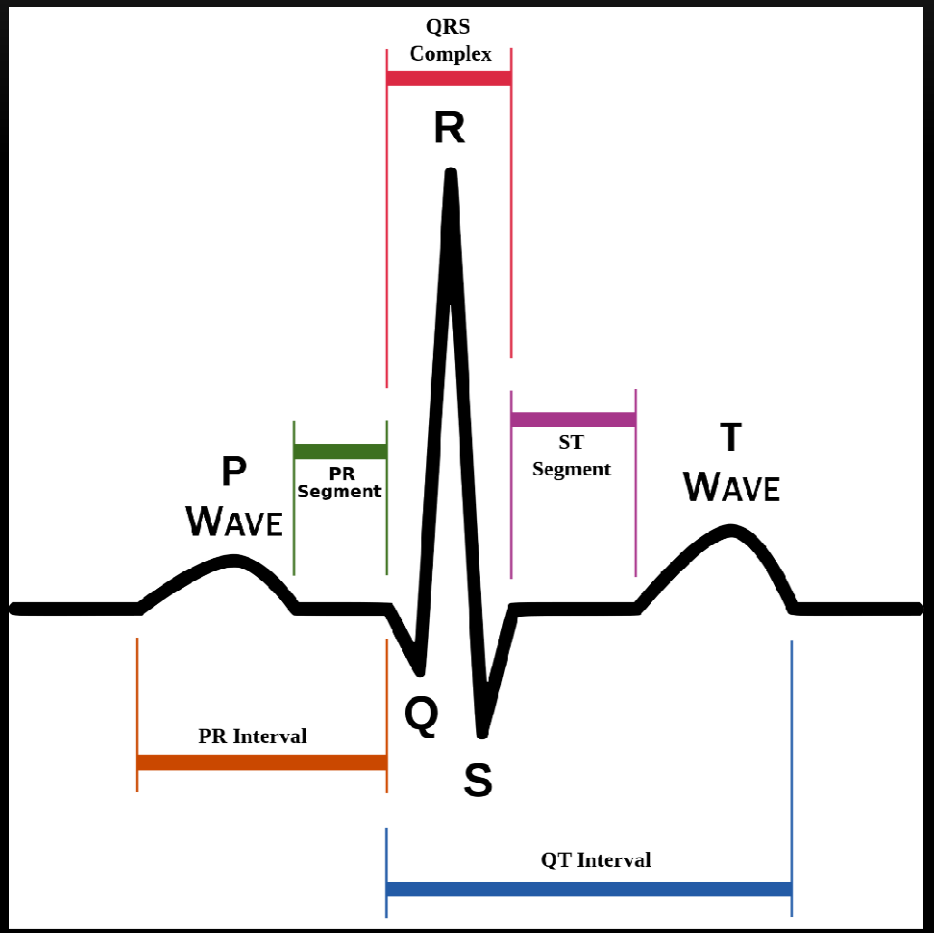
ECG

- J Point
  - Point where the QRS complex and ST-segment meet



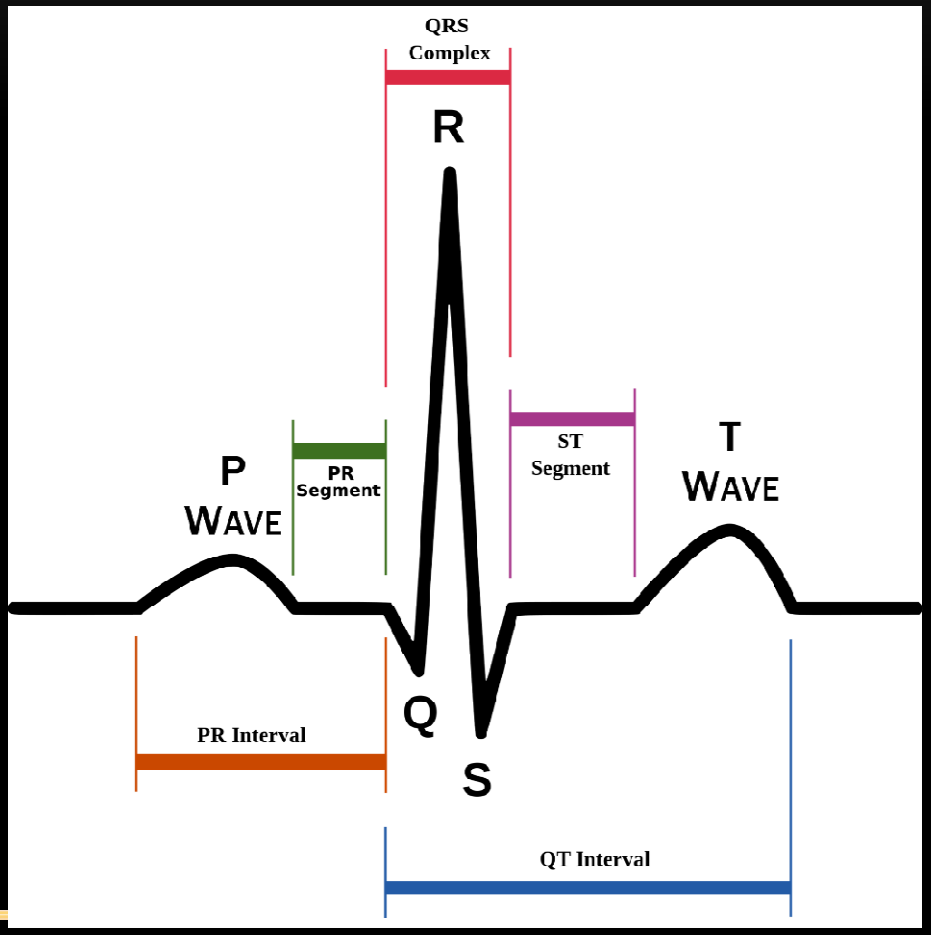
ECG

- PR Interval
  - Measurement where P wave leaves baseline to beginning of QRS complex
  - 0.12 - .20 sec.
- QRS Interval
  - Measurement from beginning of the Q wave until the end of the S wave.
  - 0.06 - .12 sec.



ECG

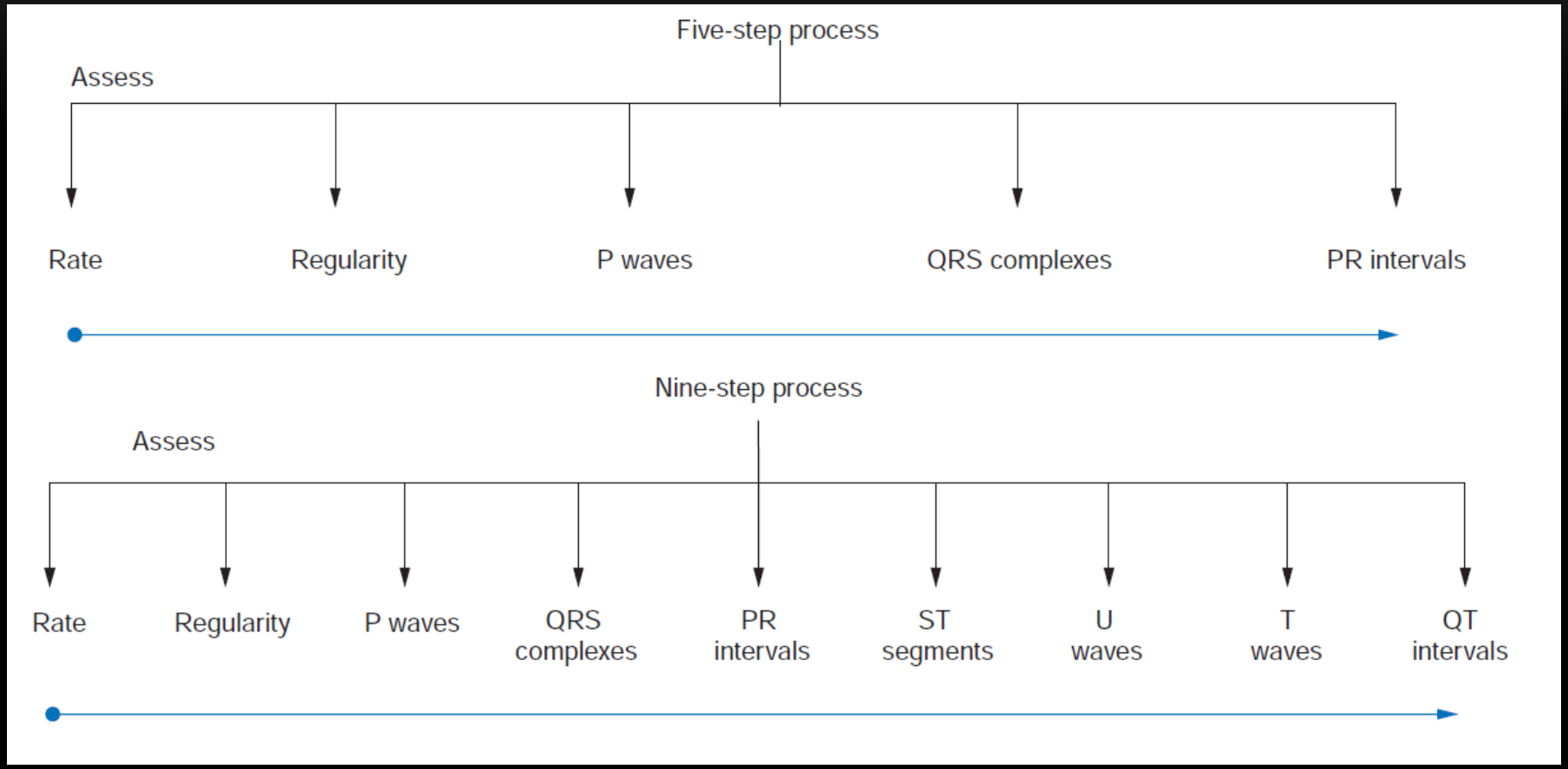
- QT interval
  - Begins at isoelectric line from end of S wave to the beginning of the T wave - 0.44 sec.
  - Represents total ventricular activity
  - Measured from beginning of QRS complex to end of T wave.



ECG ANALYSIS

- Determine Rate
  - Normal? Fast? Slow?
  - Atrial Rate? Ventricular Rate?
- Is it Regular? (R-R and P-P intervals)
  - Regularly irregular (pattern) or irregularly irregular?
- Are P-waves Present?
  - Are there p waves before every QRS?
  - Is the P-P interval constant?
  - Is The P-R interval normal?
- Is the QRS normal?
  - Is the morphology of the QRS the same?

ECG ANALYSIS



RATE

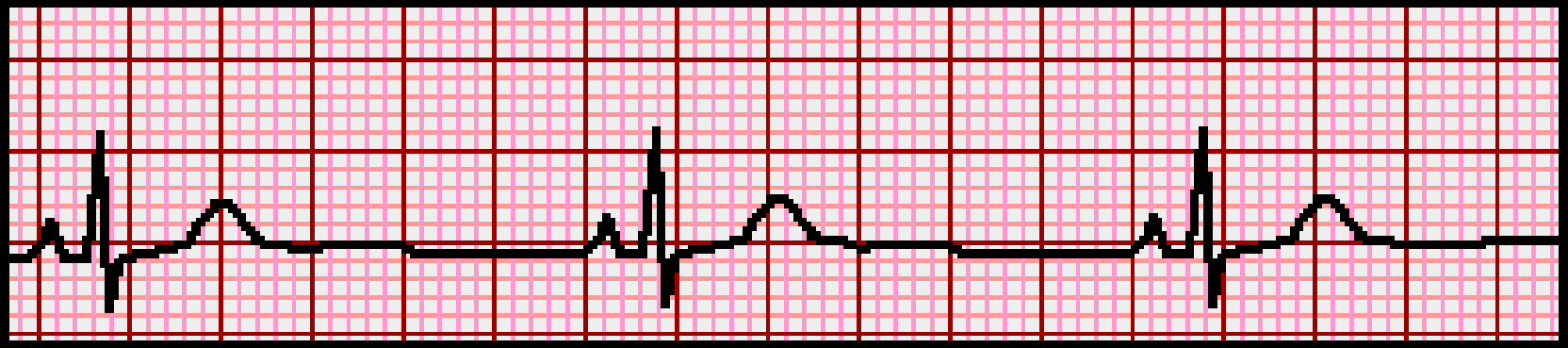
- Rule of 300 / 1500
- 6 / 10 Second Rule

RULE OF 300

Take the number of “big boxes” between neighboring QRS complexes, and divide this into 300. The result will be approximately equal to the rate

Although fast, this method only works for regular rhythms.

WHAT IS THE HEART RATE?



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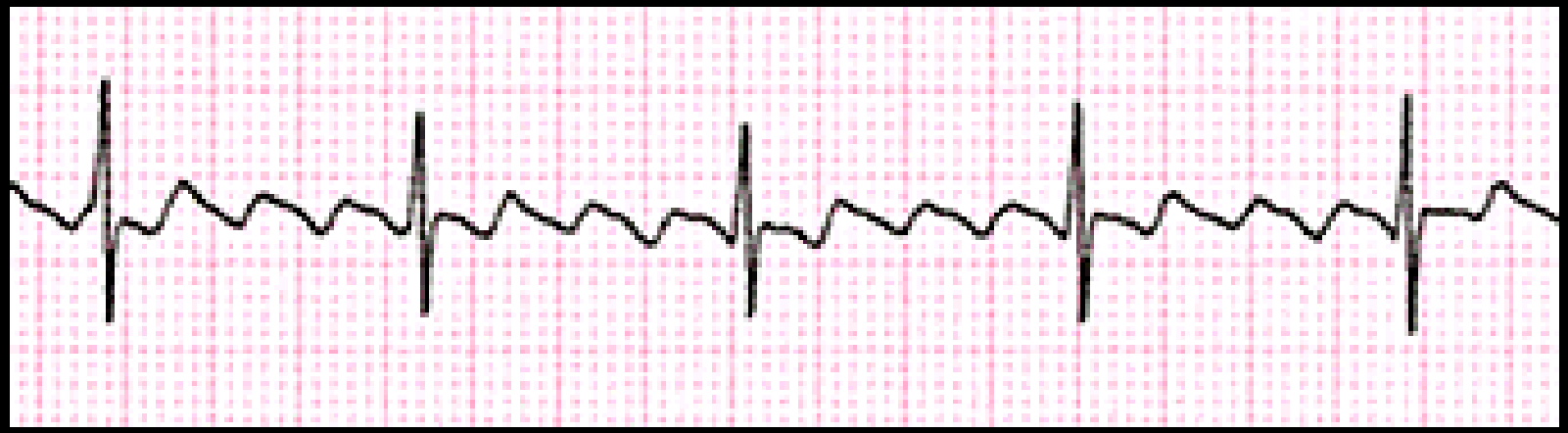
(300 / 6) = 50 bpm

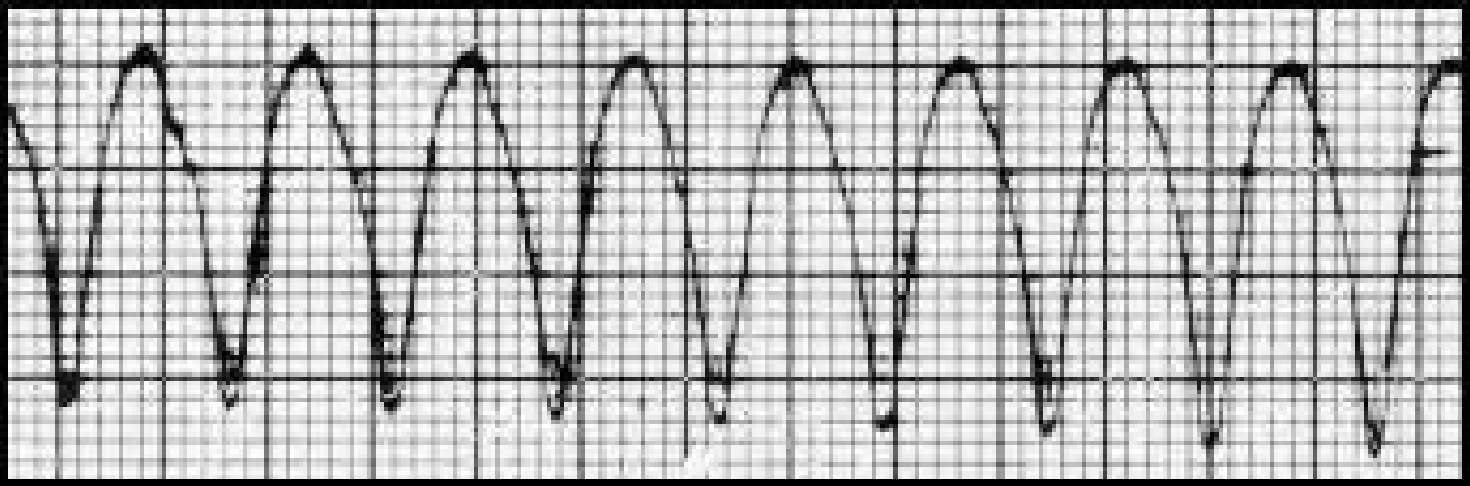
WHAT IS THE HEART RATE?



www.uptodate.com

(300 / ~ 4) = ~ 75 bpm

WHAT IS THE HEART RATE?

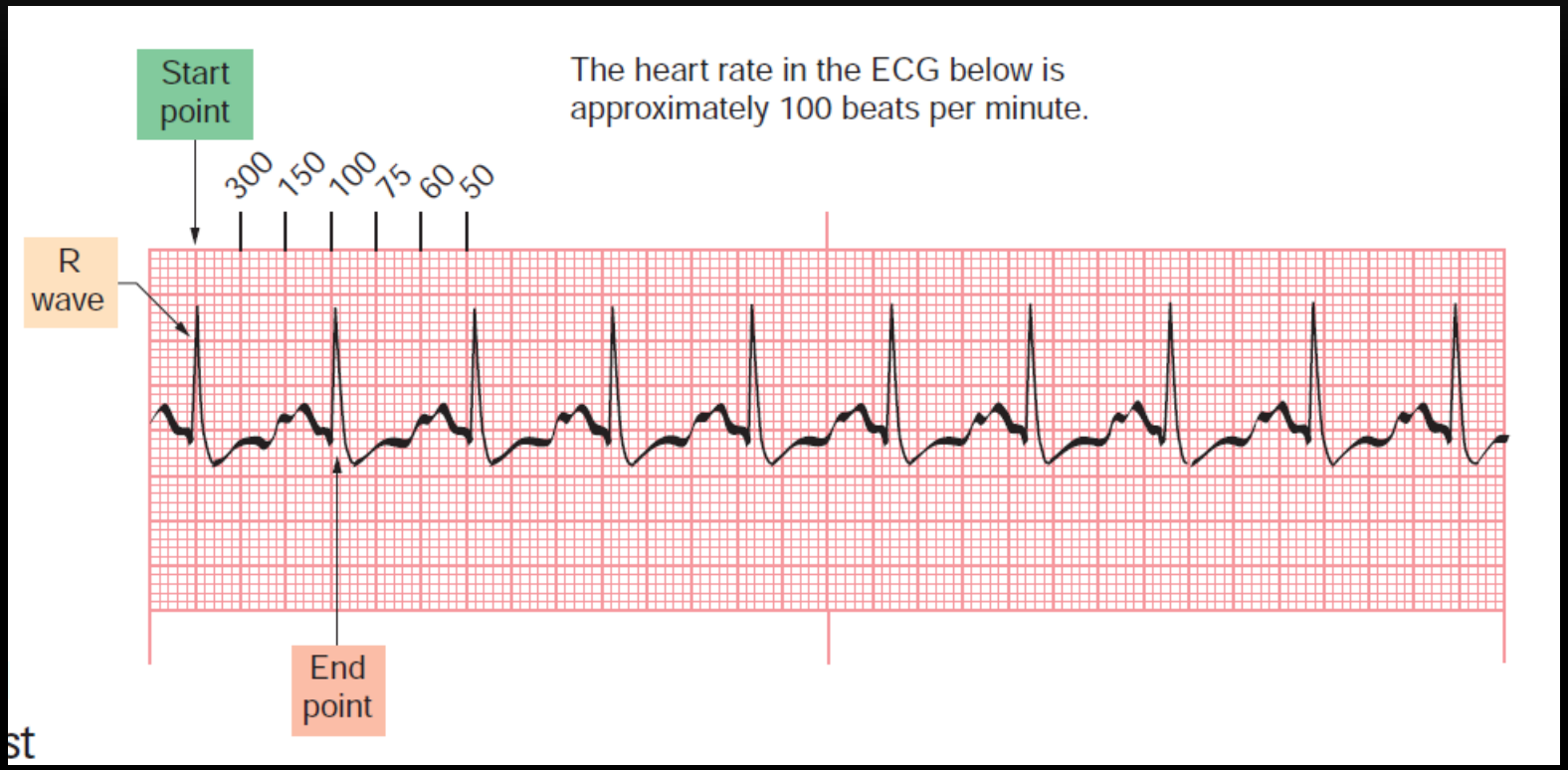


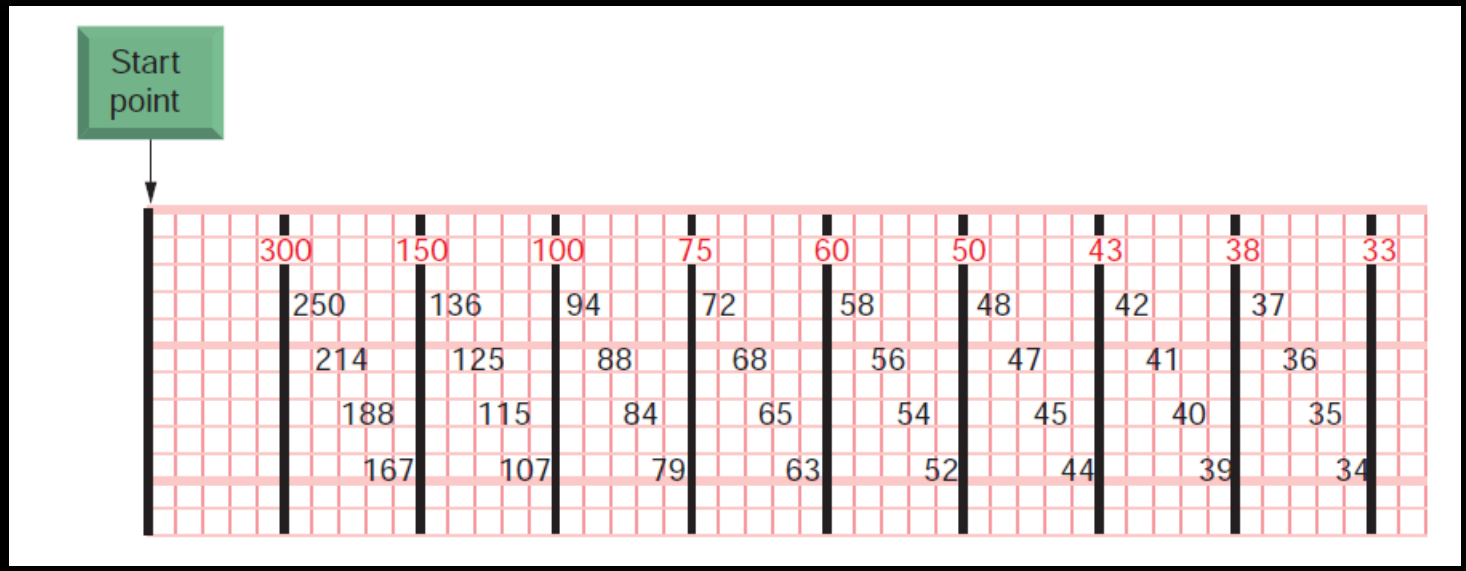
(300 / 1.5) = 200 bpm

THE RULE OF 300

It may be easiest to memorize the following table:

# of big boxes	Rate
1	300
2	150
3	100
4	75
5	60
6	50


Start point
The heart rate in the ECG below is approximately 100 beats per minute.
300
150
100
75
60
50
R wave
End point


Start point
300
250
214
188
167
150
136
125
115
107
100
94
88
84
79
75
72
68
65
63
60
58
56
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52
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48
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44
43
42
41
40
39
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37
36
35
34
33

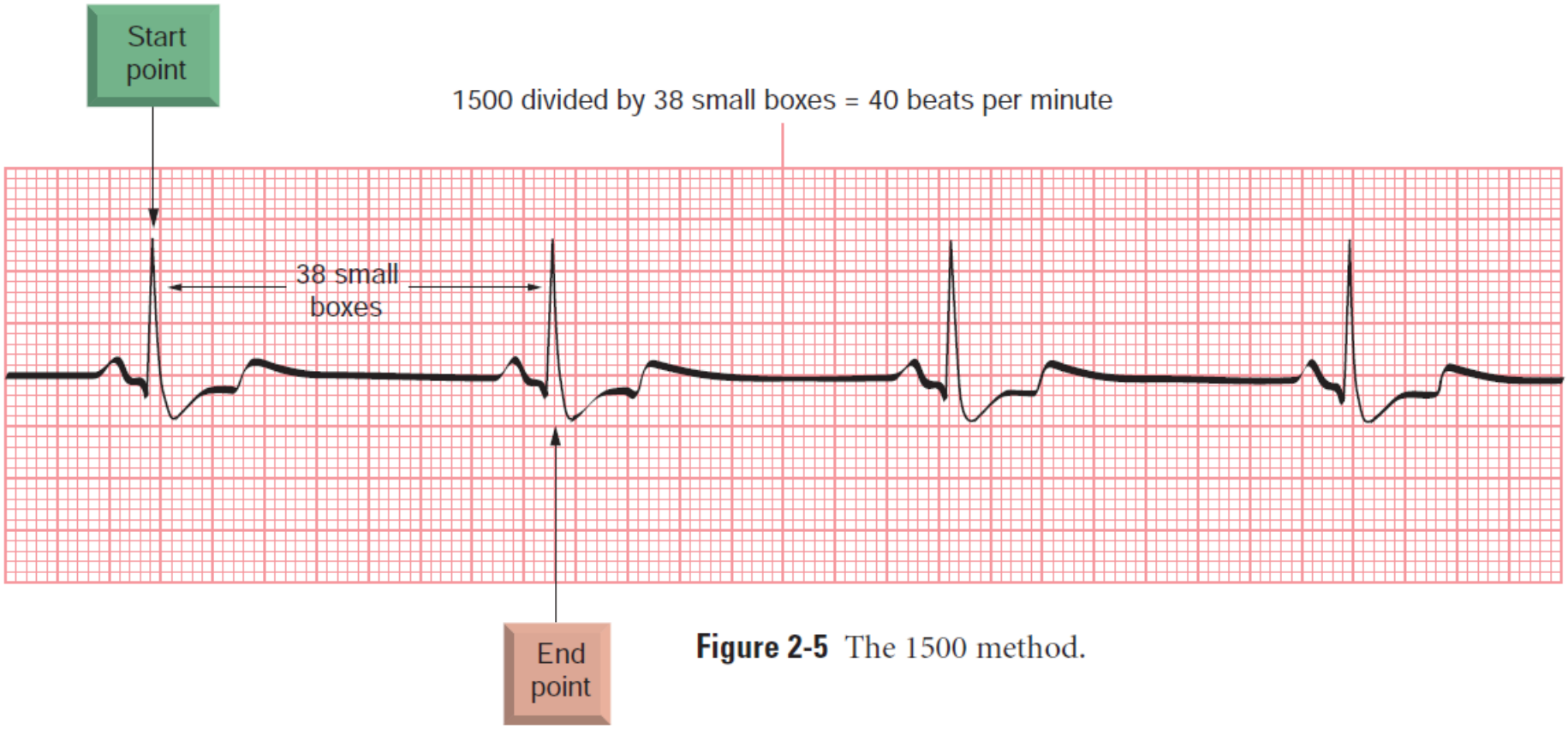
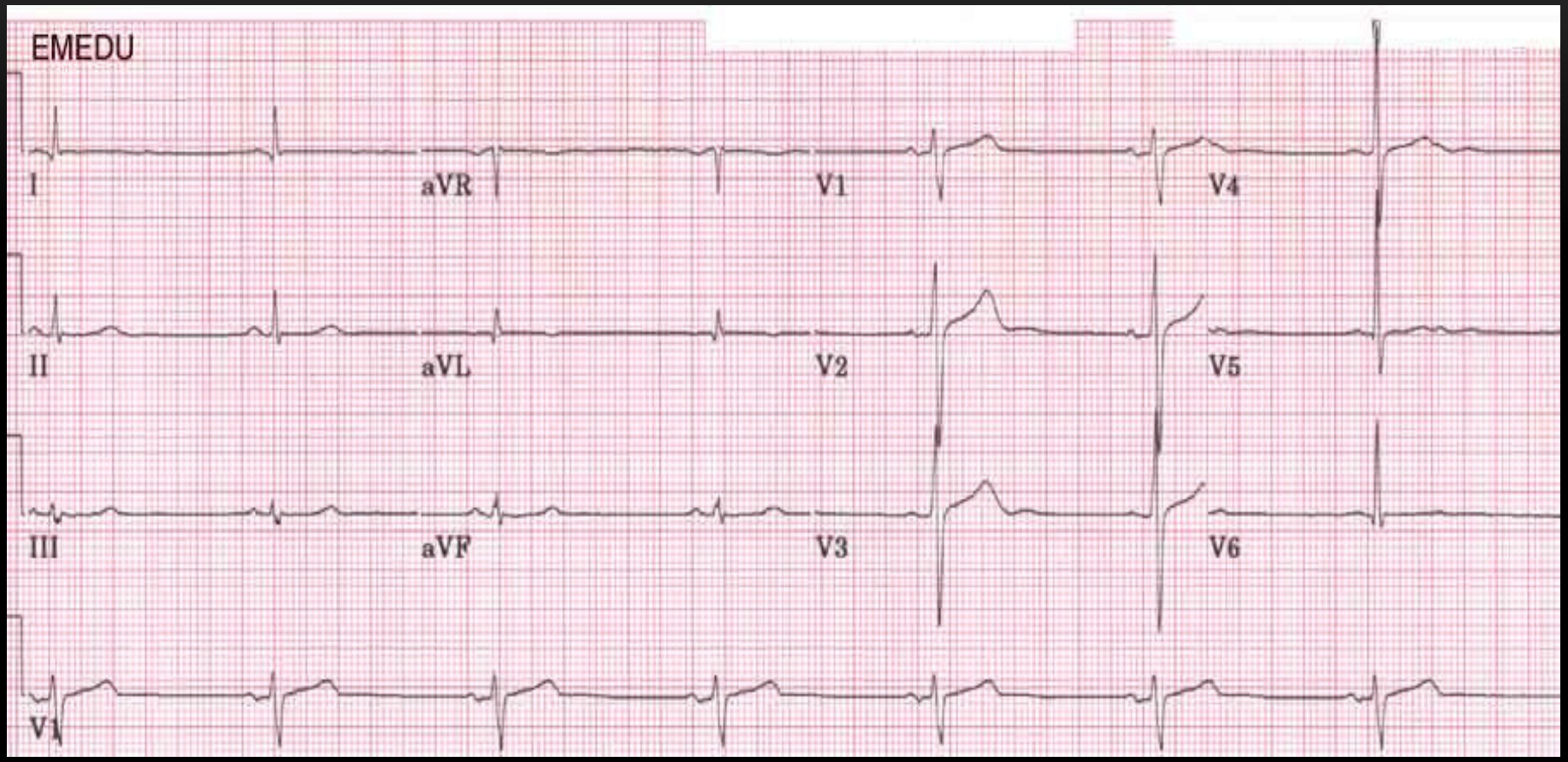


Figure 2-5 The 1500 method.

10 SECOND RULE

As most EKGs record 10 seconds of rhythm per page, one can simply count the number of beats present on the EKG and multiply by 6 to get the number of beats per 60 seconds.

This method works well for irregular rhythms.


EMEDU
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
V1

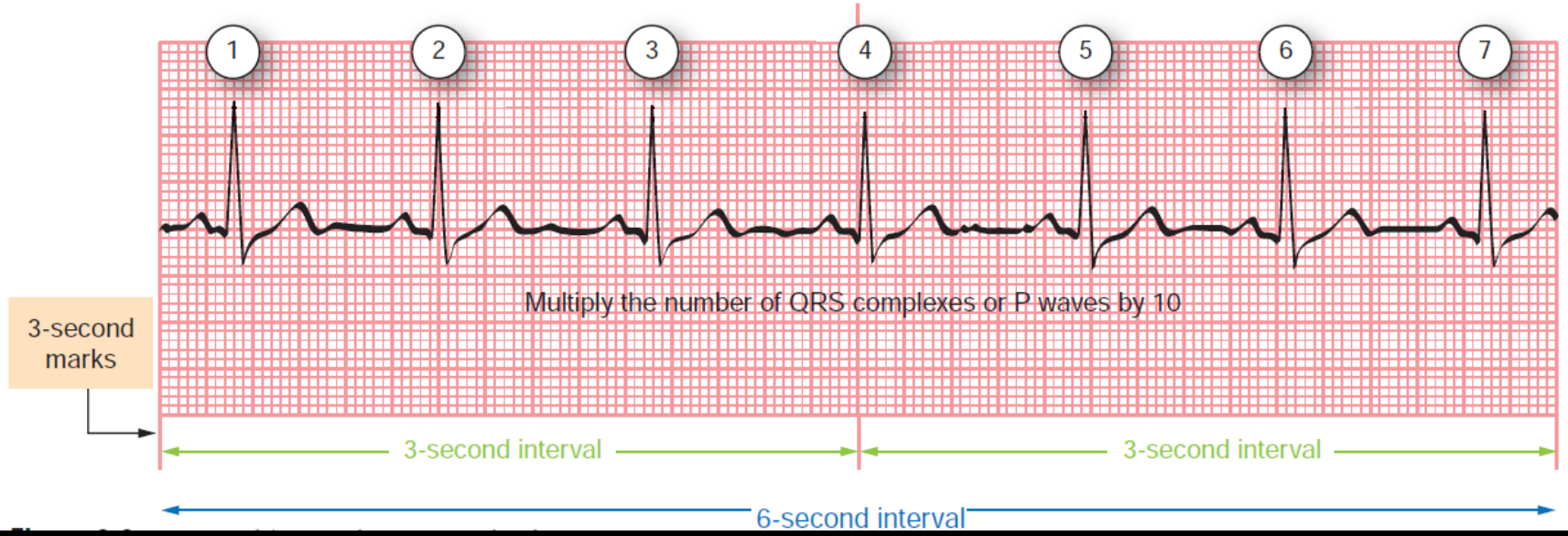
WHAT IS THE HEART RATE?

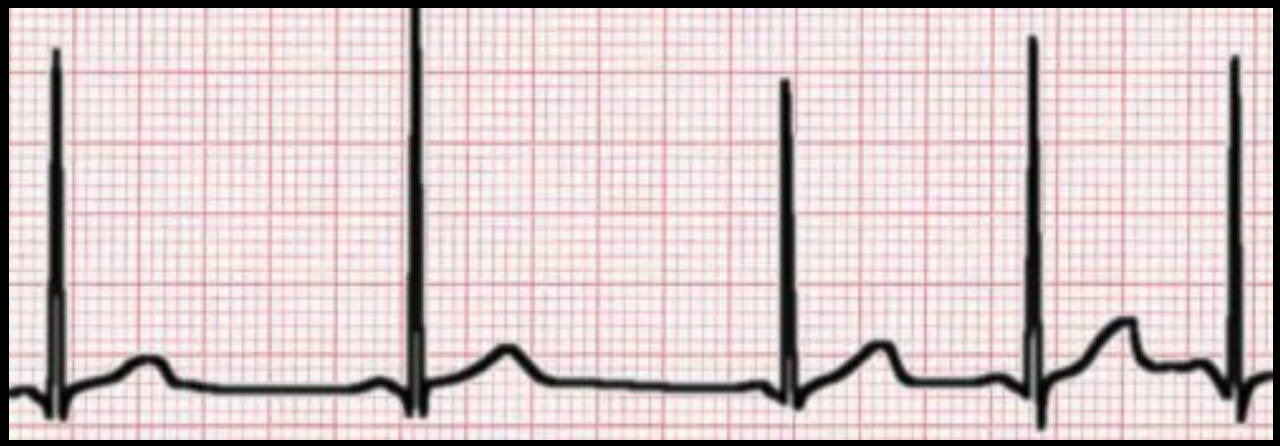
The Alan E. Lindsay ECG Learning Center, http://medstat.med.utah.edu/kw/ecg/

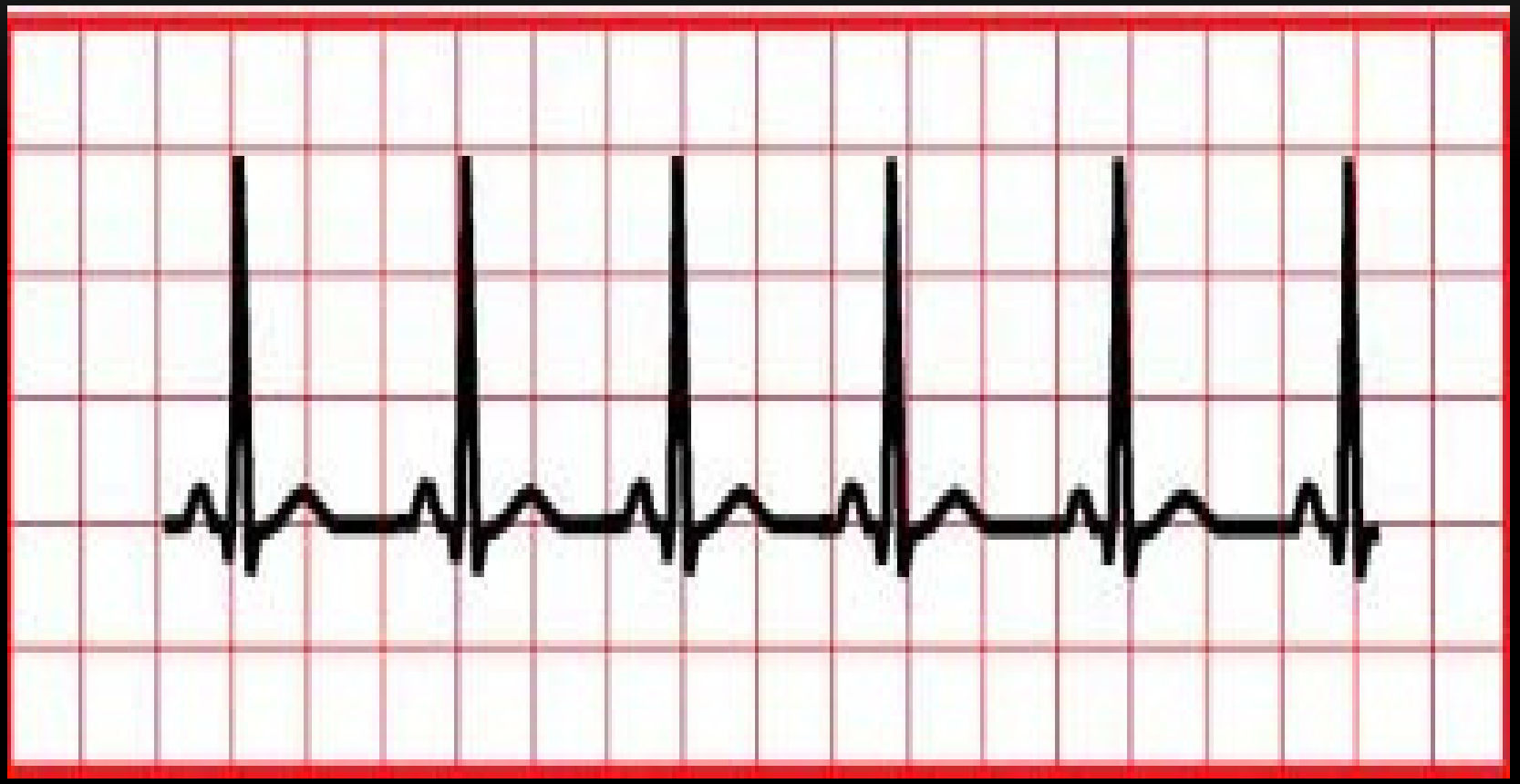
33 x 6 = 198 bpm

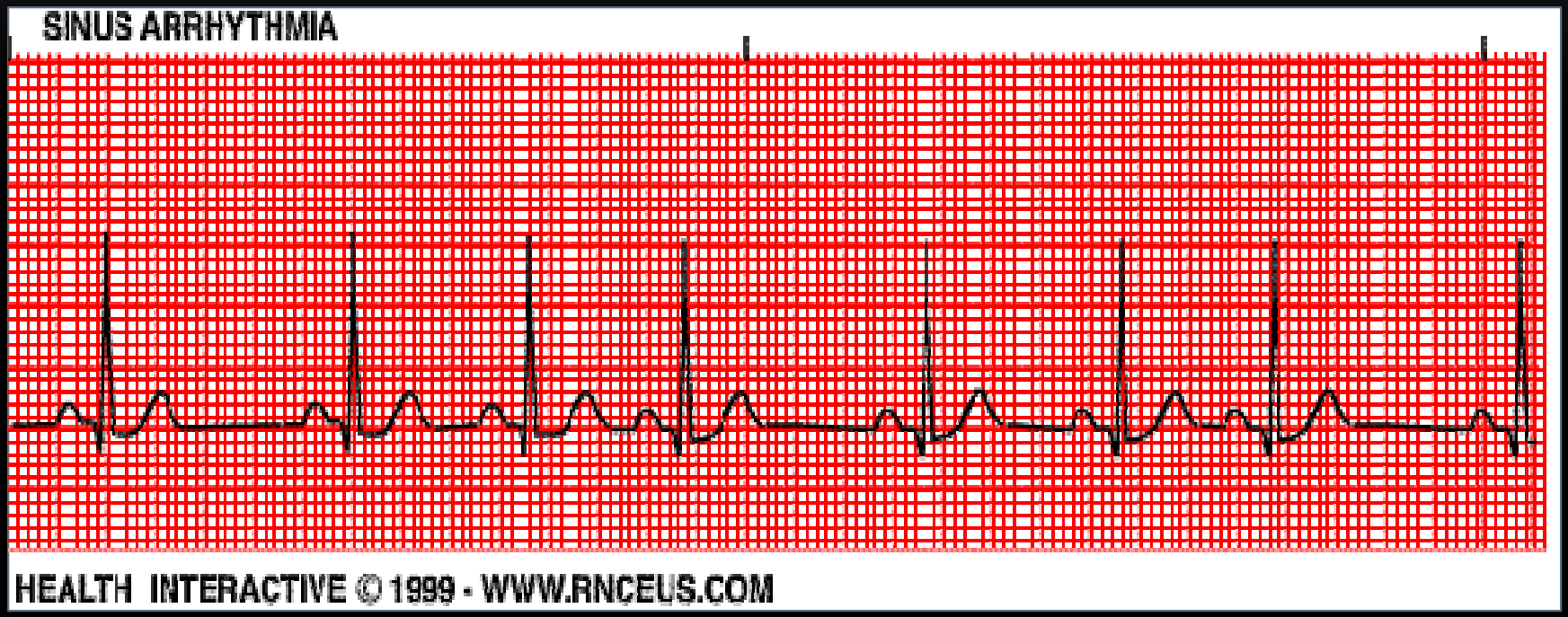
Using the 6-second × 10 method

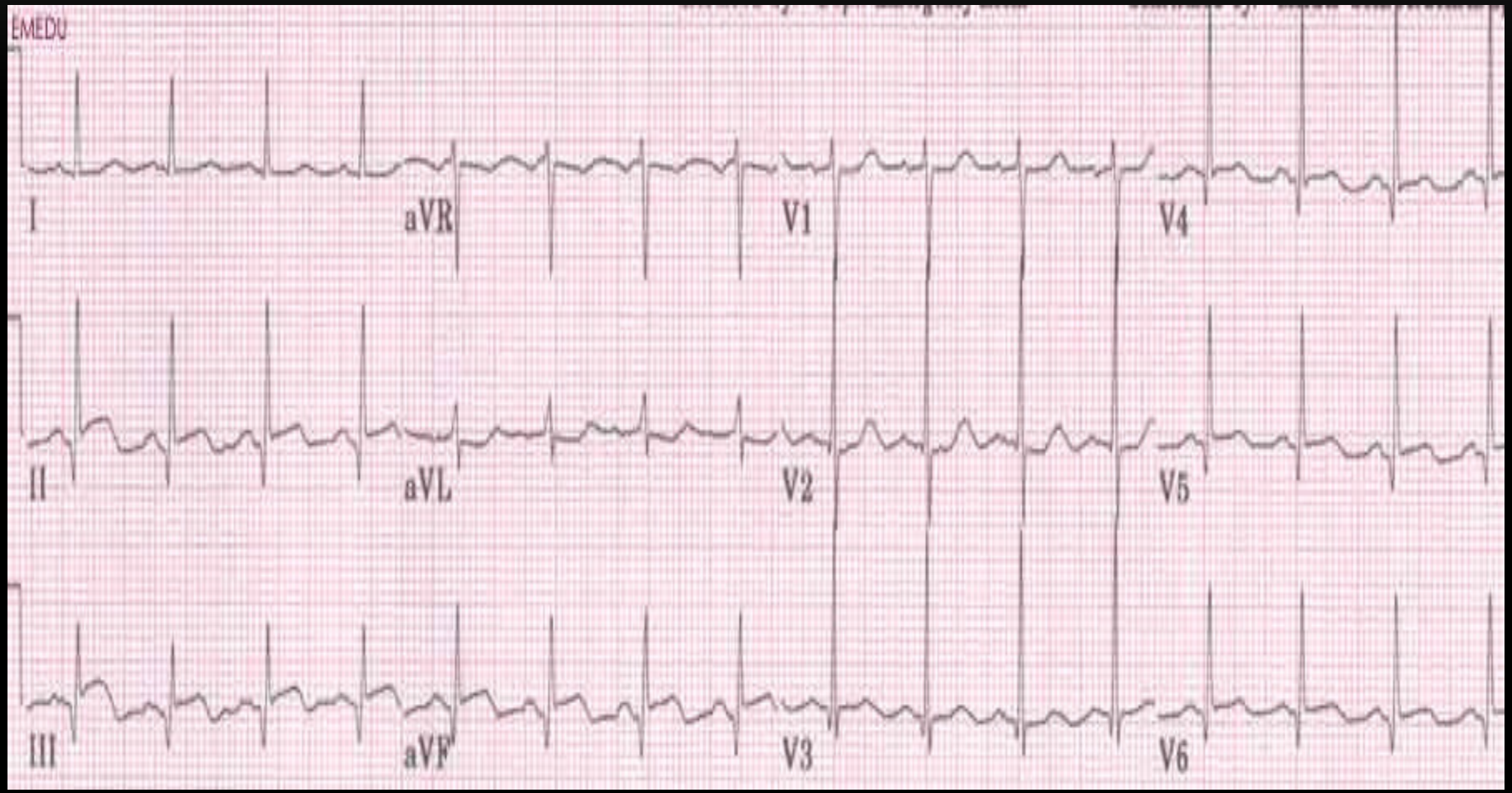
- Multiply by 10 the number of QRS complexes (for the ventricular rate) and the P waves (for the atria rate) found in a 6-second portion of ECG tracing. The rate in the ECG below is approximately 70 beats per minute.



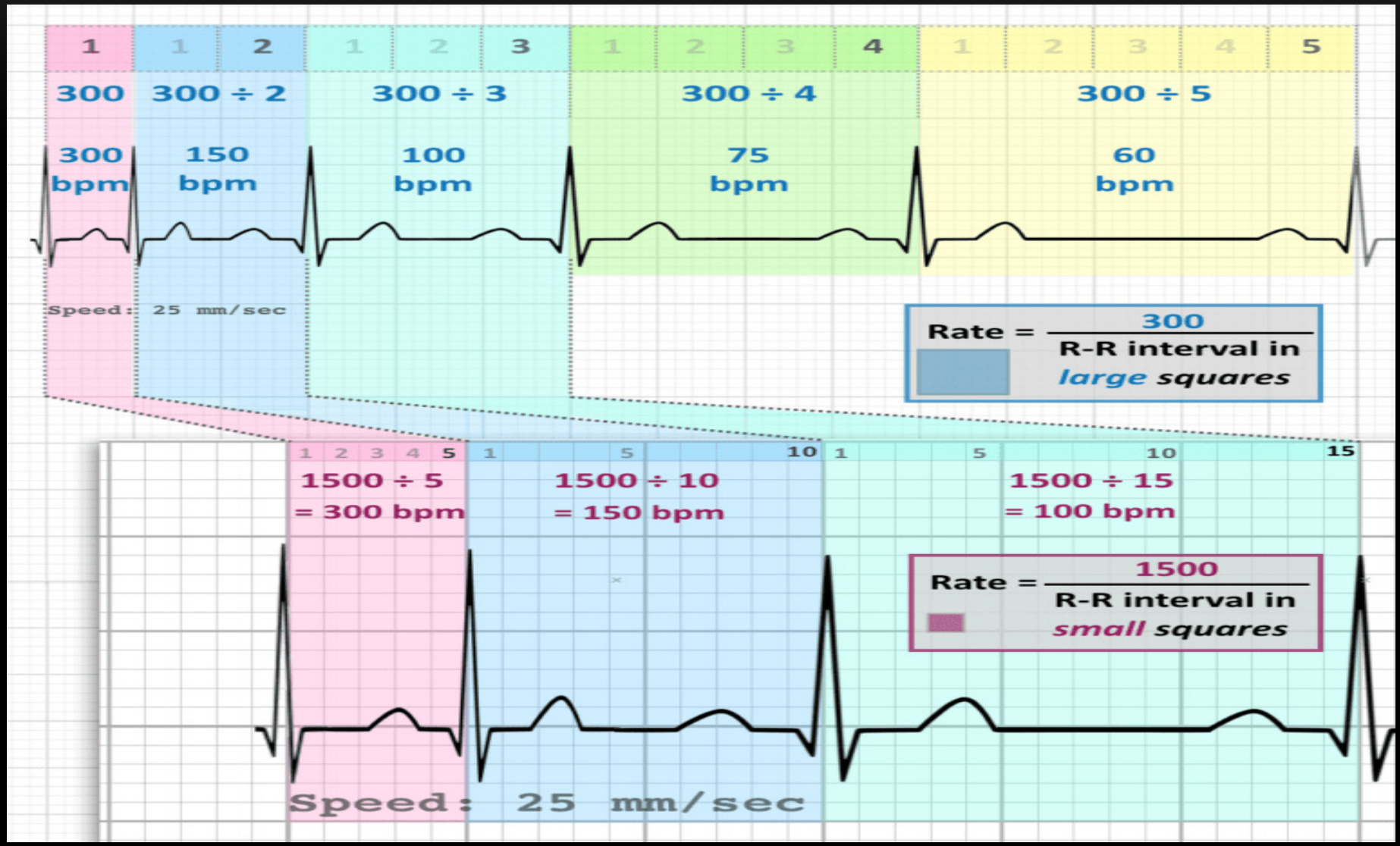





SINUS ARRHYTHMIA
HEALTH INTERACTIVE © 1999 - WWW.RNCEUS.COM

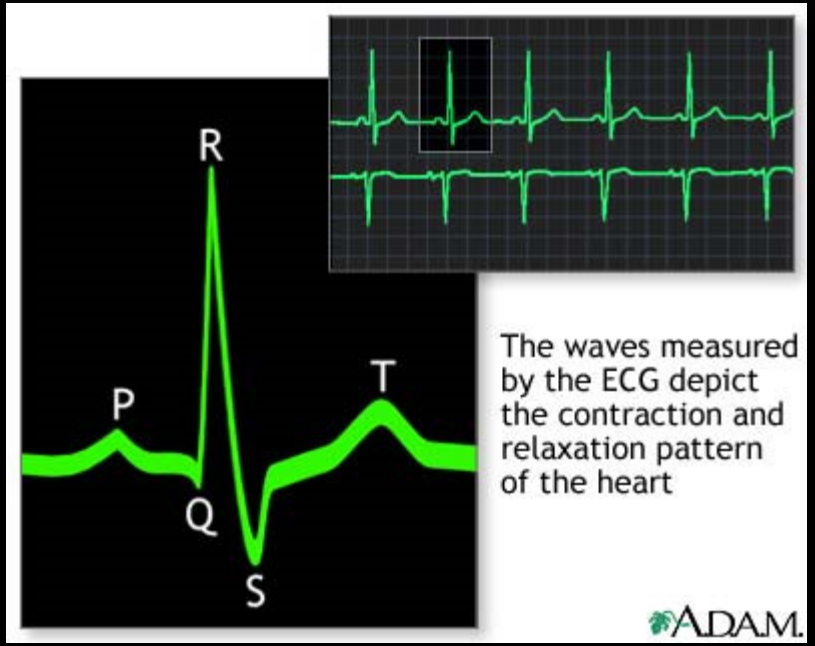

EMEDU
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6

RATE - SUMMARY

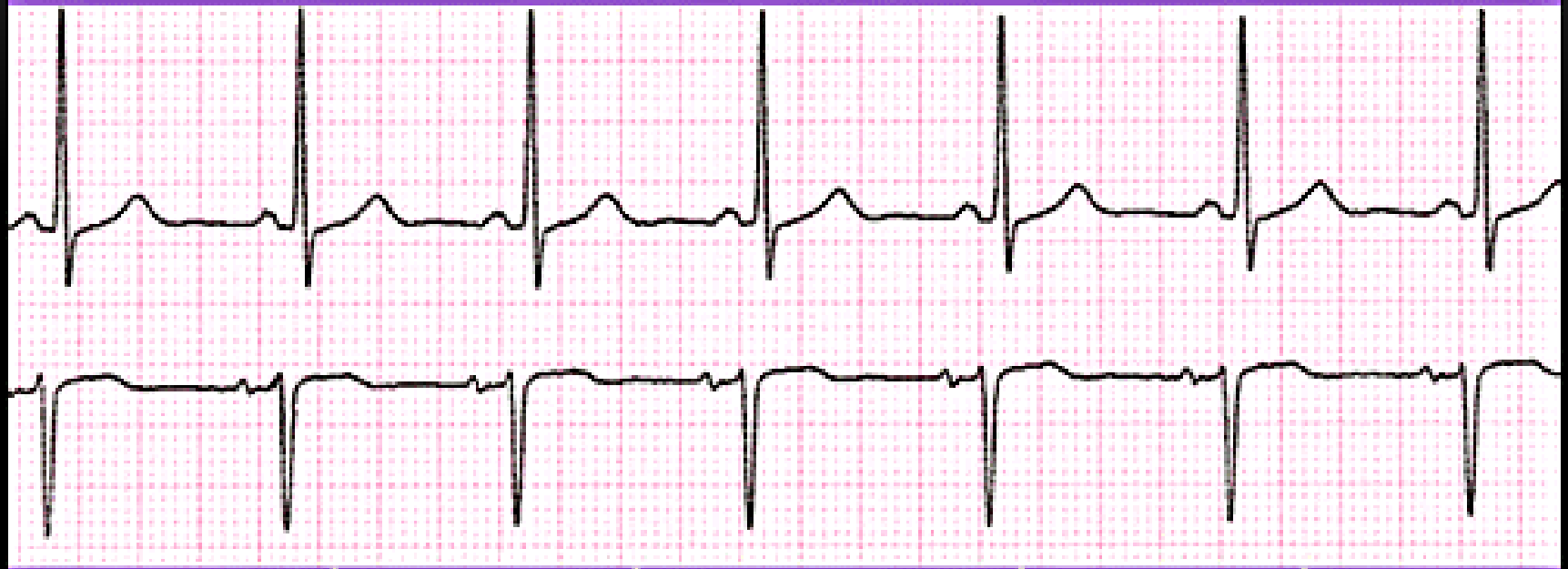


ECG - RHYTHM

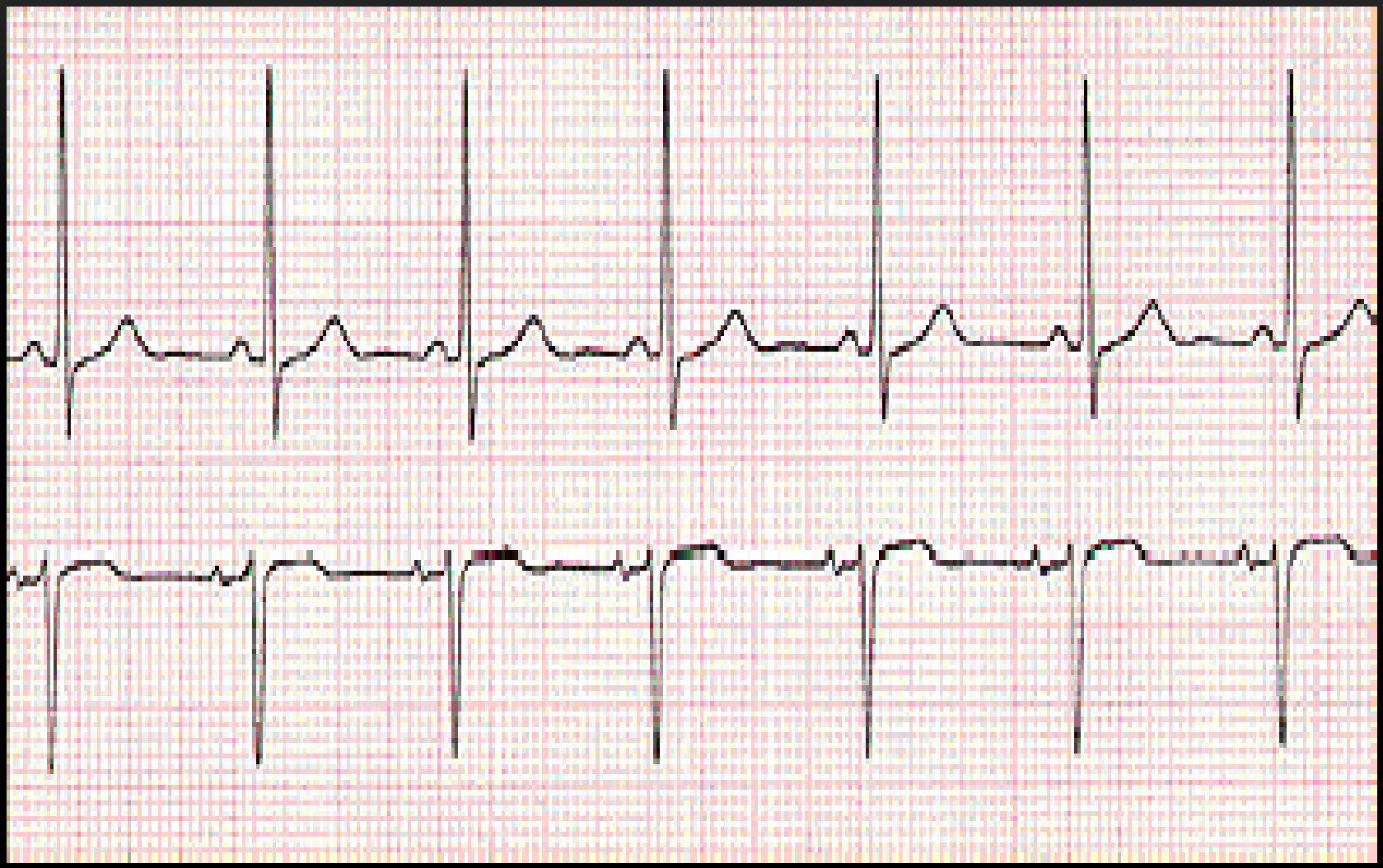
- <u>Normal Sinus Rhythm</u>
  - Electrical activity activity starts in SA node
    - AV Junction
    - Bundle Branches
    - Ventricles
    - Depolarization of atria and ventricles
  - Rate: 60-100 /Regular
  - PR interval / QRS duration normal

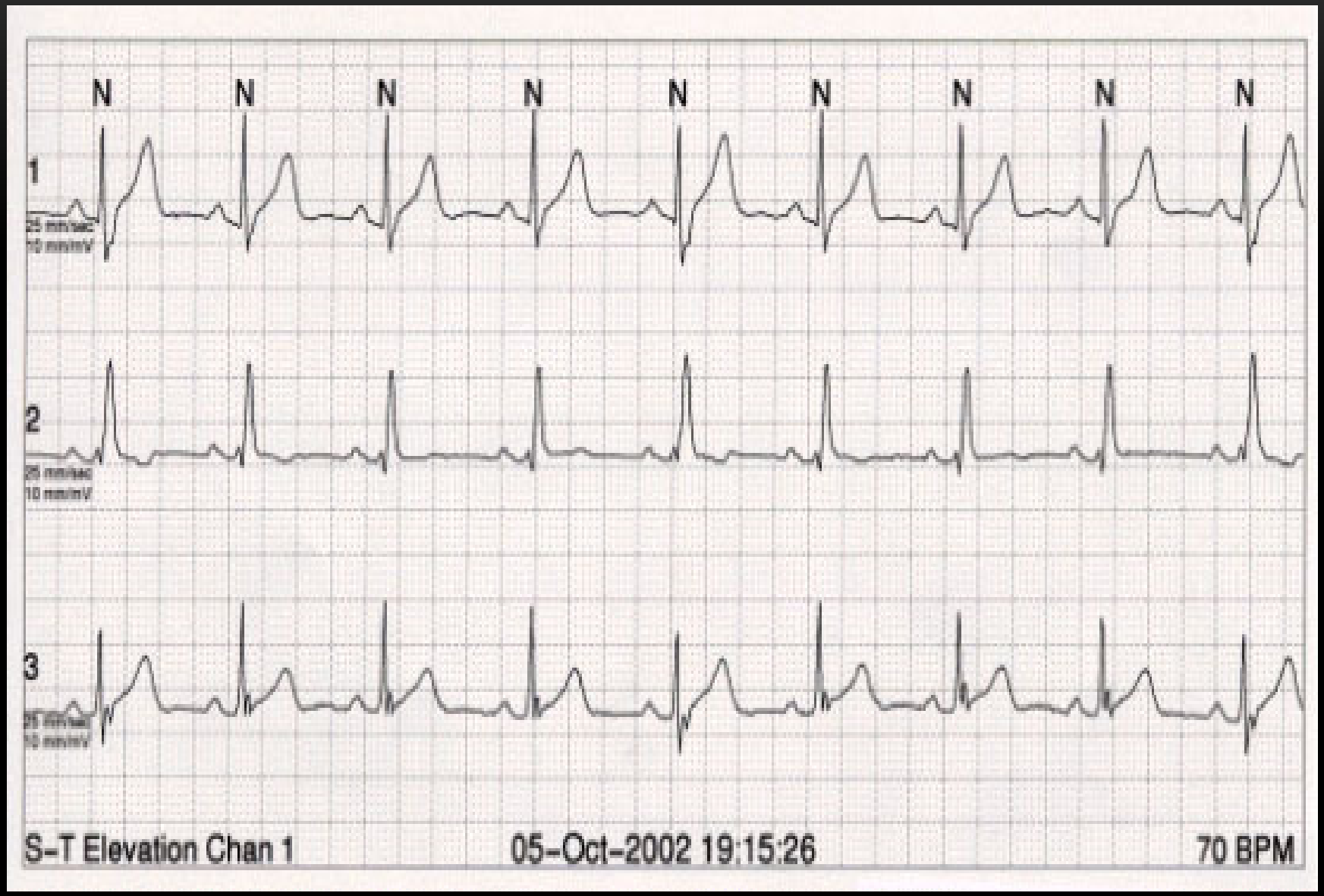


Normal Sinus Rhythm



Heart Rate	Rhythm	P Wave	PR interval (in seconds)	QRS (in seconds)
60-100 bpm	Regular	Before each QRS, identical	.12 to .20	<.12




N N N N N N N N N
1
25 mm/sec
10 mm/mV
2
25 mm/sec
10 mm/mV
3
S-T Elevation Chan 1
05-Oct-2002 19:15:26
70 BPM

ECG - AXIS

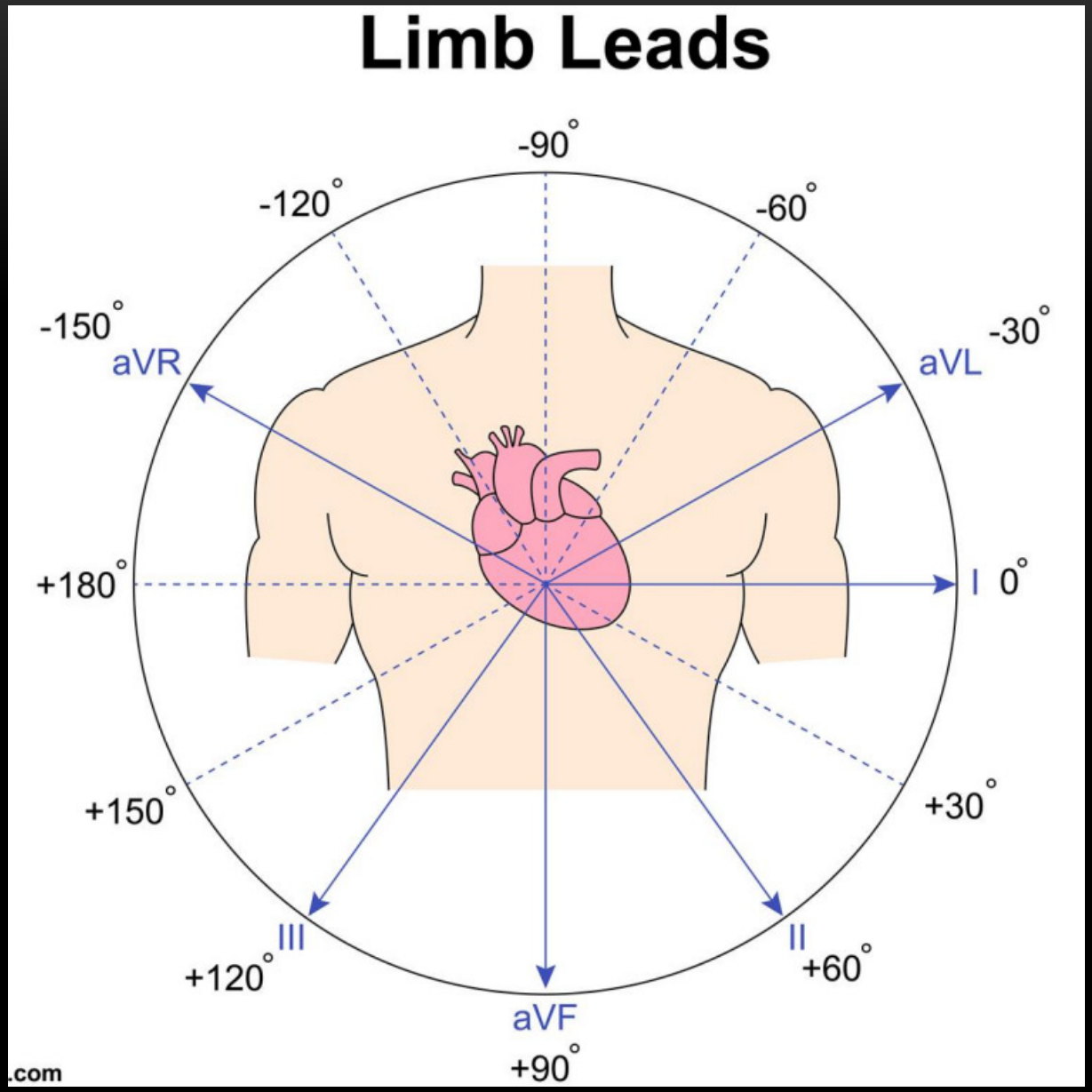
- The Quadrant Approach
- The Equiphasic Approach

DETERMINING THE AXIS

Predominantly Positive

Predominantly Negative

Equiphasic

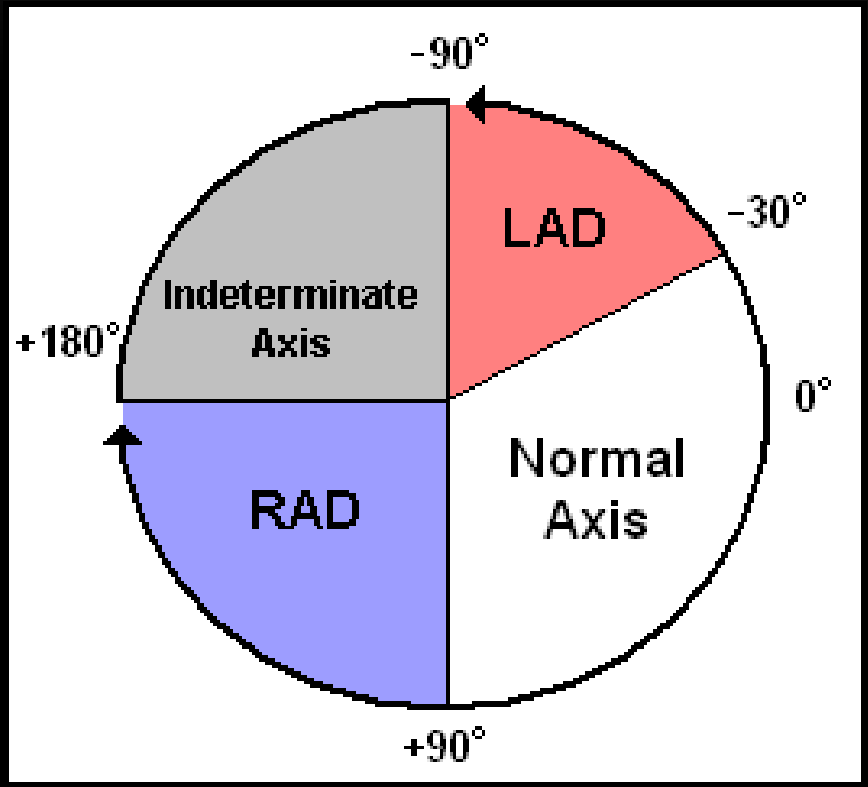

Limb Leads
-90°
-120°
-60°
-150°
-30°
aVR
aVL
+180°
I 0°
+150°
+30°
III
II
+120°
+60°
aVF
+90°
.com

THE QRS AXIS

By near-consensus, the normal QRS axis is defined as ranging from -30° to +90°.

-30° to -90° is referred to as a left axis deviation (LAD)

+90° to +180° is referred to as a right axis deviation (RAD)



THE QUADRANT APPROACH

1. Examine the QRS complex in leads I and aVF to determine if they are predominantly positive or predominantly negative. The combination should place the axis into one of the 4 quadrants below.

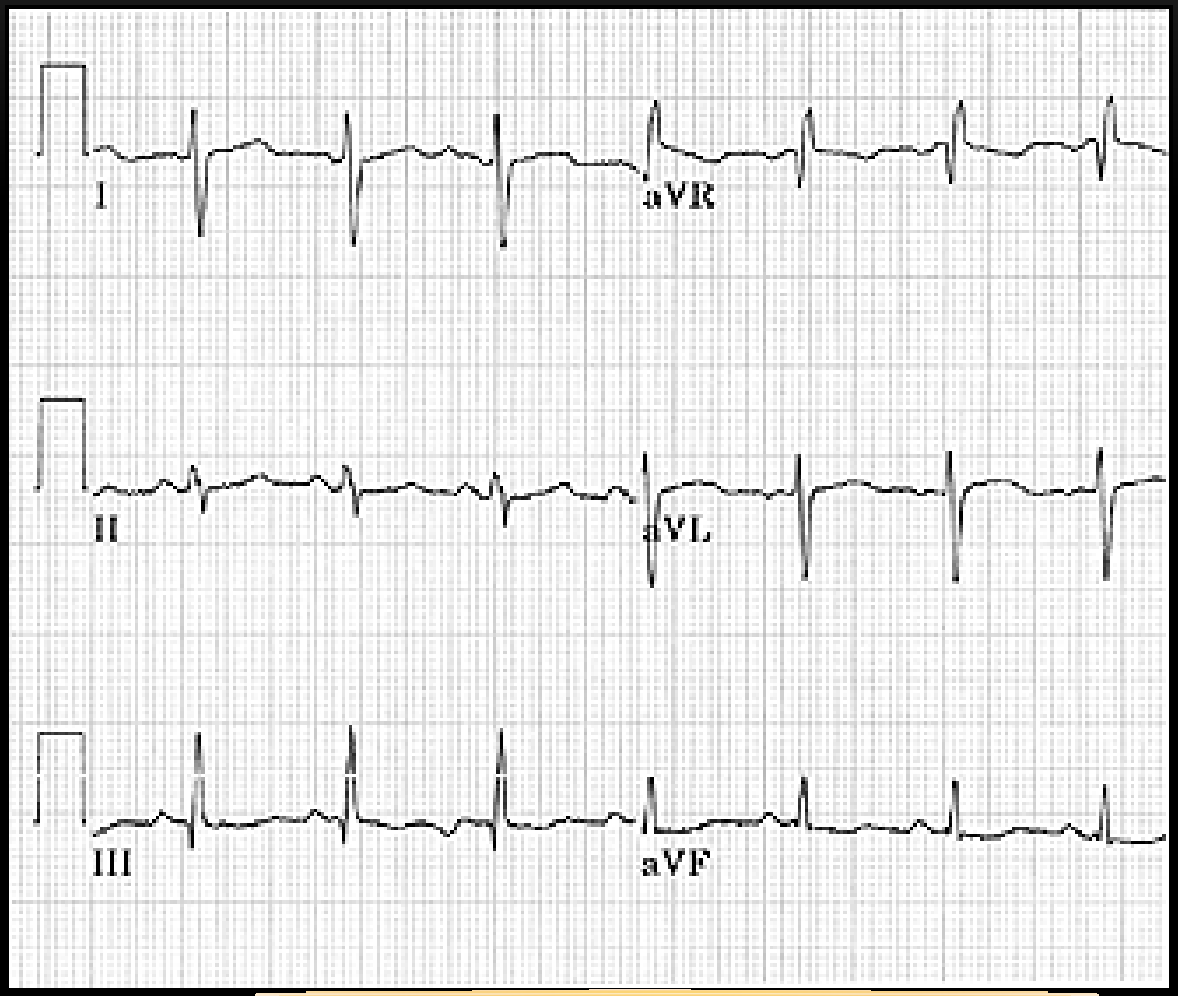
		Lead aVF	
		Positive	Negative
Lead I	Positive	Normal Axis	LAD
	Negative	RAD	Indeterminate Axis

THE QUADRANT APPROACH

2. In the event that LAD is present, examine lead II to determine if this deviation is pathologic. If the QRS in II is predominantly positive, the LAD is non-pathologic (in other words, the axis is normal). If it is predominantly negative, it is pathologic.

		Lead aVF	
		Positive	Negative
Lead I	Positive	Normal Axis	LAD
	Negative	RAD	Indeterminate Axis

QUADRANT APPROACH: EXAMPLE 1



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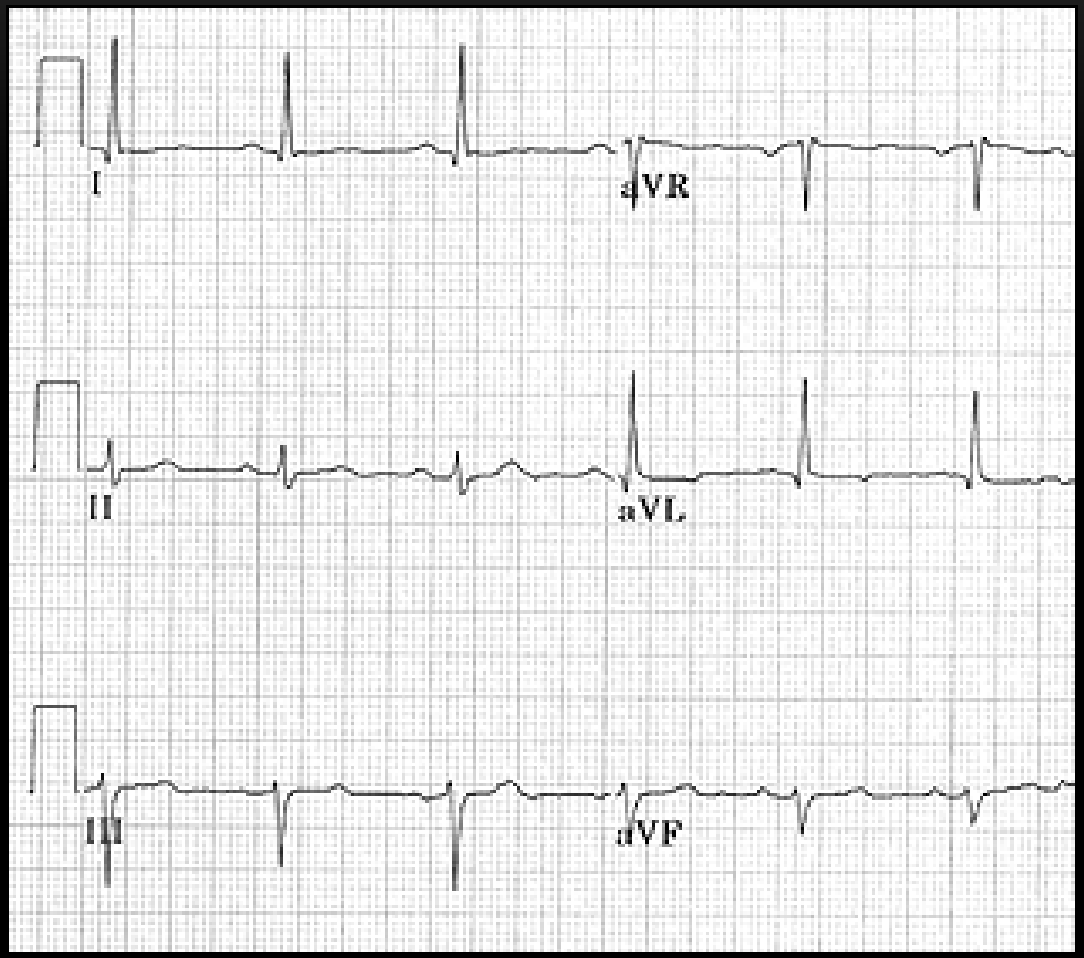
Negative in I, positive in aVF → RAD

QUADRANT APPROACH: EXAMPLE 2



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Positive in I, negative in aVF → Predominantly positive in II →

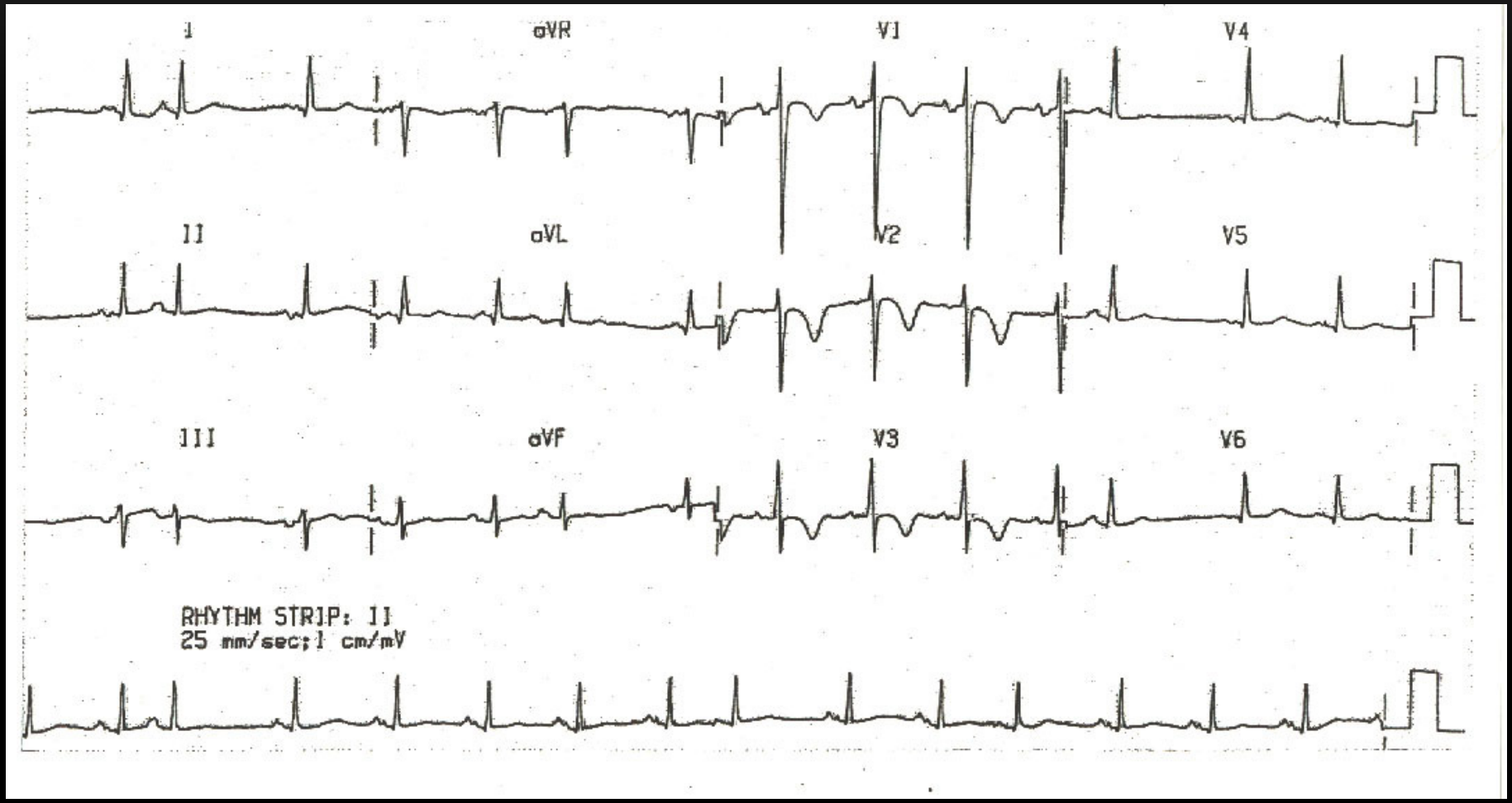
Normal Axis (non-pathologic LAD)

THE EQUIPHASIC APPROACH

1. Determine which lead contains the most equiphasic QRS complex. The fact that the QRS complex in this lead is equally positive and negative indicates that the net electrical vector (i.e. overall QRS axis) is perpendicular to the axis of this particular lead.

2. Examine the QRS complex in whichever lead lies 90° away from the lead identified in step 1. If the QRS complex in this second lead is predominantly positive, than the axis of this lead is approximately the same as the net QRS axis. If the QRS complex is predominantly negative, than the net QRS axis lies 180° from the axis of this lead.

EQUIPHASIC APPROACH: EXAMPLE 1



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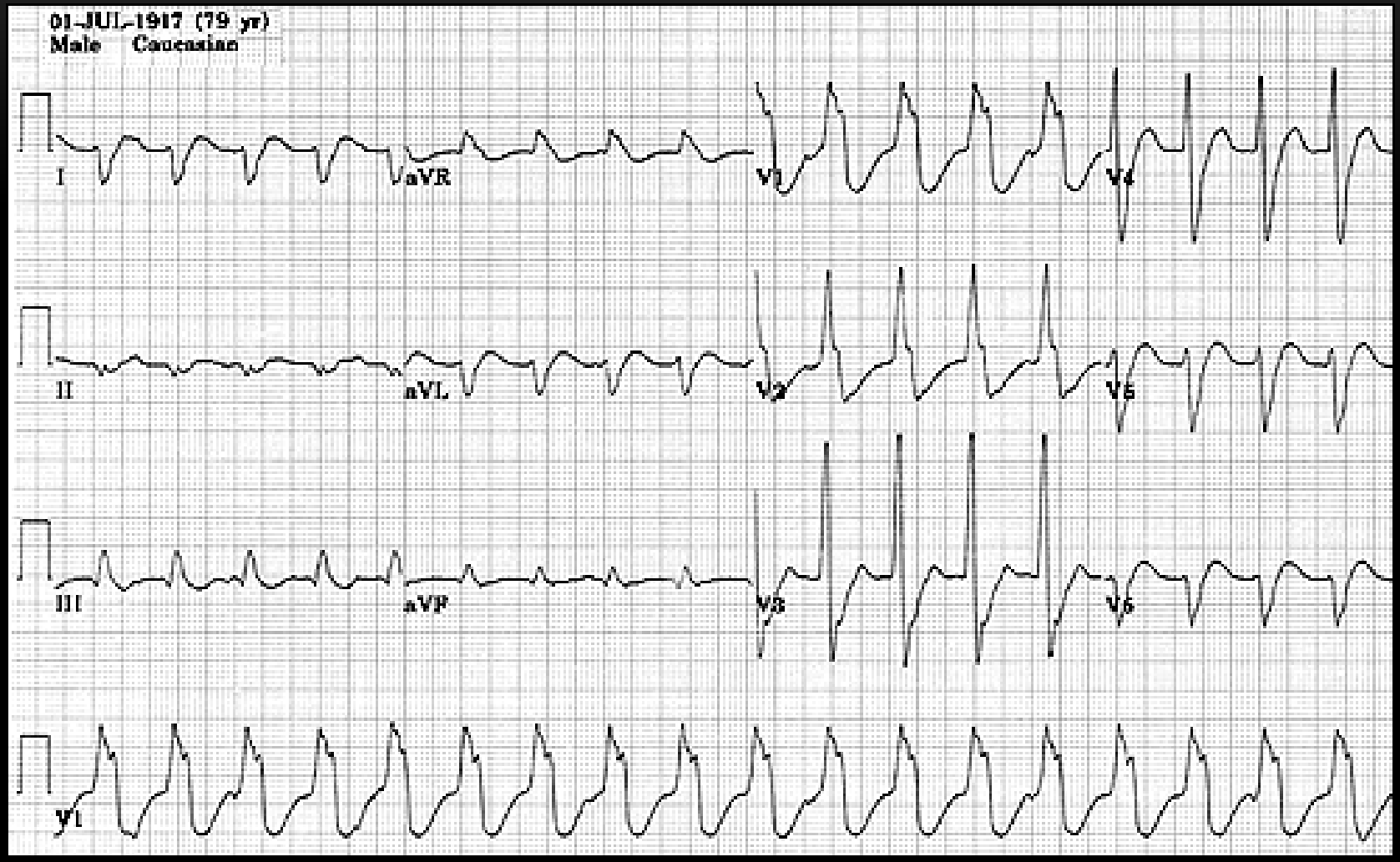
Equiphasic in aVF → Predominantly positive in I → QRS axis ≈ 0°

EQUIPHASIC APPROACH: EXAMPLE 2



The Alan E. Lindsay ECG Learning Center ; http://medstat.med.utah.edu/kw/ecg/

Equiphasic in II → Predominantly negative in aVL → QRS axis ≈ +150°

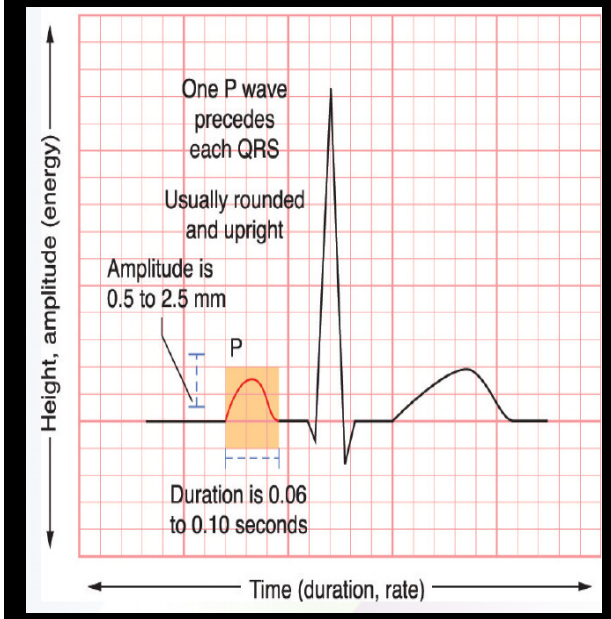
SYSTEMATIC APPROACH

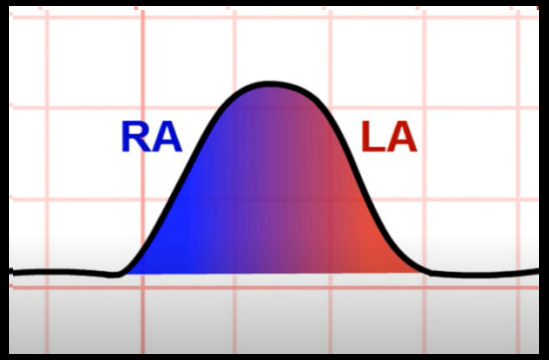
- Rate
- Rhythm
- Axis
- Wave / Intervals / Segments

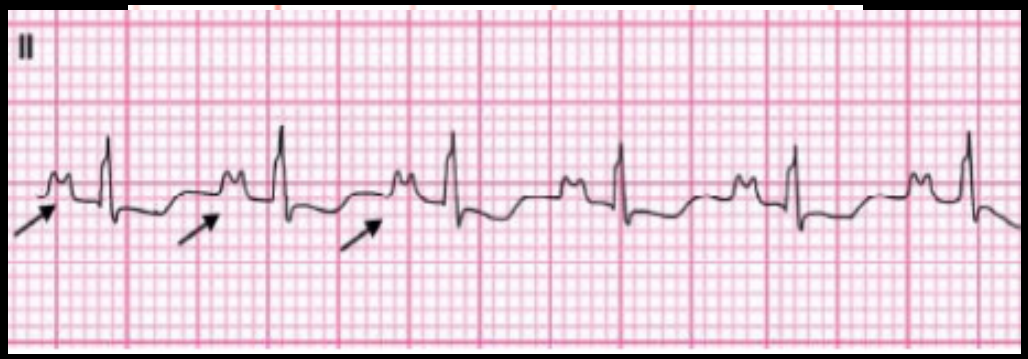
P - WAVE

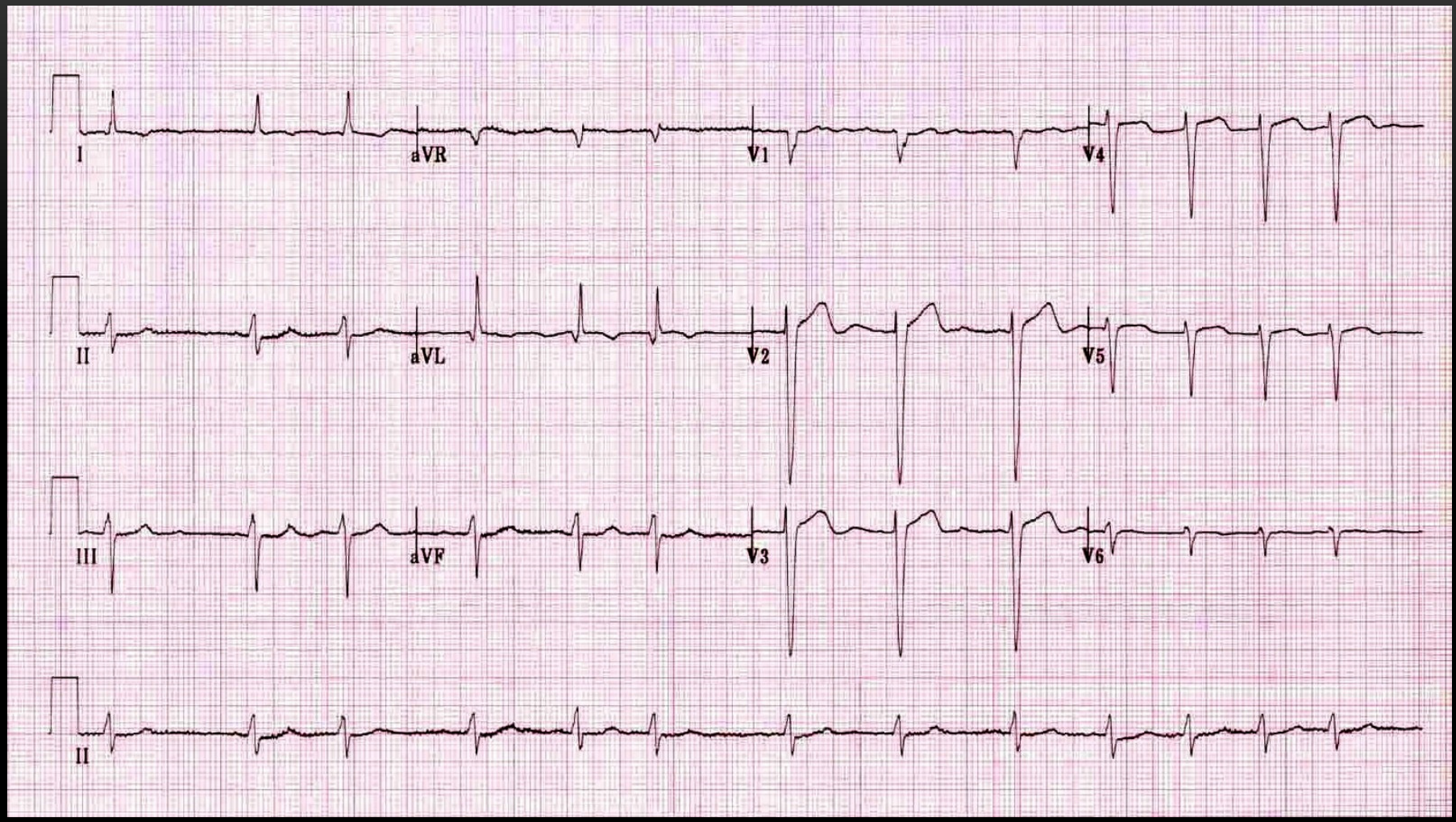
P mitrale, P Pulmonale,
Inverted / Polymorphic
Flutter/ Fibrillatory / Absent

2.5 x 2.5, II







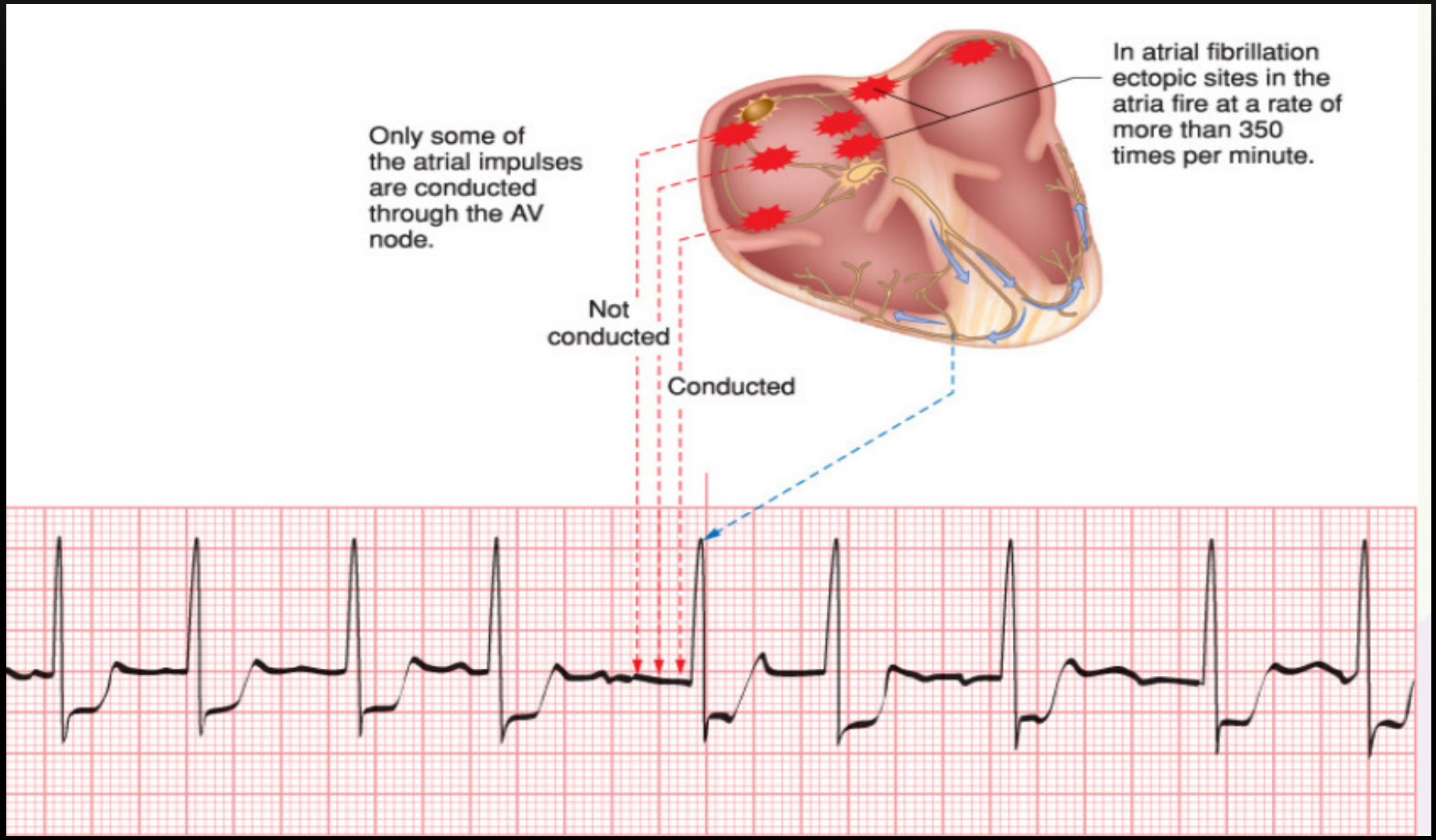


Rate:100/min P: Absent,Fibrillating baseline QRS: Normal

Rhythm : Irregularly irregular ST / Others : Normal

ATRIAL FIBRILLATION

ATRIAL FIBRILLATION



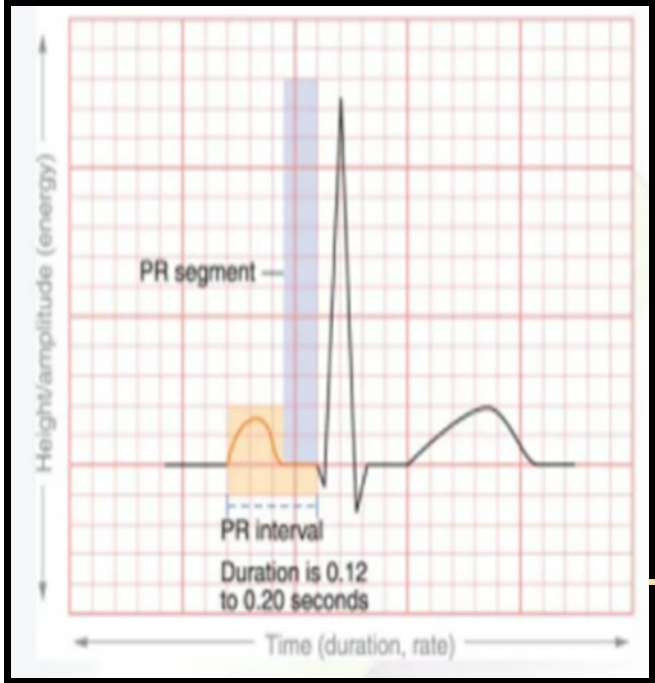
PR INTERVAL

NORMAL

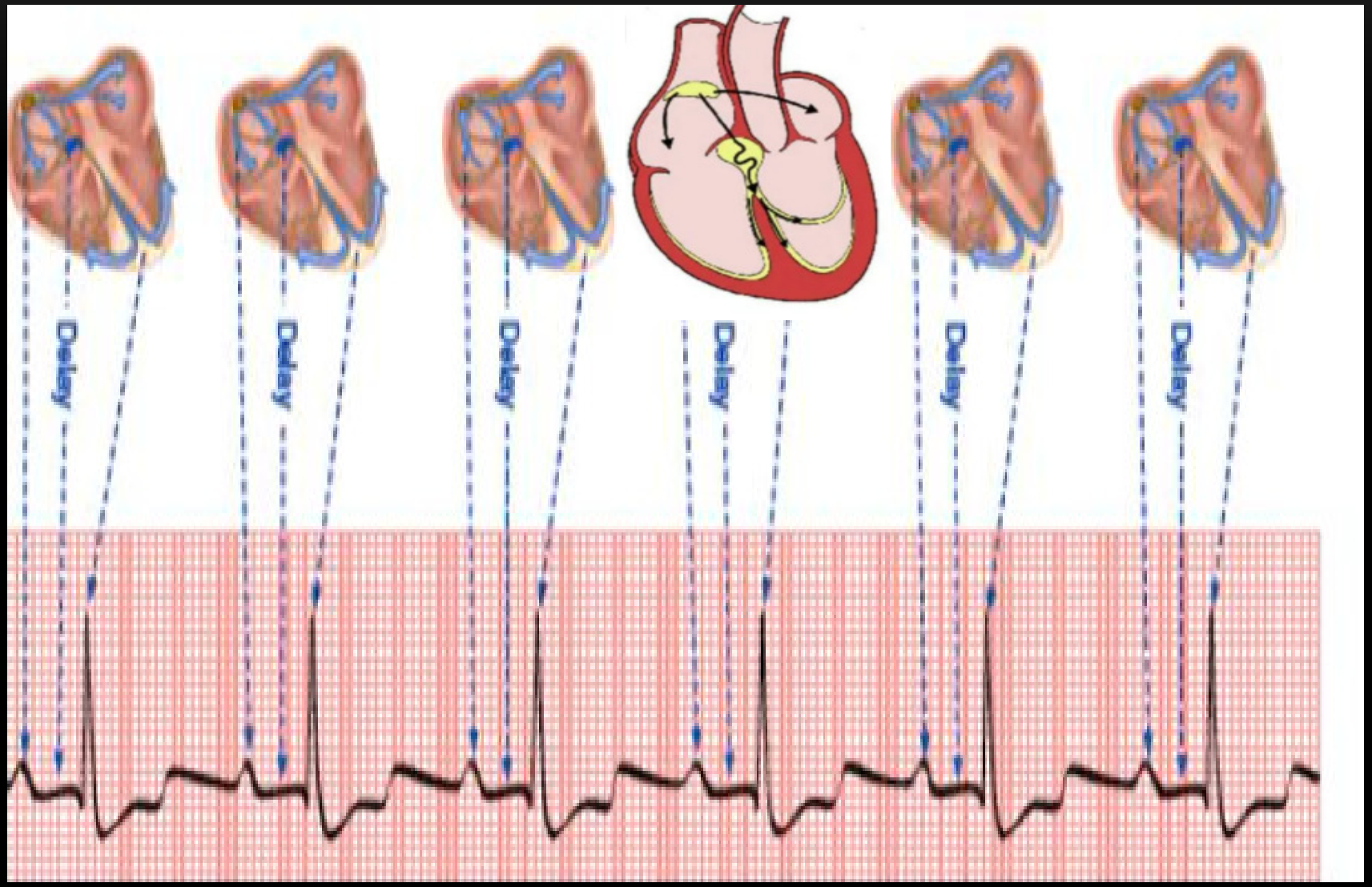
SHORT – WPW Syndrome
- L-G-L Syndrome

PROLONGED – 1st AV block

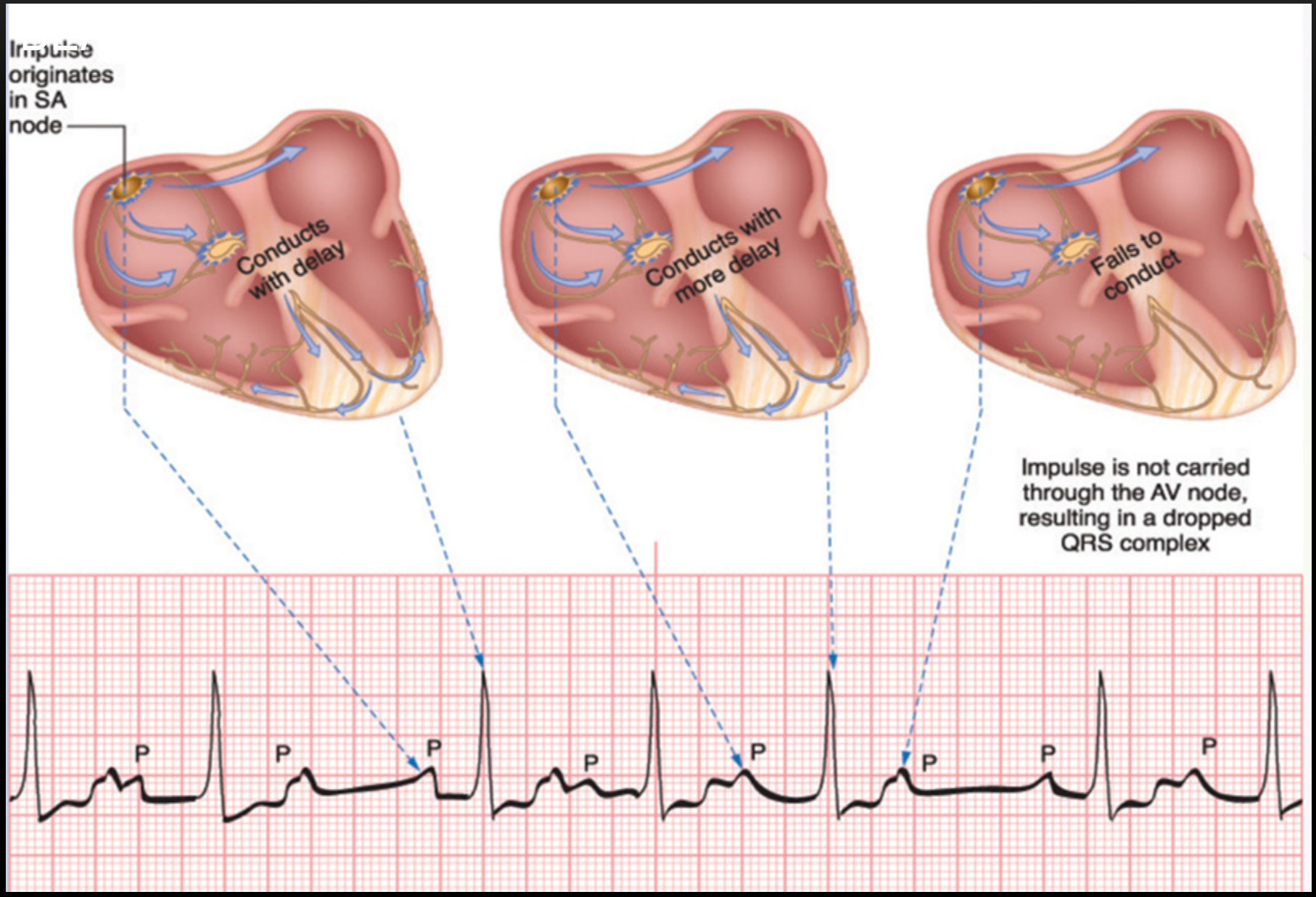
VARIABLE – 2nd / 3rd AV block



FIRST DEGREE AV BLOCK – FIXED PR PROLONGATION

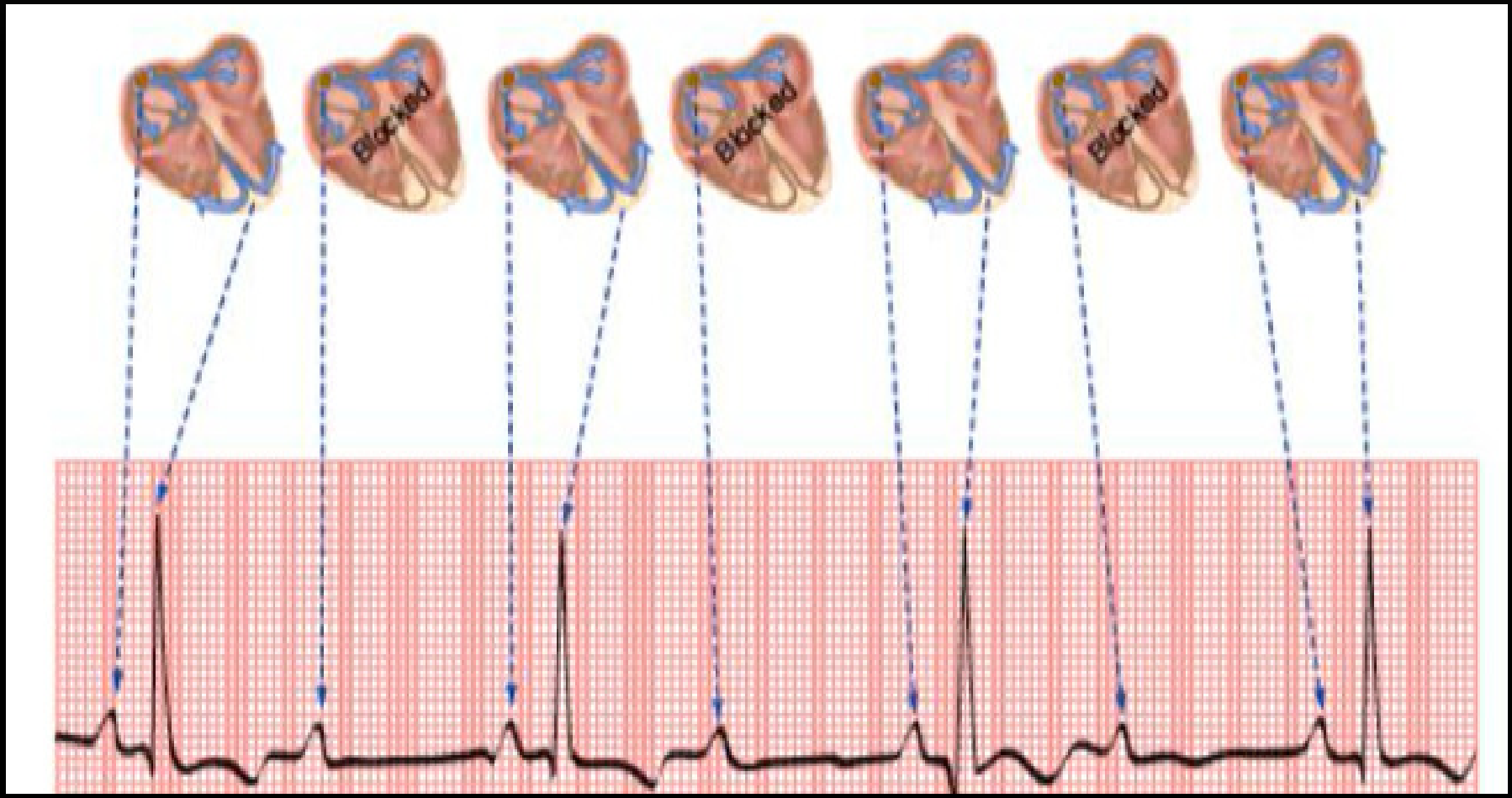


SECOND DEGREE AV BLOCK – WENKEBACH - MOBITZ TYPE 1 SEQUENTIAL ↑(WIDENING) PR →1 DROPPED

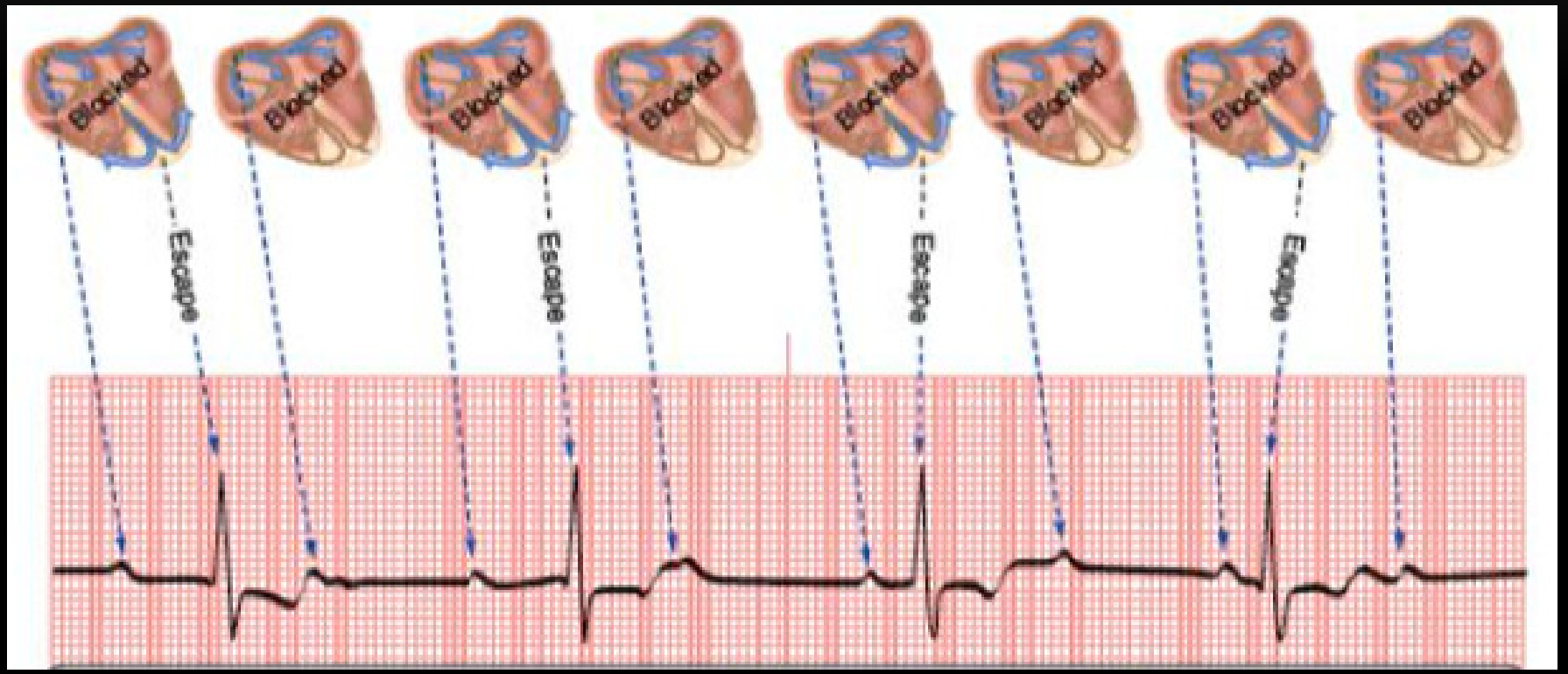


2ND HEART BLOCK – MOBITZ TYPE 2

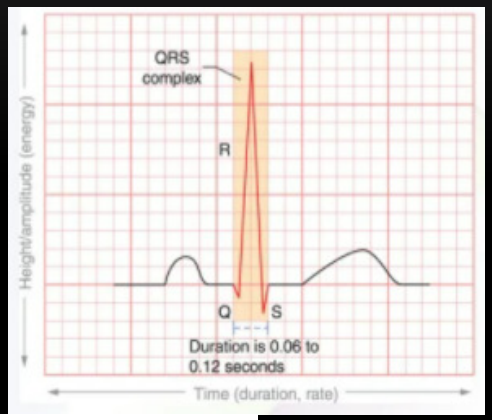
2 TYPES P – P-QRS (NORMAL PR), P × QRS



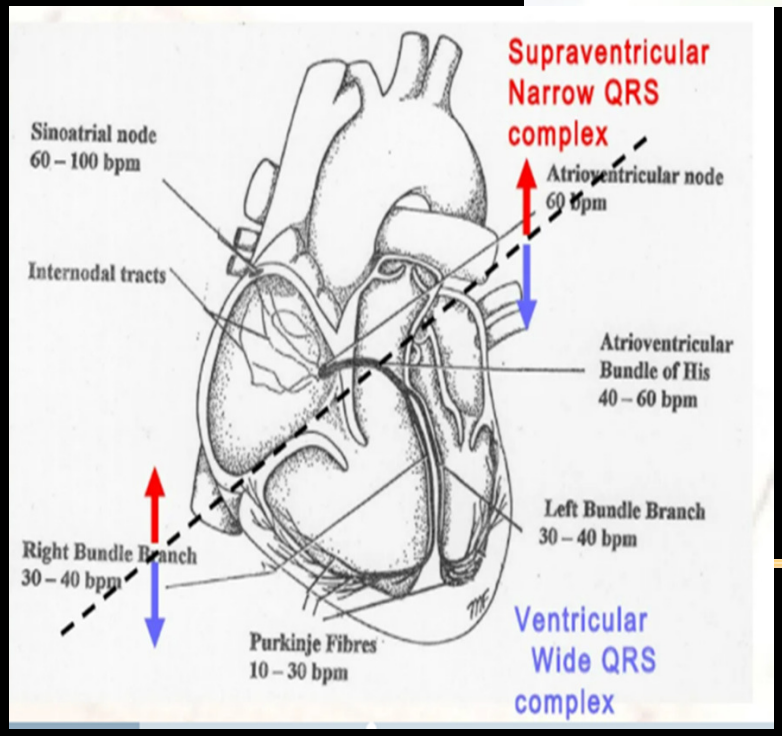
COMPLETE / 3RD DEGREE HEART BLOCK
COMPLETELY BLOCKED – ESCAPE RHYTHM



QRS - WAVE



- Depolarization - Ventricles
- **≤120 ms**
- **Three small squares**
- **Cardiac axis**



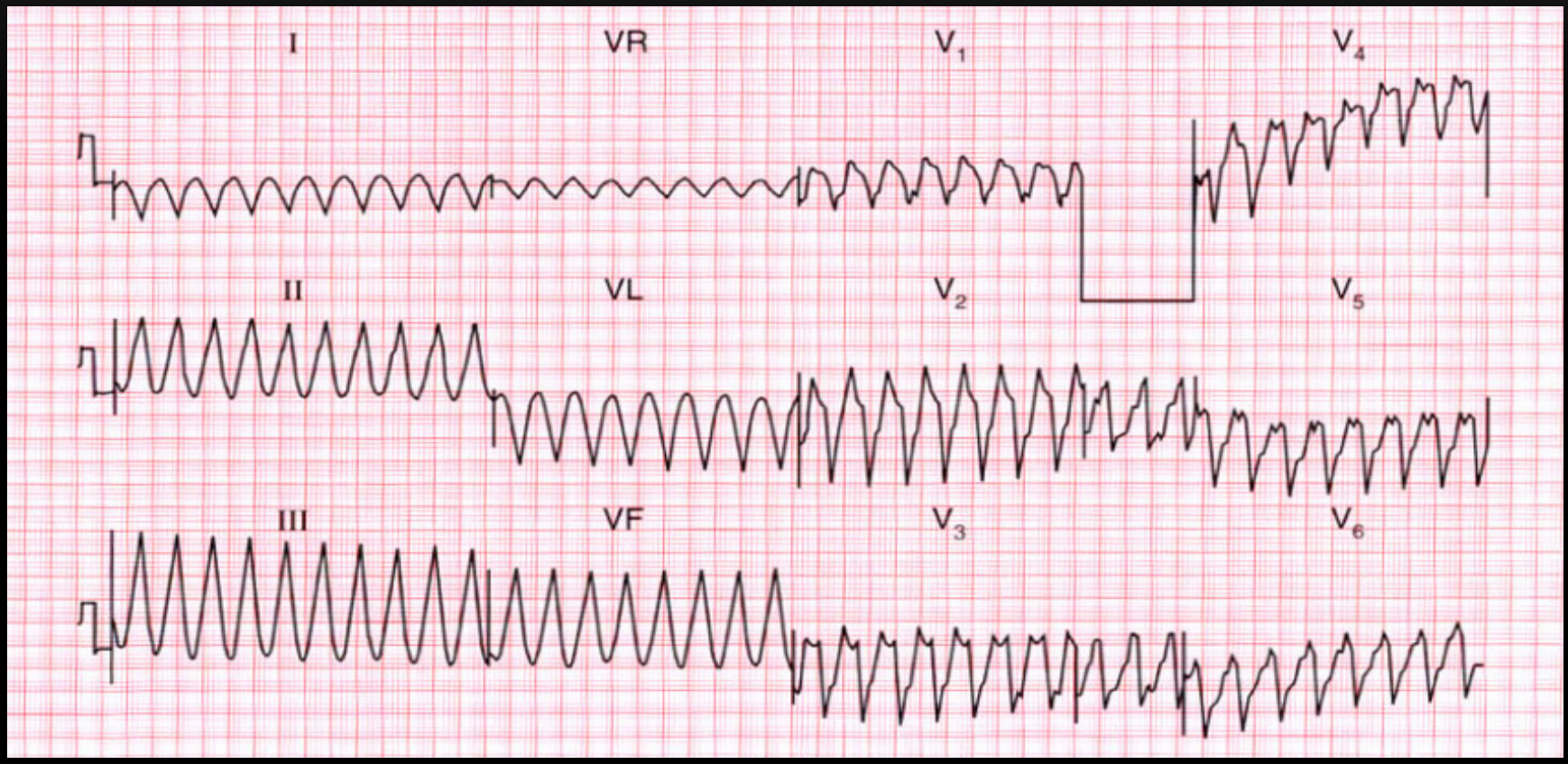
WIDE QRS

- Origin of depolarisation from ventricle
- Bundle branch block

TALL QRS

Ventricular hypertrophy

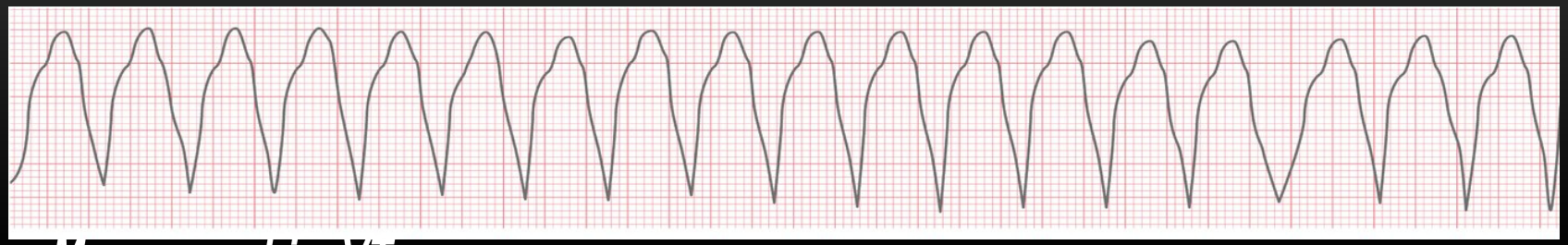
Patient admitted 1 h previously with an acute anterior myocardial infarction. The patient was cold and clammy, and confused, and his blood pressure was unrecordable.



Rate : 250/min P : Absent QRS: Wide

Rhythm : Regular

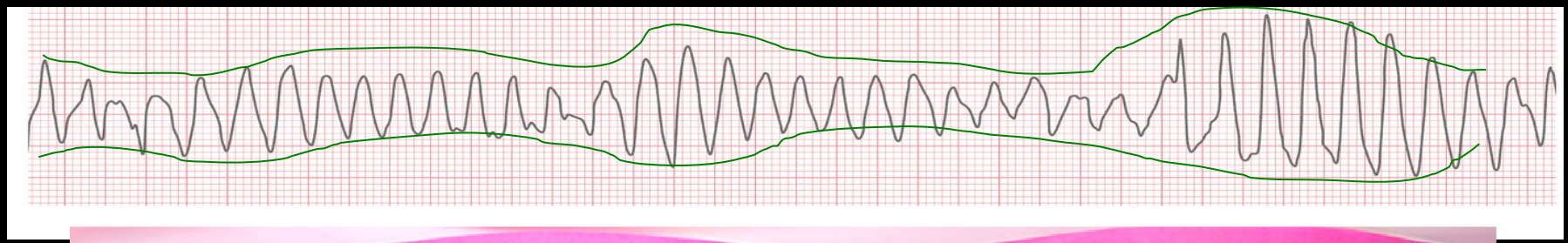
Ventricular Tachycardia



Monomorphic VT

Pattern of spread of each beat ('activation sequence') is the same

Scar-related



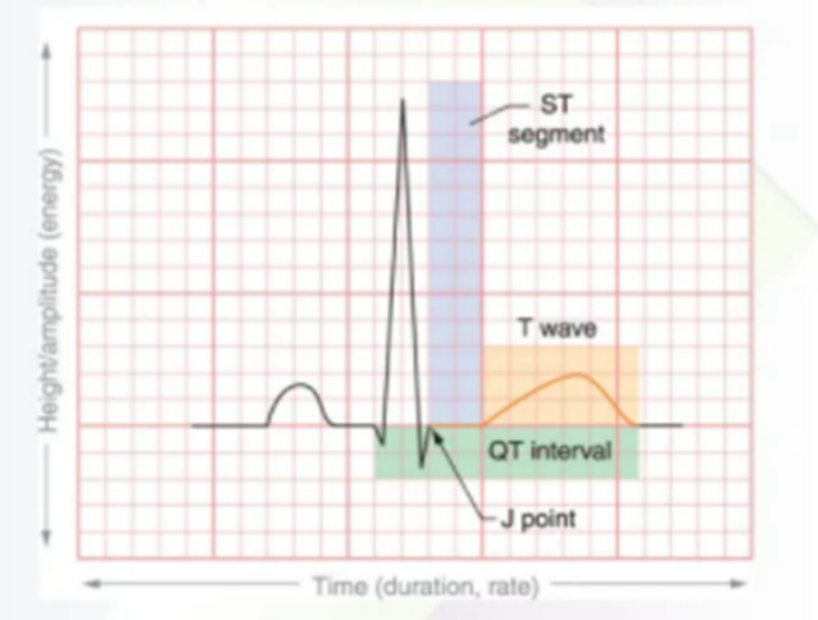
Torsades de pointes

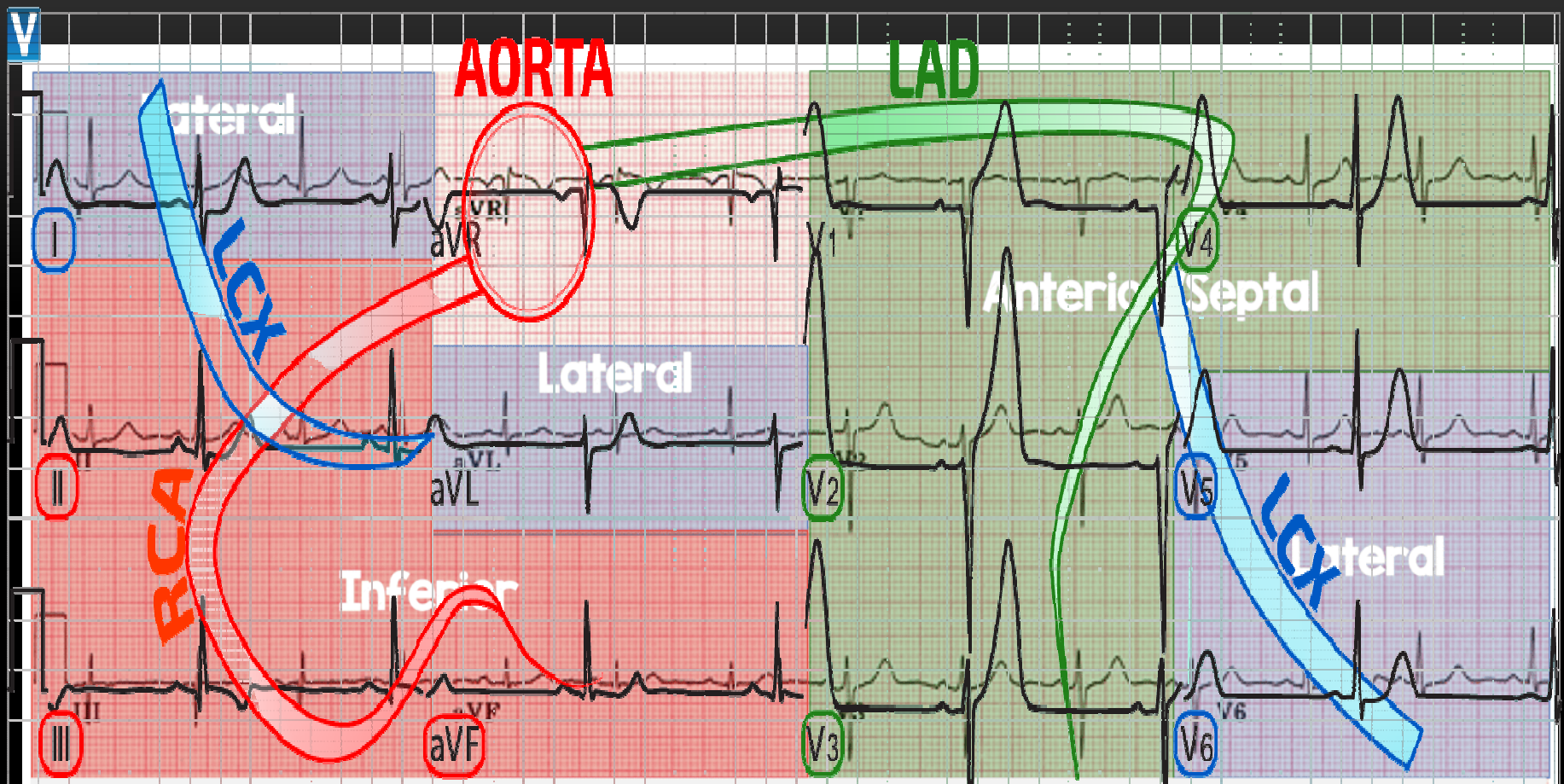
Activation sequence differs randomly between beats

Continually changing ~~axis (and QRS size)~~.

Genetic or Acquired channelopathies.

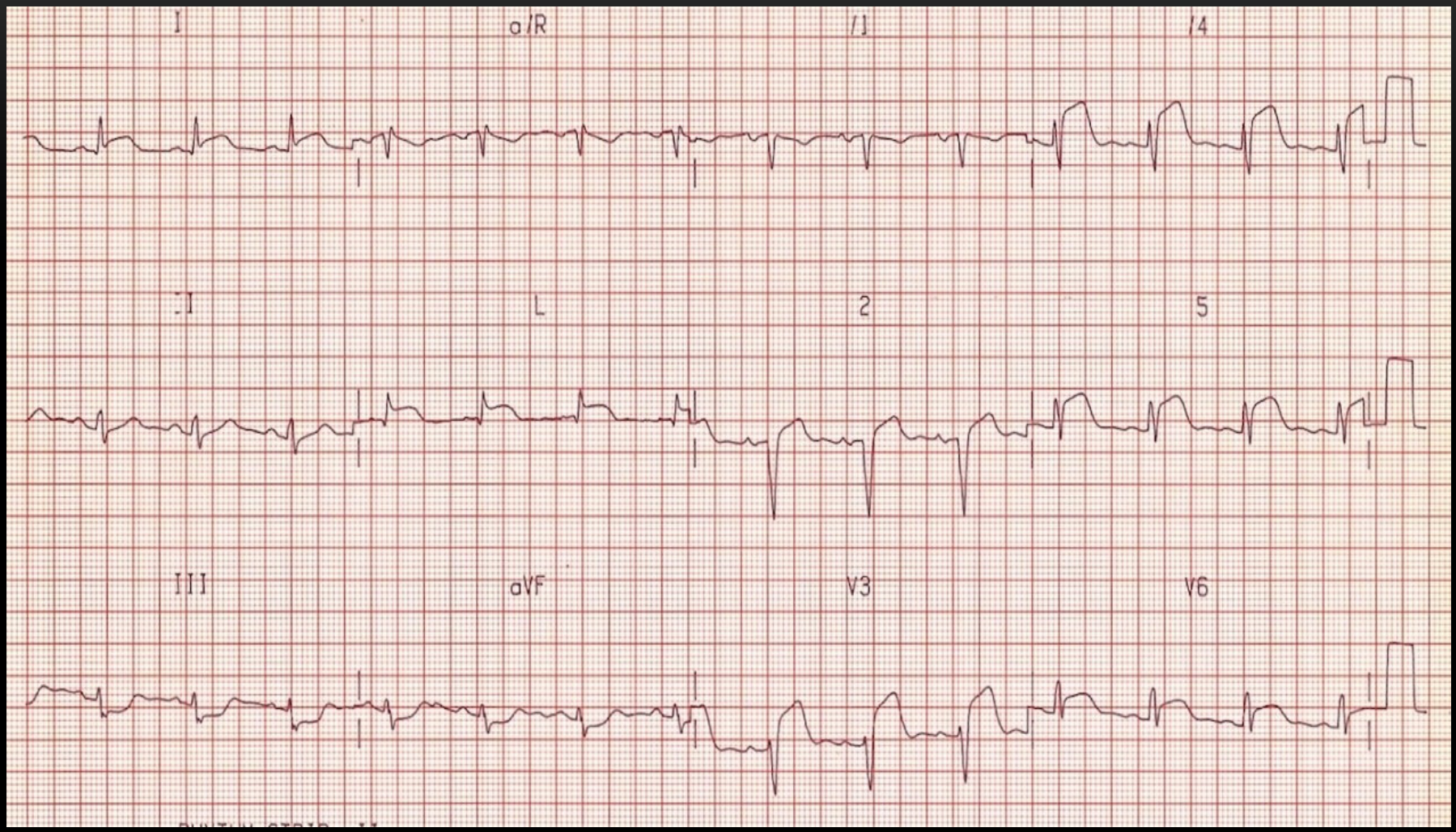
ST SEGMENT


ST
segment
T wave
QT interval
J point
Height/amplitude (energy)
Time (duration, rate)



Lateral Leads	I, aVL, V5 - V6	LCx or Diagonal of LAD
Inferior Leads	II, III, aVF	RCA and/or LCx
Anterior/Septal Leads	V1 - V4	LAD

60 yr old man c/o tight central chest pain radiating to left shoulder

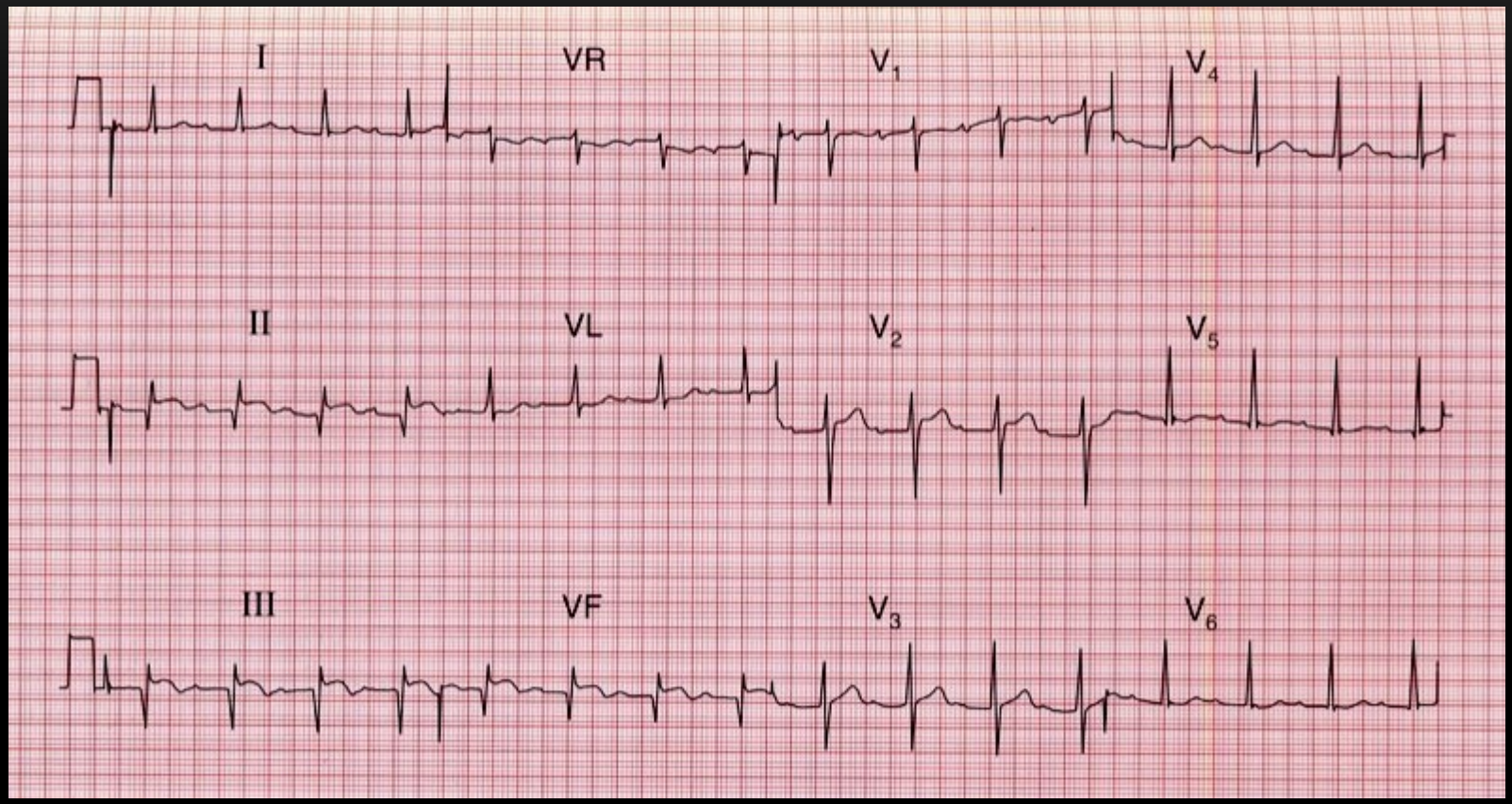


Rate : 90/min P /PR : Normal QRS: Normal

Rhythm : Regular ST: Elevation V2-V6, Reciprocal II,III, aVF

Acute Myocardial Ischemia - Anterolateral

70 year old woman presents with sudden onset of chest pain.



Rate : 70/min P : Normal QRS: Normal

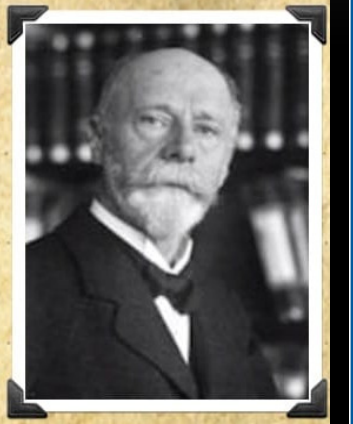
Rhythm : Regular PR : Normal ST: ST elevation II,III,aVF

Myocardial Ischemia – Inferior Wall

WINDOW TO HEART

Willem EINTHOVEN

1860 – 1927



Einthoven triangle

Einthoven law

Einthoven string galvanometer

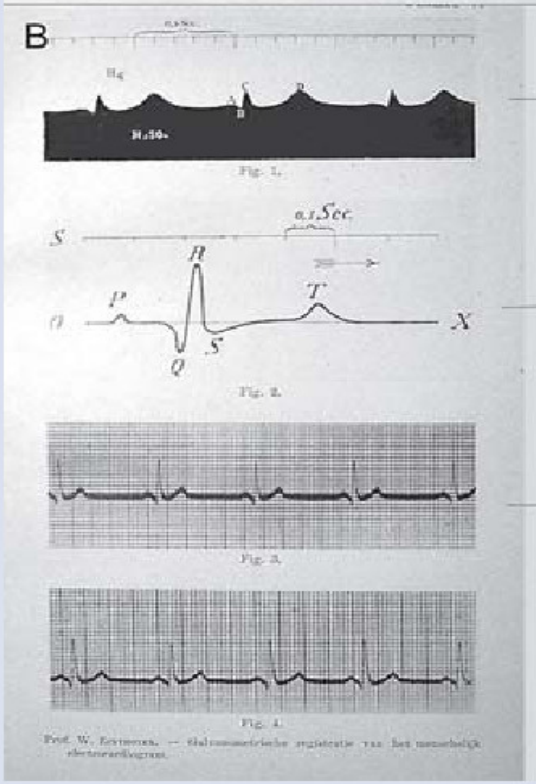
A

Galvanometrische registratie van het menschelijk electrocardiogram

Dr. W. EINTHOVEN,

Hoogleeraar te Leiden.

B



Capillary electrometer recording

"Corrected" tracing

String galvanometer


thankyou
thankyou
thankyou
thankyou