12 lead EKG

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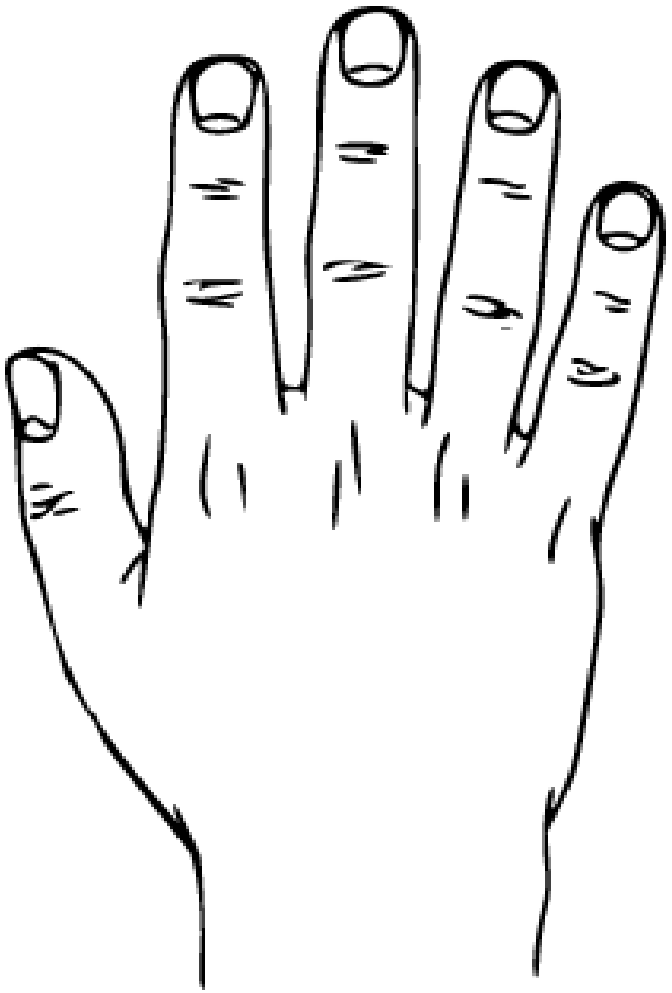
Disclosures

- I have no disclosures

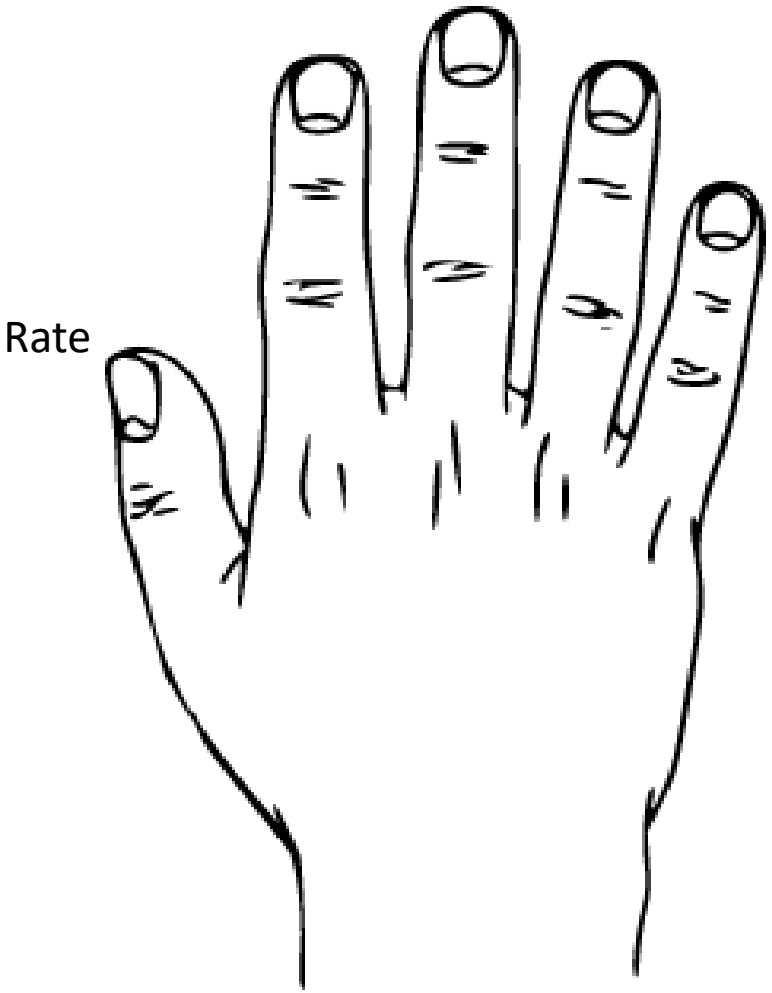
Objectives

- At the conclusion of this presentation the participant will be able to
  - **Outline a systematic approach to 12 lead ECG interpretation**
  - Dysrhythmias
  - Demonstrate the process for determining axis
  - List criteria for LVH, RVH, RAE, LAE LBBB, RBBB, Bifasicular and trifasicular block, acute and chronic MI changes
  - Define other significant findings

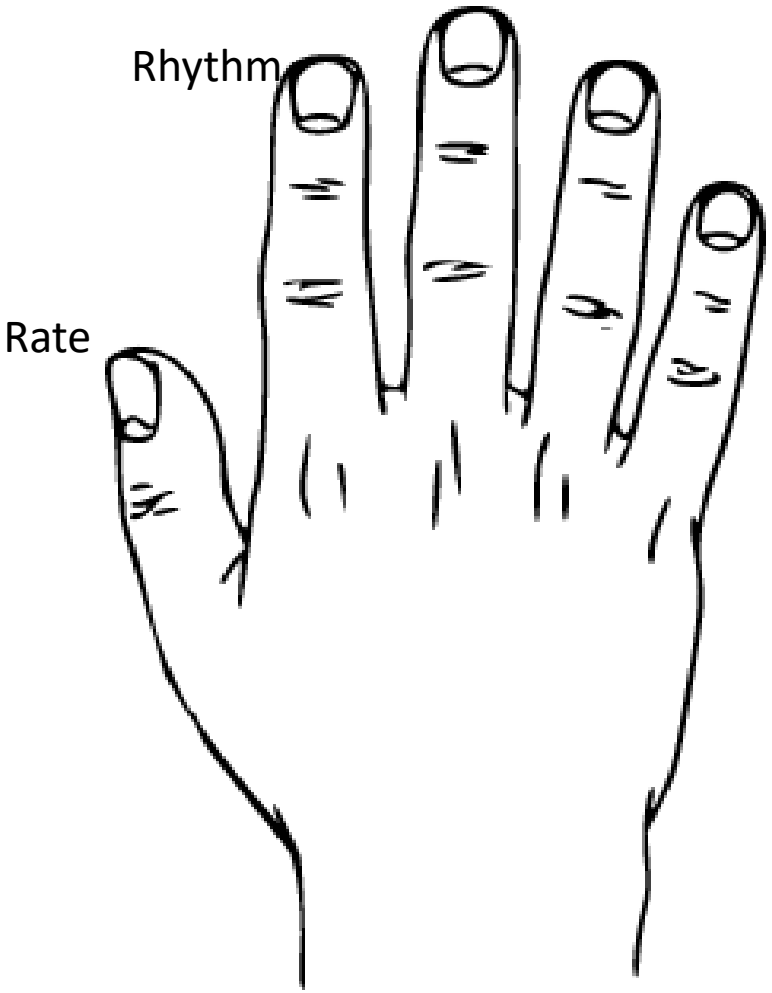
5 Finger approach



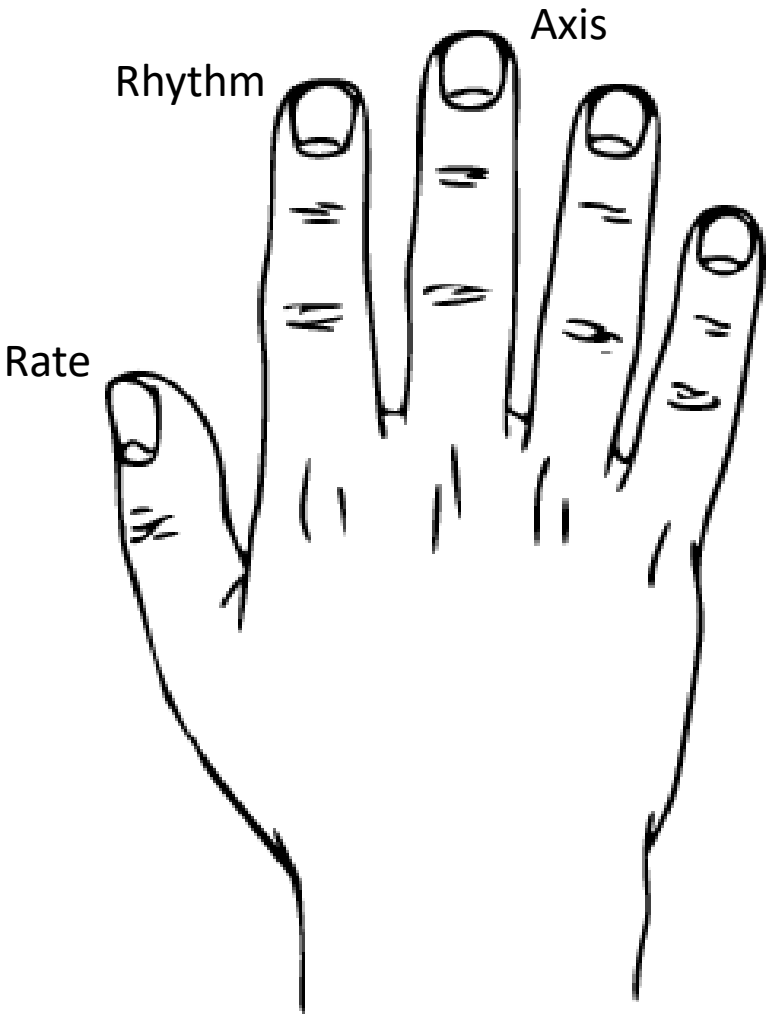
5 Finger approach



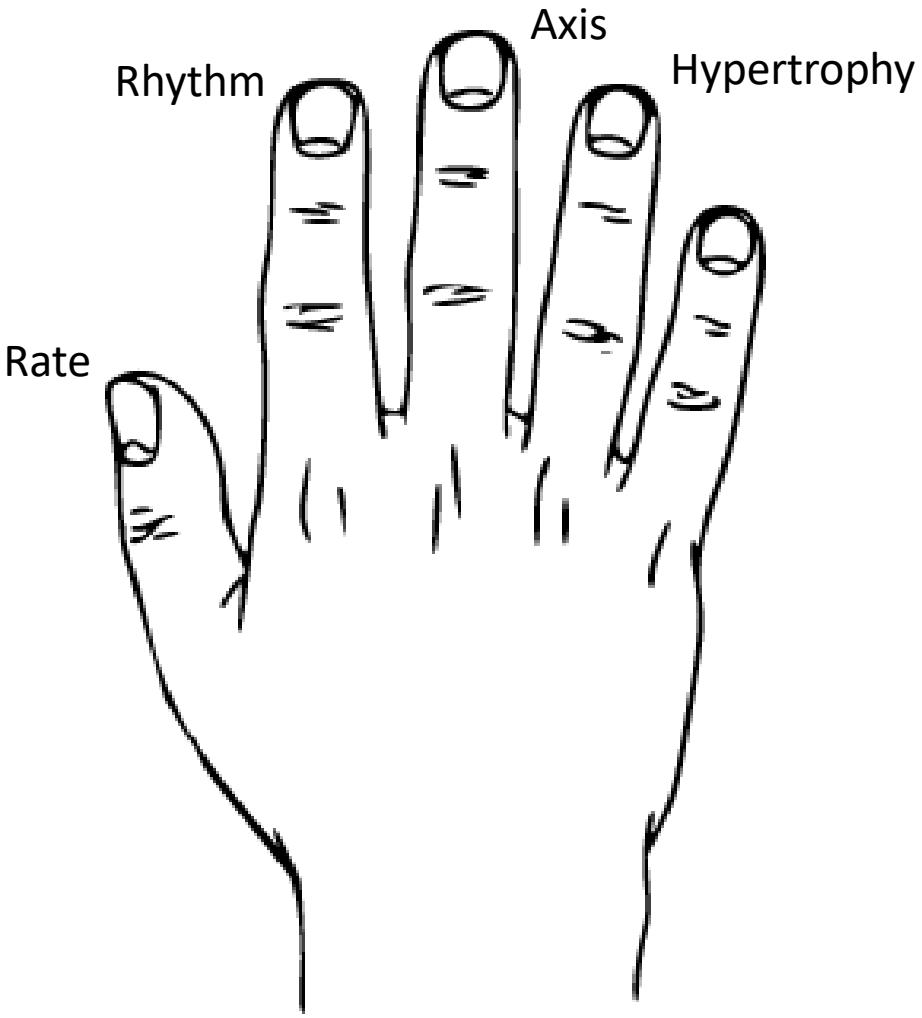
5 Finger approach



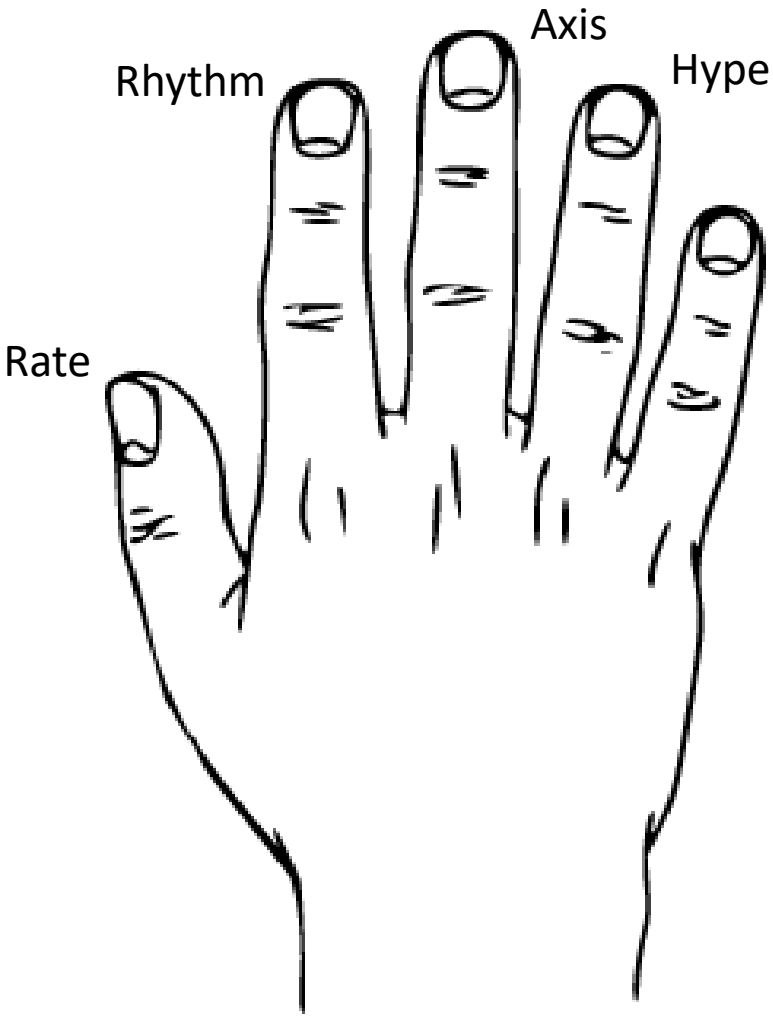
5 Finger approach



5 Finger approach



5 Finger approach



The “I’s and ”others”
Intervals
Ischemia
Injury (acute)
Infarct (old)
others

ECG Lead System
What we hope to cover

- Normal ECG
- Axis deviation
- Hypertrophy
- QRS interval/Bundle Branch Block
- Intervals
- Ischemia
- Injury
- Infarct
- Other

Introduction

- Section I
  - Normal ECG, laying the ground work
- Section 2
  - Dysrhythmias
- Section 3
  - Axis
- Section 4
  - Hypertrophy

Introduction

- Section 5
  - BBB, Hemiblock, Bi and Tri block
- Section 6
  - Landscape of the I’s
- Section 7
  - Other Cardiac conditions

Section I

Normal ECG

Laying the ground work

Laying the ground work for 12 lead interpretation

- A tool, a sign, an extension of the history and physical examination
- Must take a sensible approach to analyze an ECG
- The ECG reflects the heart and all its functions

Laying the ground work cont.

- The ECG language is not difficult, just different
- Practice, Practice, Practice
- Obtain good, easy to understand resources

12 lead ECG

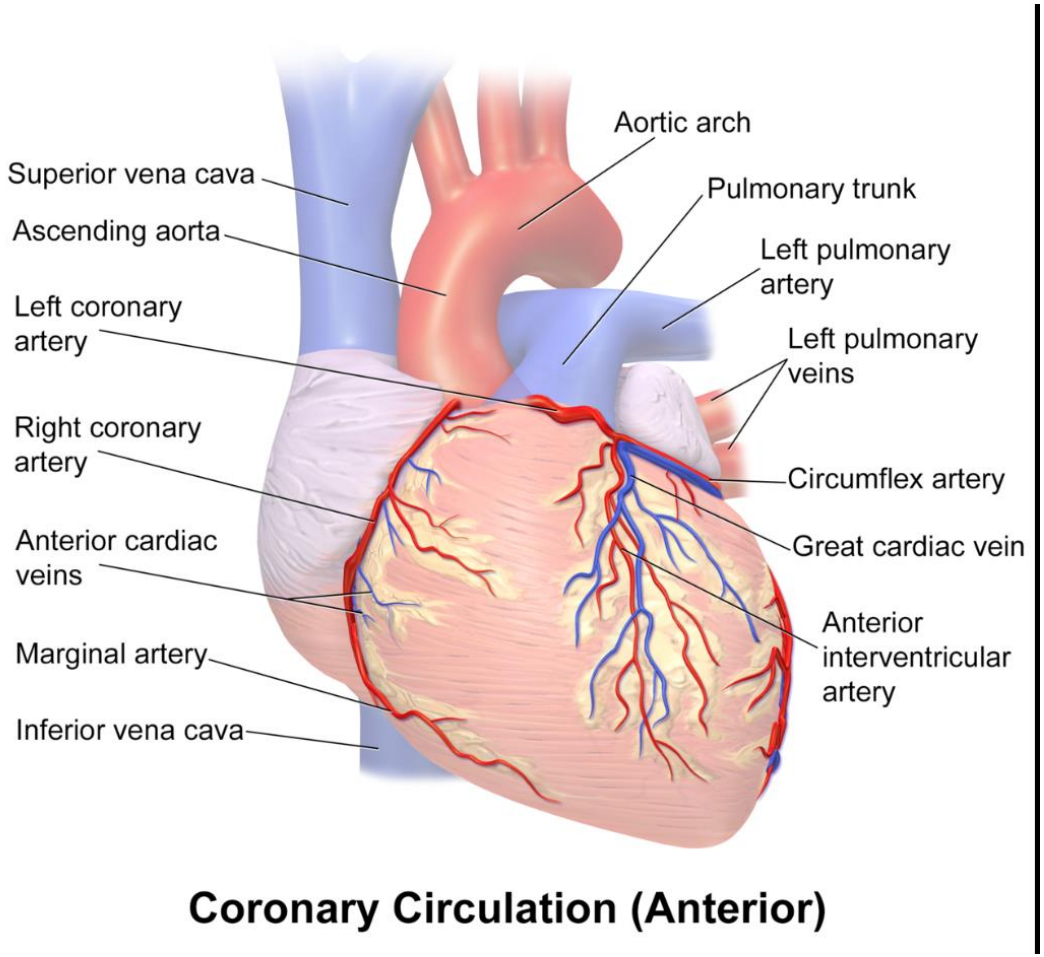
- A Normal ECG is dependent on intact plumbing, electrical, and structural components of the heart

ECG
Dependent Factors

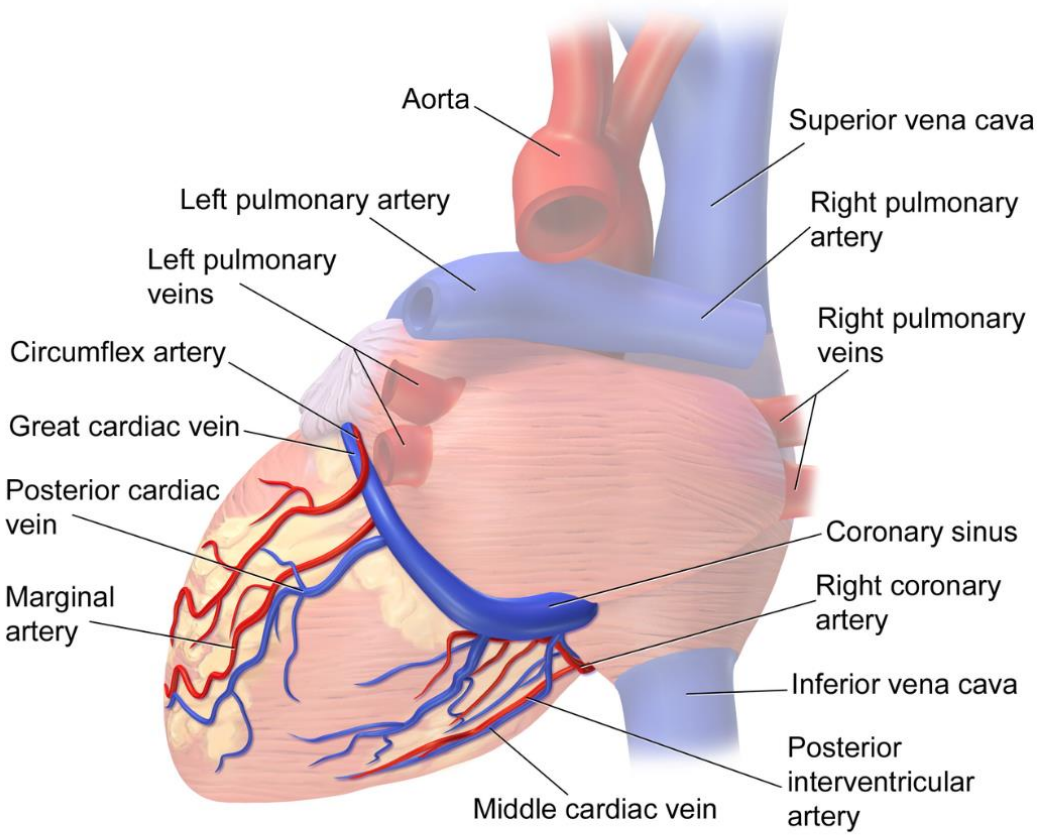
- Plumbing
- Electrical
- Structural

ECG
Plumbing

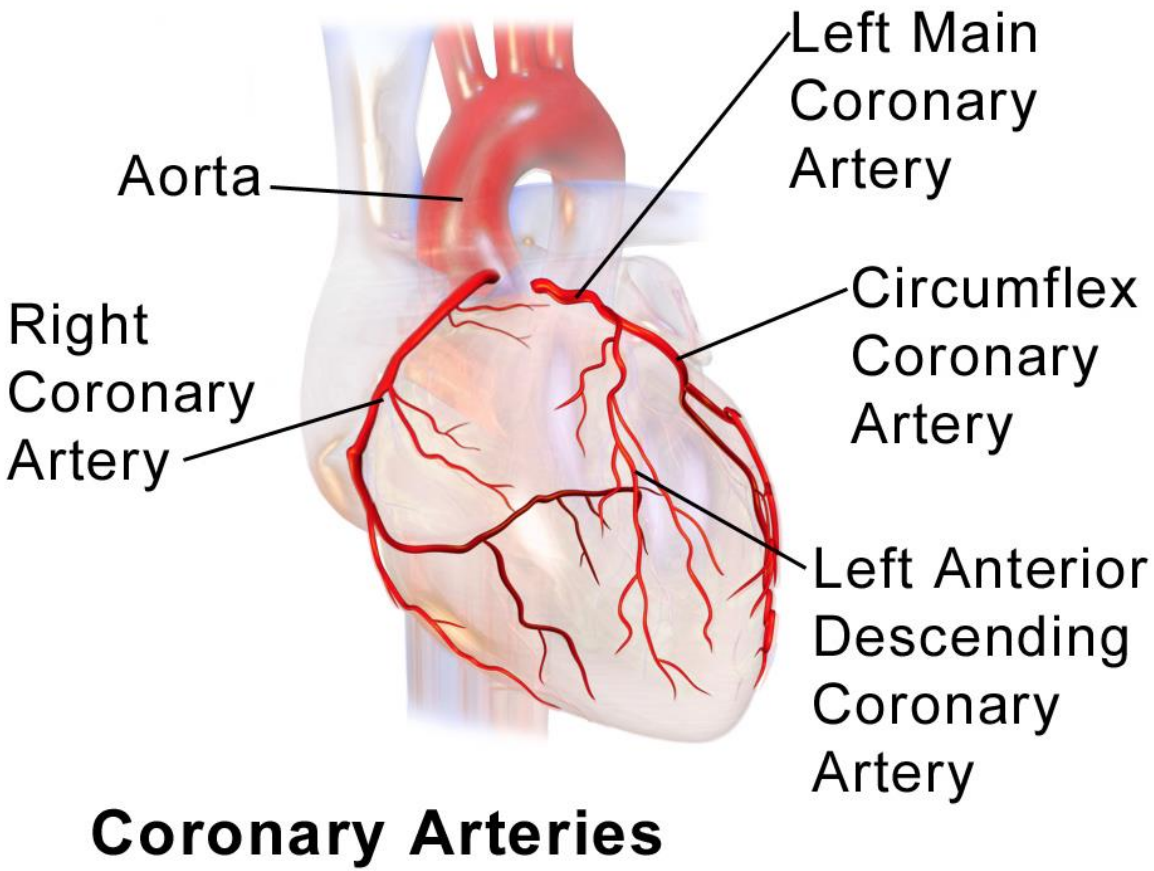
- Coronary Arteries
  - Right coronary
  - Left Main Coronary
    - Left anterior descending
    - Circumflex artery



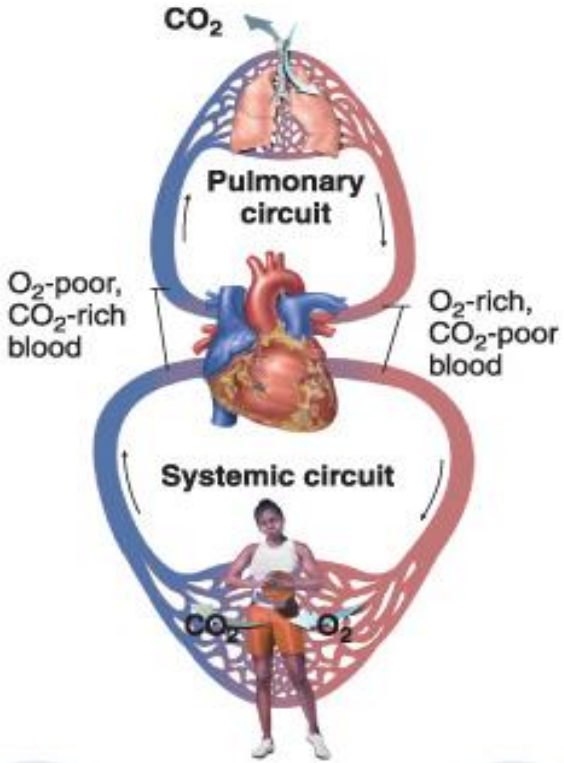
Coronary Circulation (Anterior)



Coronary Circulation (Posterior)



Coronary Arteries



Superior and inferior vena cava → Right atrium → Tricuspid valve → Right atrium → Pulmonary semilunar valves → Pulmonary trunk → Pulmonary arteries → Lung tissue (pulmonary circulation) → Pulmonary veins → Left atrium → Bicuspid valve → Left ventricle → Aortic semilunar valves → Aorta → Body tissues (systematic circulation) → Superior and inferior vena cava

ECG
Electrical

- **SA node**: major electrical pacemaker

  Blood supply: Right coronary artery

- **AV node**: initiates ventricular contraction

  Blood supply: Right coronary artery and or circumflex

ECG
Electrical

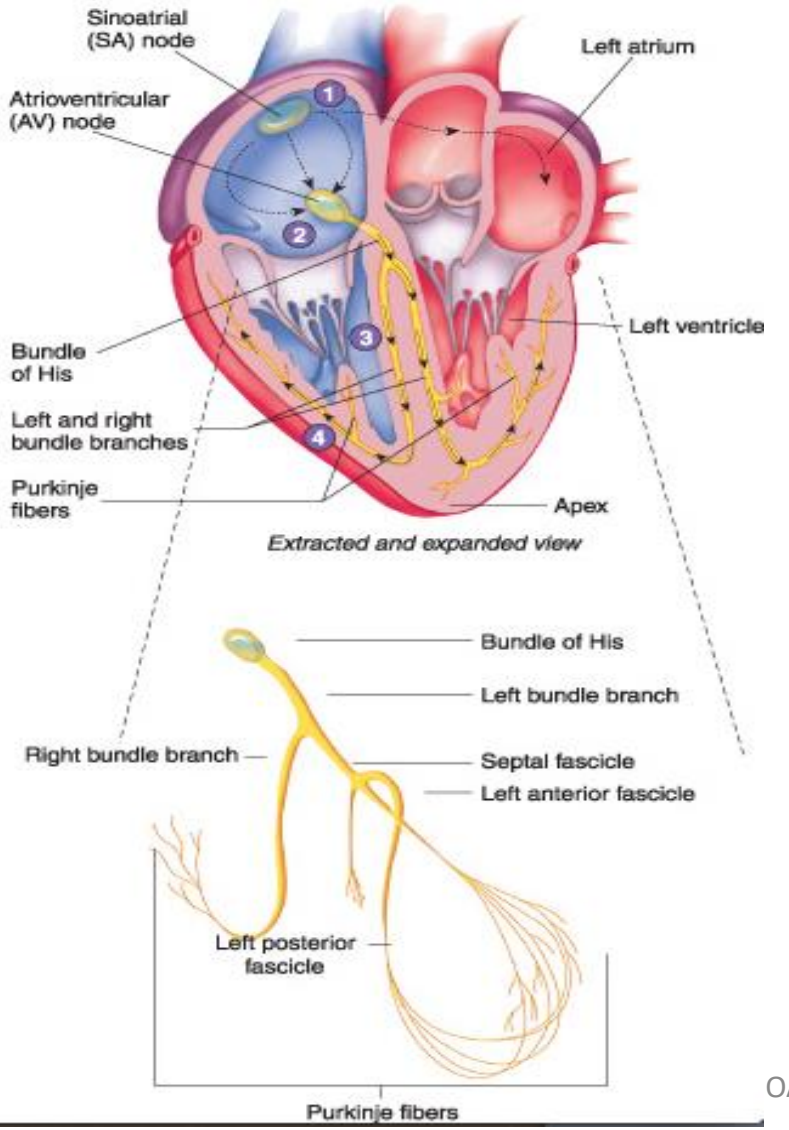
- **Bundle of HIS**: ventricular contraction

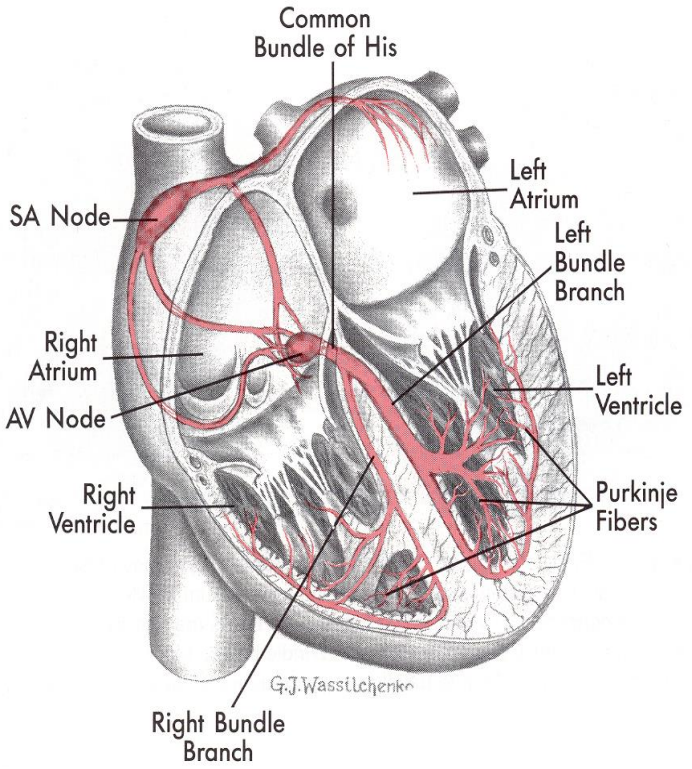
  Blood supply: Left anterior descending

- **Purkinje fibers**: ventricular contraction

  Blood supply: Left anterior descending

Electrical

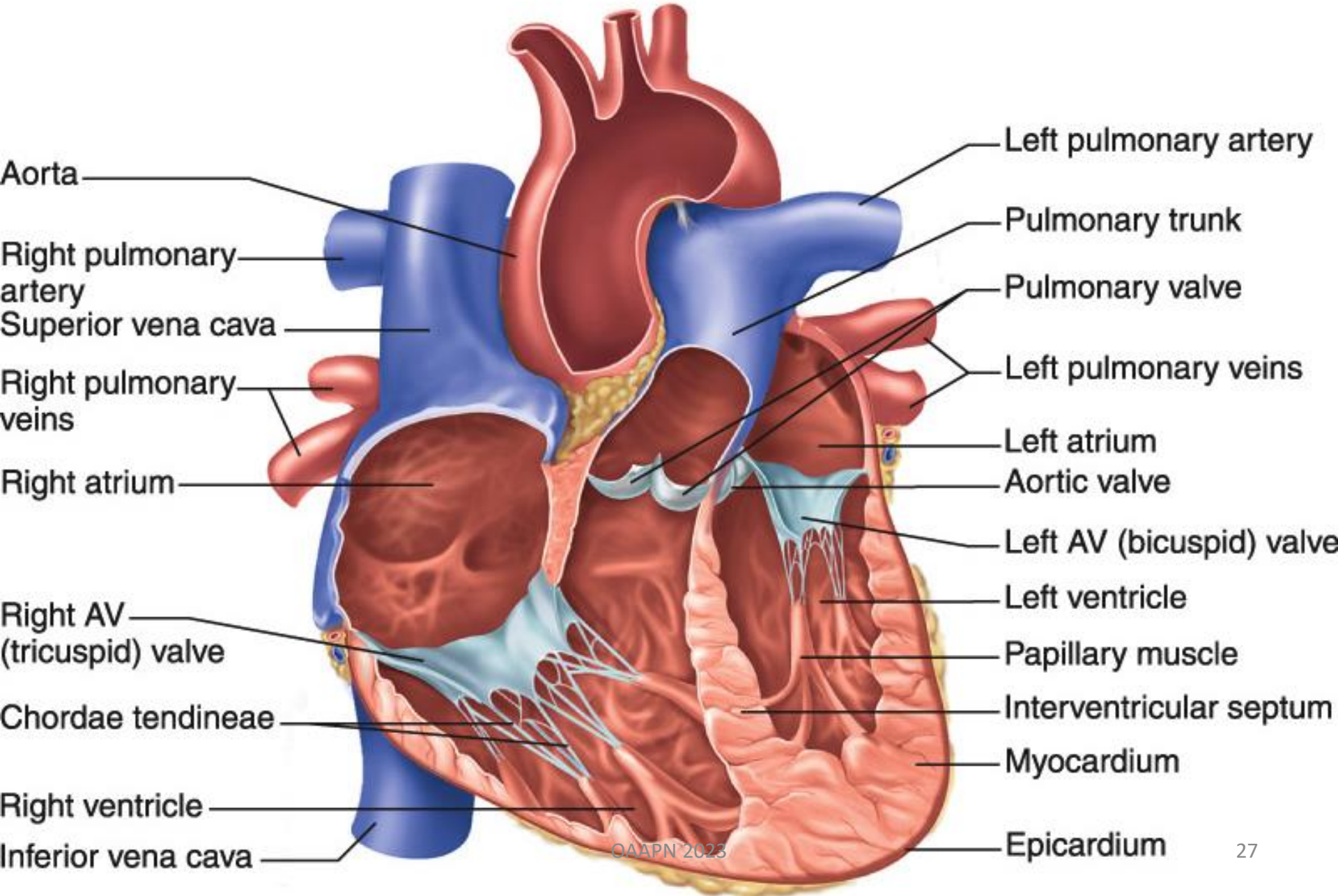

Sinoatrial (SA) node
Left atrium
Atrioventricular (AV) node
1
2
3
4
Left ventricle
Bundle of His
Left and right bundle branches
Purkinje fibers
Apex
Extracted and expanded view
Bundle of His
Left bundle branch
Right bundle branch
Septal fascicle
Left anterior fascicle
Left posterior fascicle
Purkinje fibers


Common Bundle of His
Left Atrium
SA Node
Left Bundle Branch
Right Atrium
Left Ventricle
AV Node
Right Ventricle
Purkinje Fibers
G.J.Wassilcheriko
Right Bundle Branch

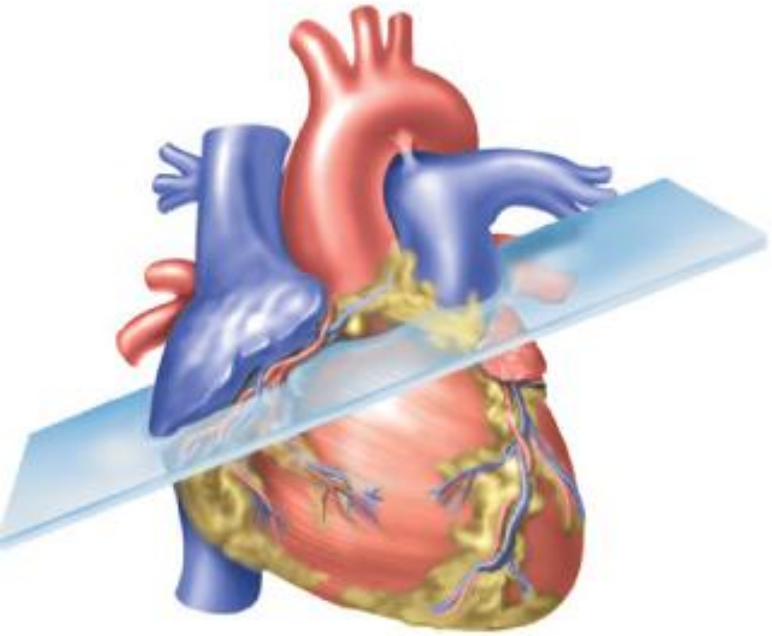
Structural

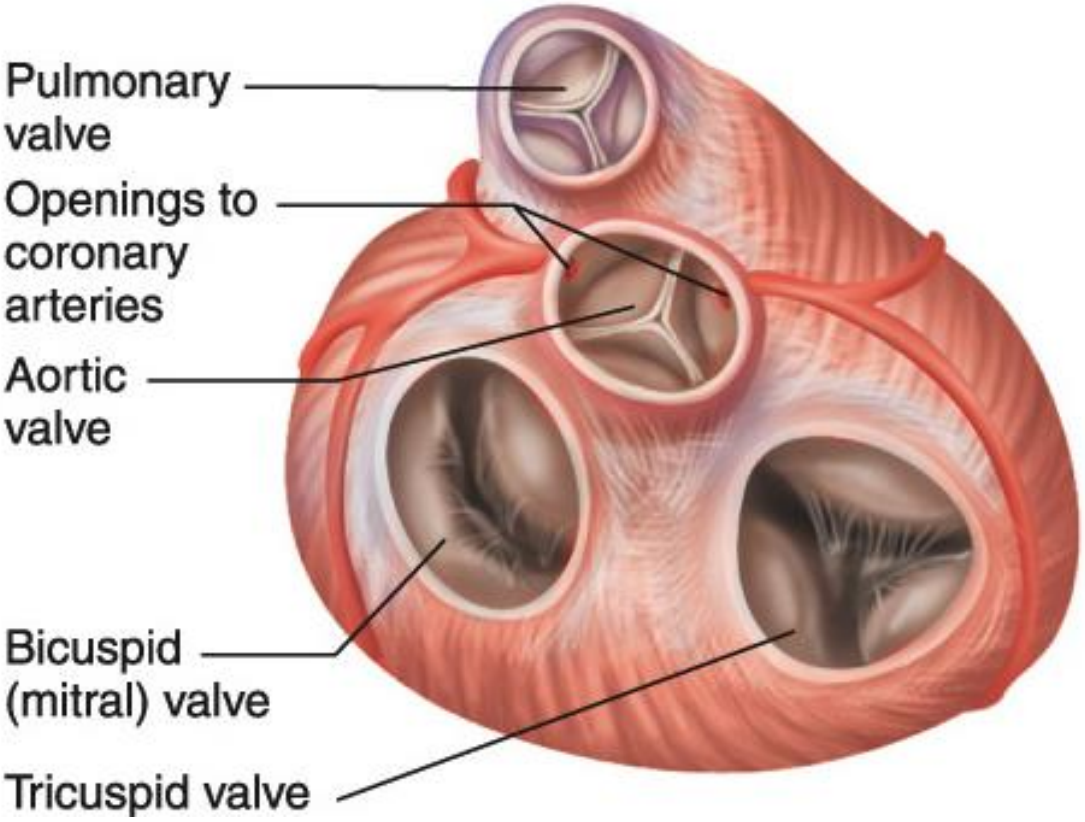
- Chambers
- Muscle
- Valves
- Nervous system
- Vascular
- Position of the heart and great vessels

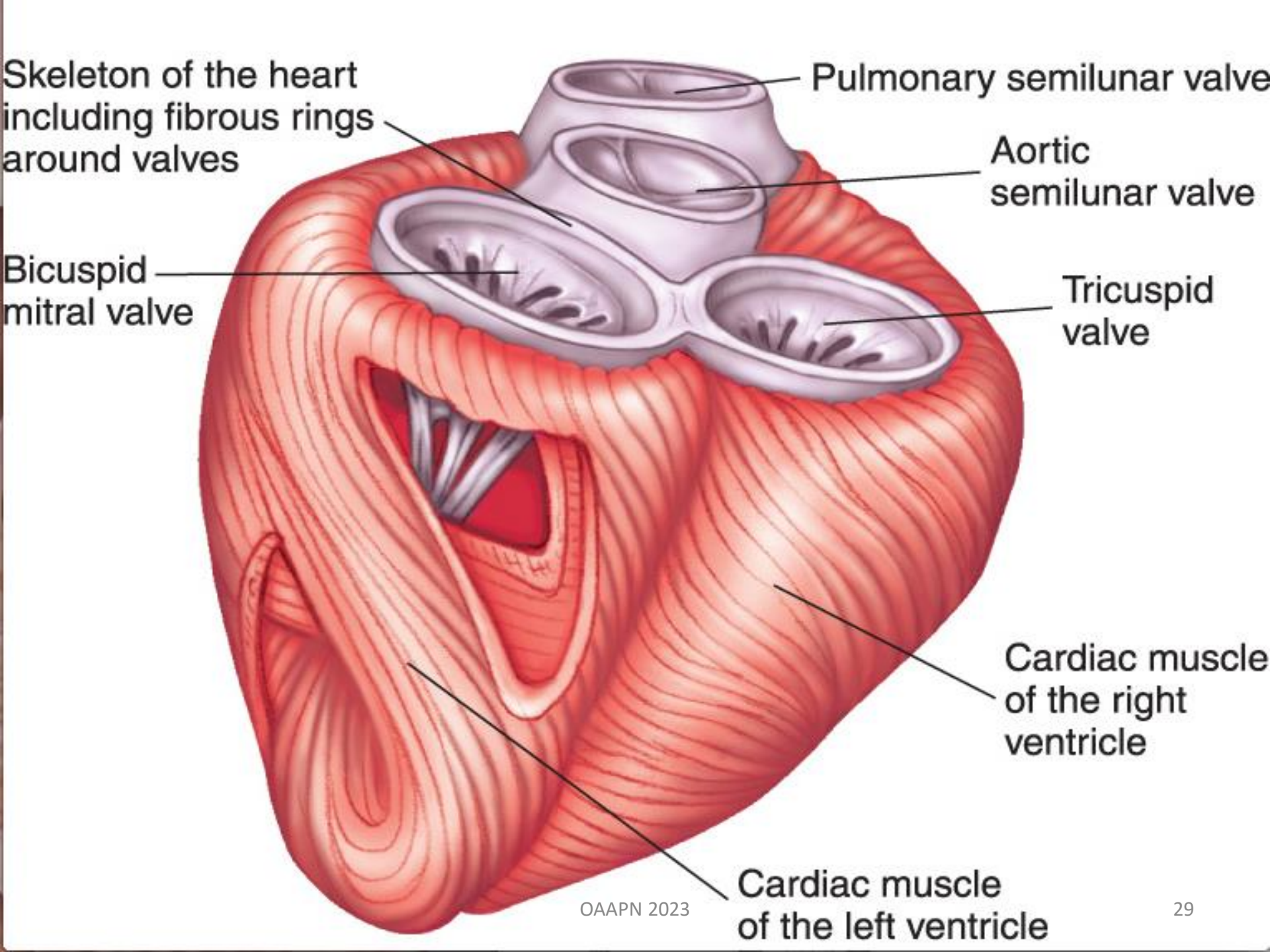
Heart Structure



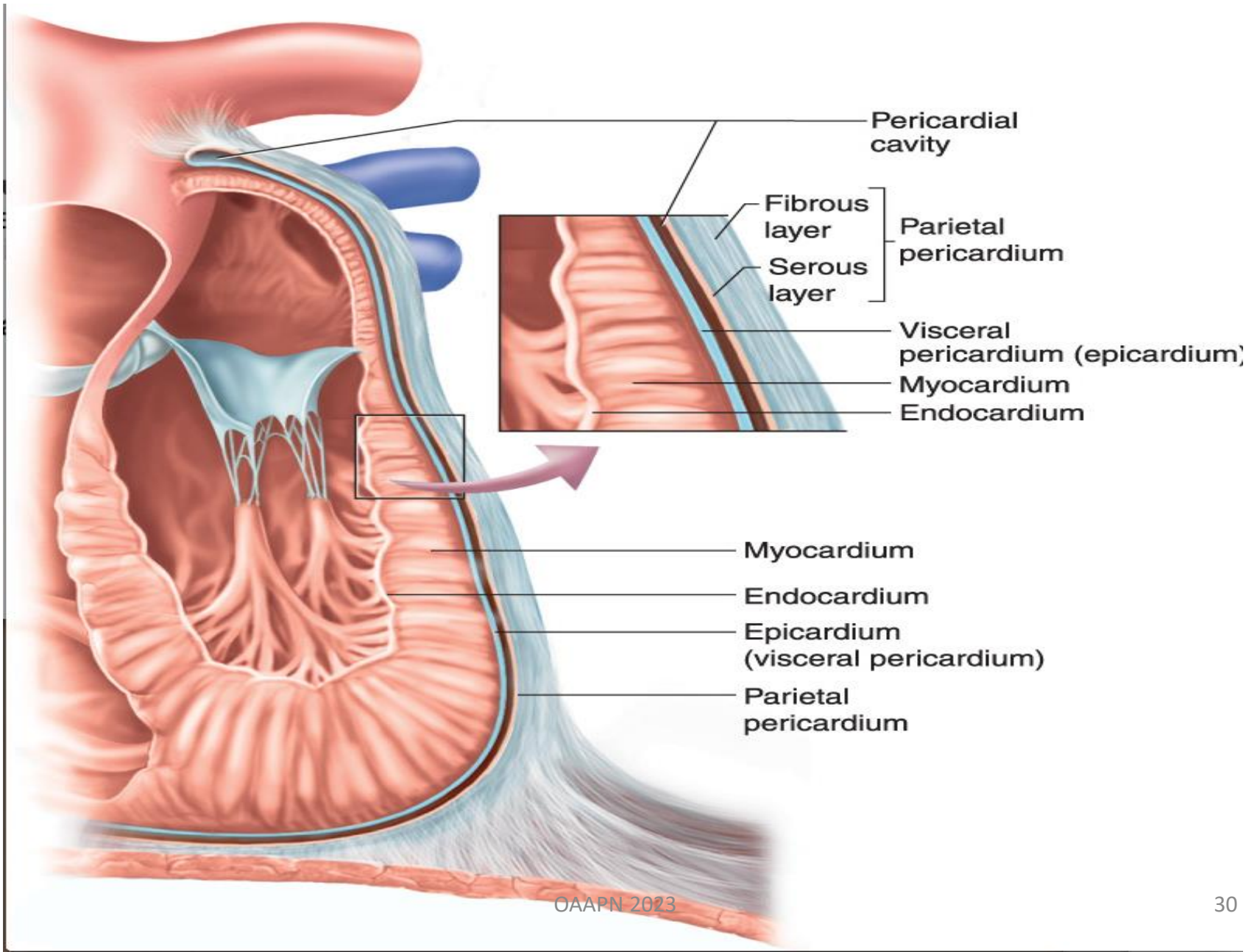
Heart Valves and positions






Skeleton of the heart including fibrous rings around valves
Pulmonary semilunar valve
Aortic semilunar valve
Bicuspid mitral valve
Tricuspid valve
Cardiac muscle of the right ventricle
Cardiac muscle of the left ventricle

Layers of the Heart

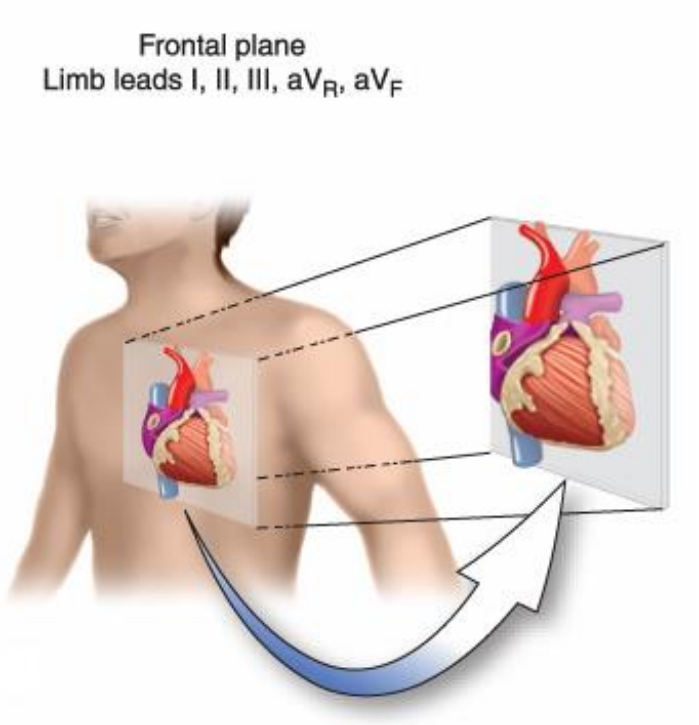


12 lead ECG

- A Normal ECG is dependent on intact plumbing, electrical, and structural components of the heart

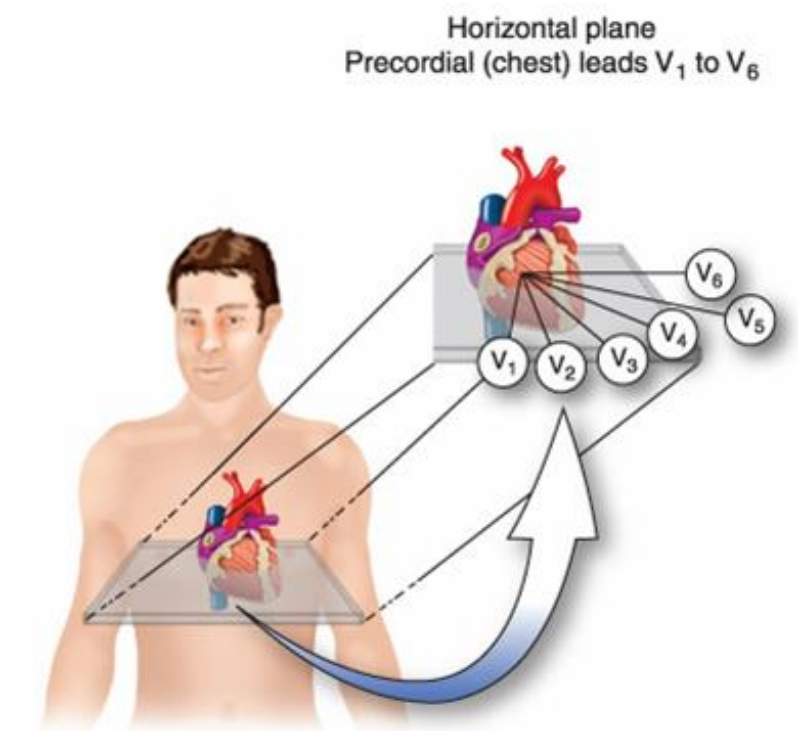
Limb Leads

- View the frontal plane
- Include leads I, II, III, aV_R, aV_L and aV_F
- Provide inferior, superior, and lateral views of heart



Precordial Leads

- View horizontal plane and include leads V_1, V_2, V_3, V_4, V_5, and V_6
- Provide inferior, superior, and lateral views of heart



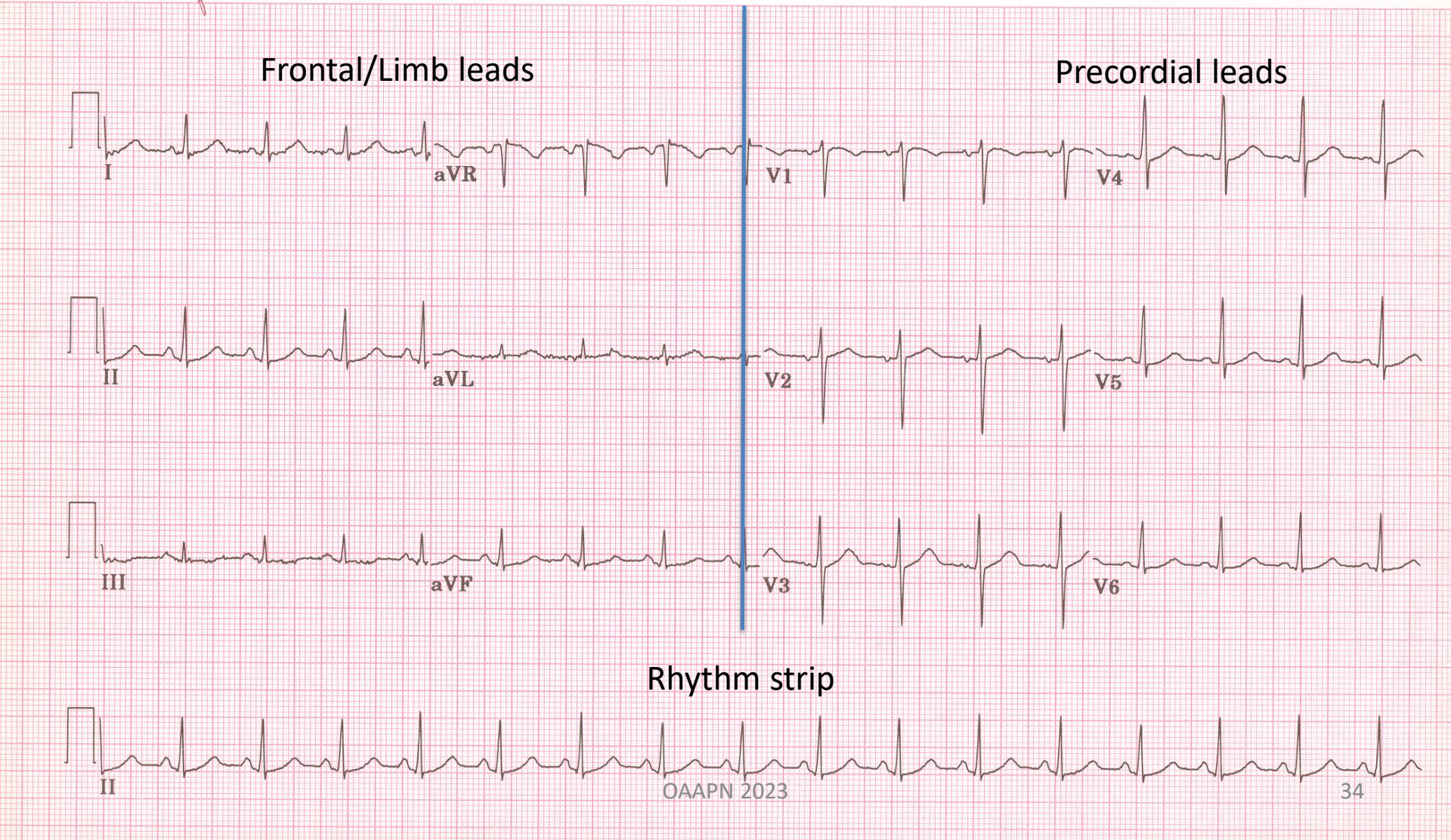
41 yr
Female Caucasian

Vent. rate	99	BPM
PR interval	124	ms
QRS duration	76	ms
QT/QTc	360/462	ms
P-R-T axes	65 54	29

NORMAL SINUS RHYTHM
NORMAL ECG

Technician ID: 503

Unconfirmed



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NORMAL SINUS RHYTHM
NORMAL ECG

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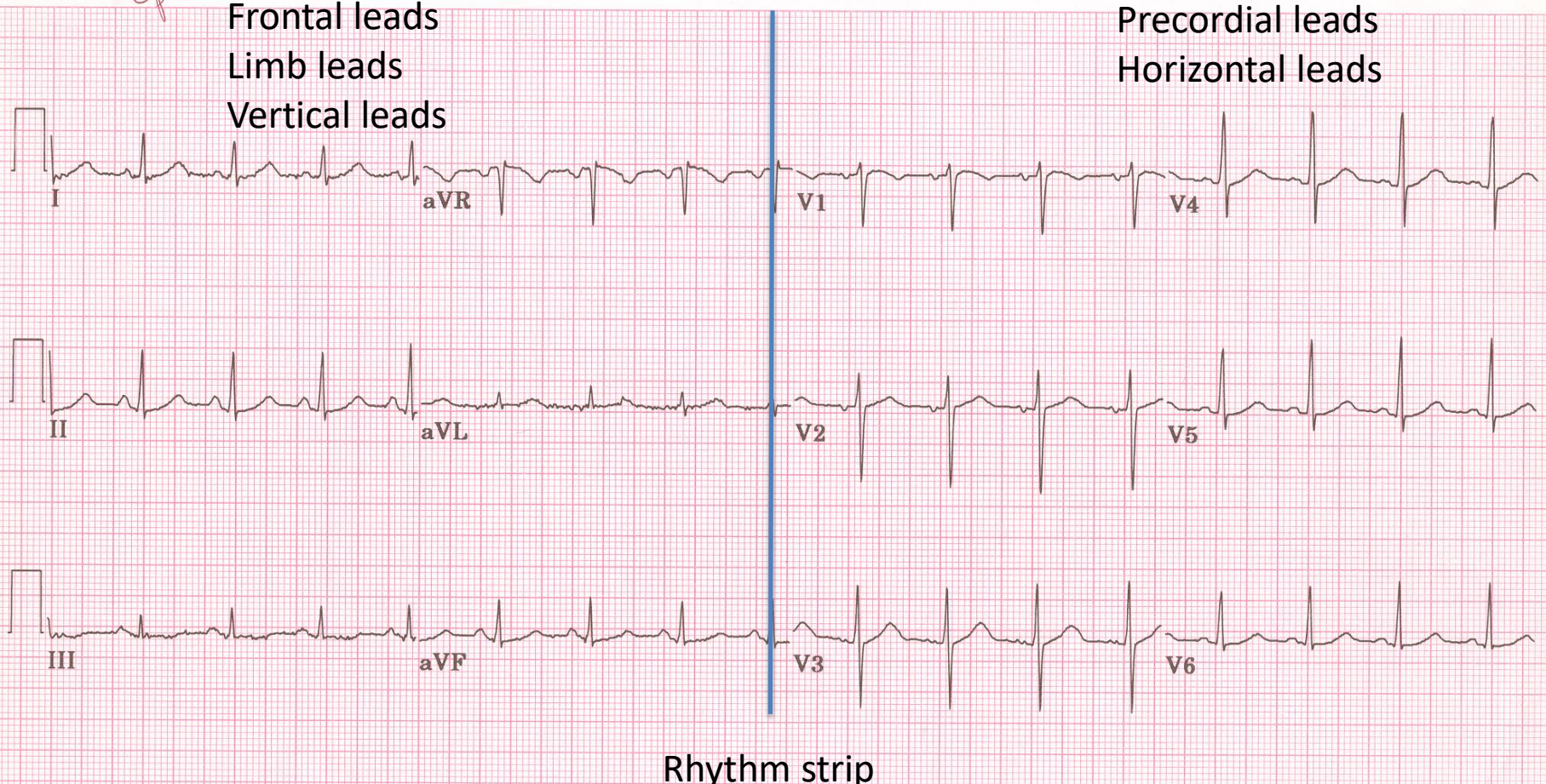
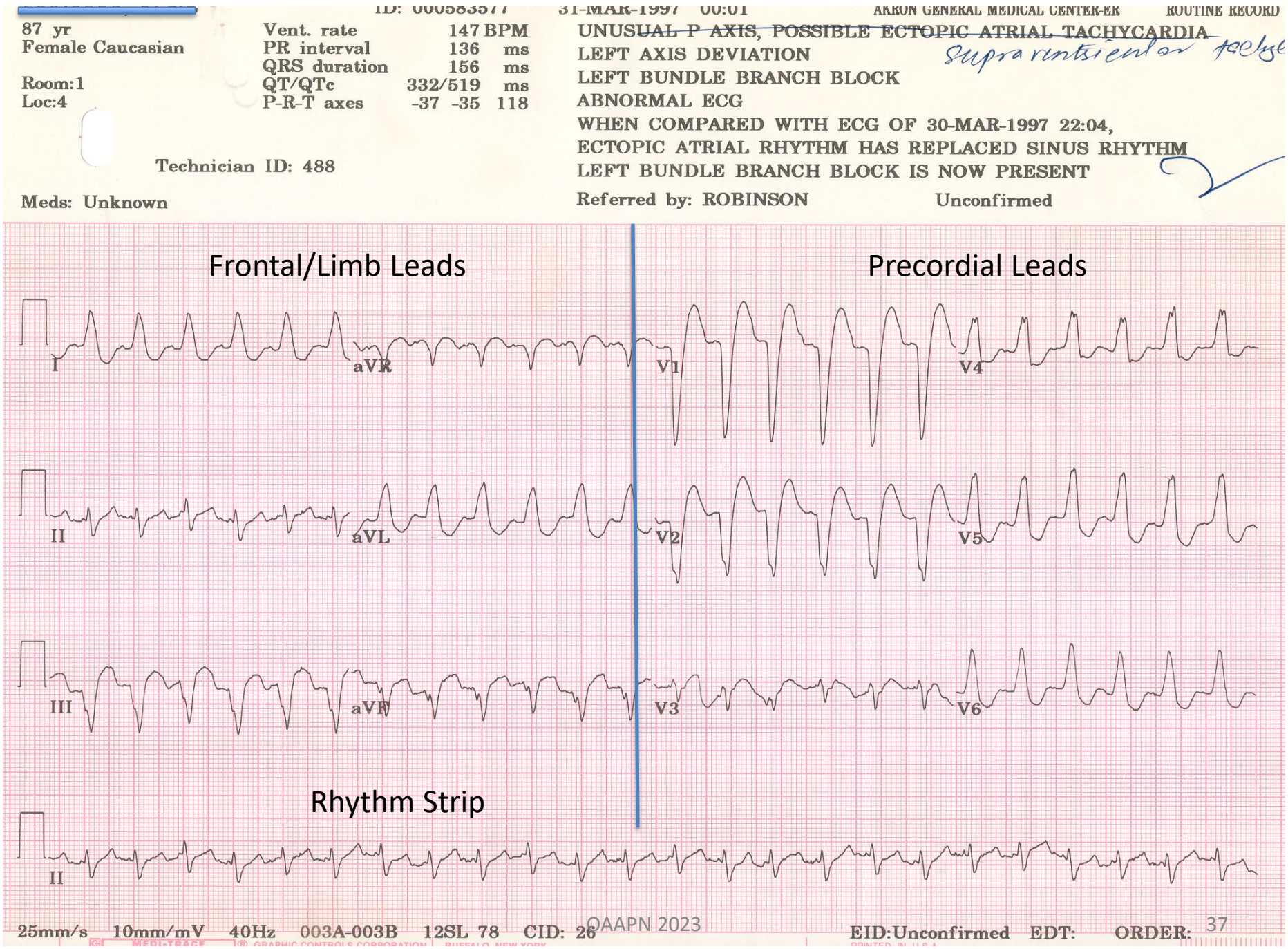


12 lead ECG

- An Abnormal ECG may result from disrupted plumbing, electrical, structure or a combination of all the above.


ID: 00583577
31-MAR-1997 00:01
AKRON GENERAL MEDICAL CENTER-ER
ROUTINE RECORD
87 yr
Female Caucasian
Room:1
Loc:4
Vent. rate 147 BPM
PR interval 136 ms
QRS duration 156 ms
QT/QTc 332/519 ms
P-R-T axes -37 -35 118
Technician ID: 488
Meds: Unknown
UNUSUAL P AXIS, POSSIBLE ECTOPIC ATRIAL TACHYCARDIA
Supraventricular tachy
LEFT AXIS DEVIATION
LEFT BUNDLE BRANCH BLOCK
ABNORMAL ECG
WHEN COMPARED WITH ECG OF 30-MAR-1997 22:04,
ECTOPIC ATRIAL RHYTHM HAS REPLACED SINUS RHYTHM
LEFT BUNDLE BRANCH BLOCK IS NOW PRESENT
Referred by: ROBINSON
Unconfirmed
Frontal/Limb Leads
Precordial Leads
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
Rhythm Strip
II
25mm/s 10mm/mV 40Hz 003A-003B 12SL 78 CID: 26
EID:Unconfirmed EDT: ORDER:

ECG
Sensible Approach

- Rate
- Rhythm
- Axis
- Hypertrophy
- 4 **I's**

  Intervals, **I**schemia, acute **I**njury, old **I**nfarction
- Other

If possible, always have an old ECG for comparison

ECG
Electrical

- There can be electrical activity and no mechanical response, but there can never be mechanical response without electrical activation

- Electrical activity precedes mechanical activity (contraction)

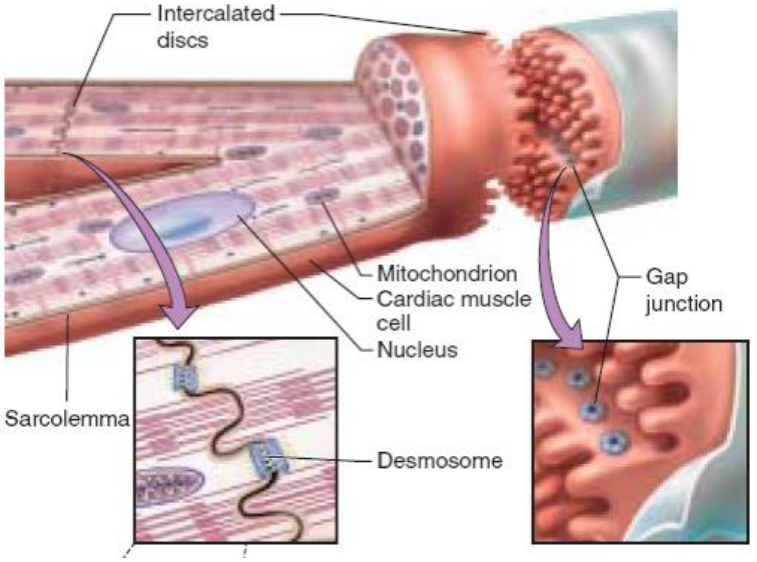
Electrophysiology of the Heart Properties of cardiac Muscle

- **Myocardial cells:** Make up bulk of heart muscle, actual contractile units.

- **Specialized cells:** Four specific properties that govern automaticity, excitability, conductivity and contractility. These cells make up the heart's electrical conduction system

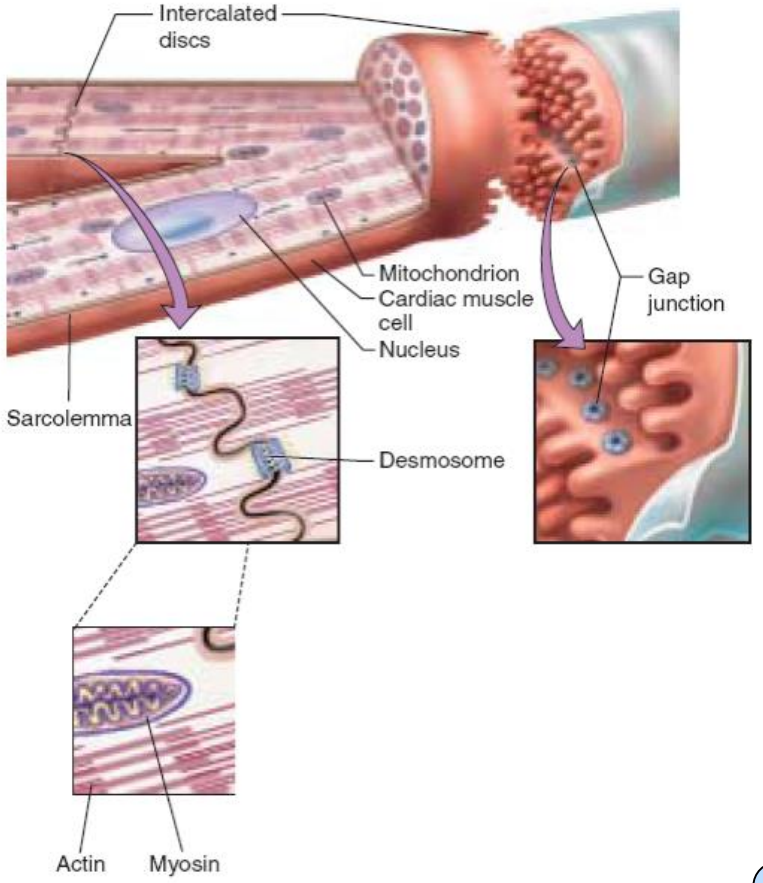
Myocardial Cells

- Cylindrical and branching at their ends
  - Intercalated disks and gap junctions allow rapid movement of electrical impulses from one cell to another
  - Desmosomes hold cells together when heart muscle contracts



Working Cells

- Myocytes
  - Enclosed in sarcolemma
  - Composed of two protein filaments
    - Actin (thin)
    - Myosin (thick)

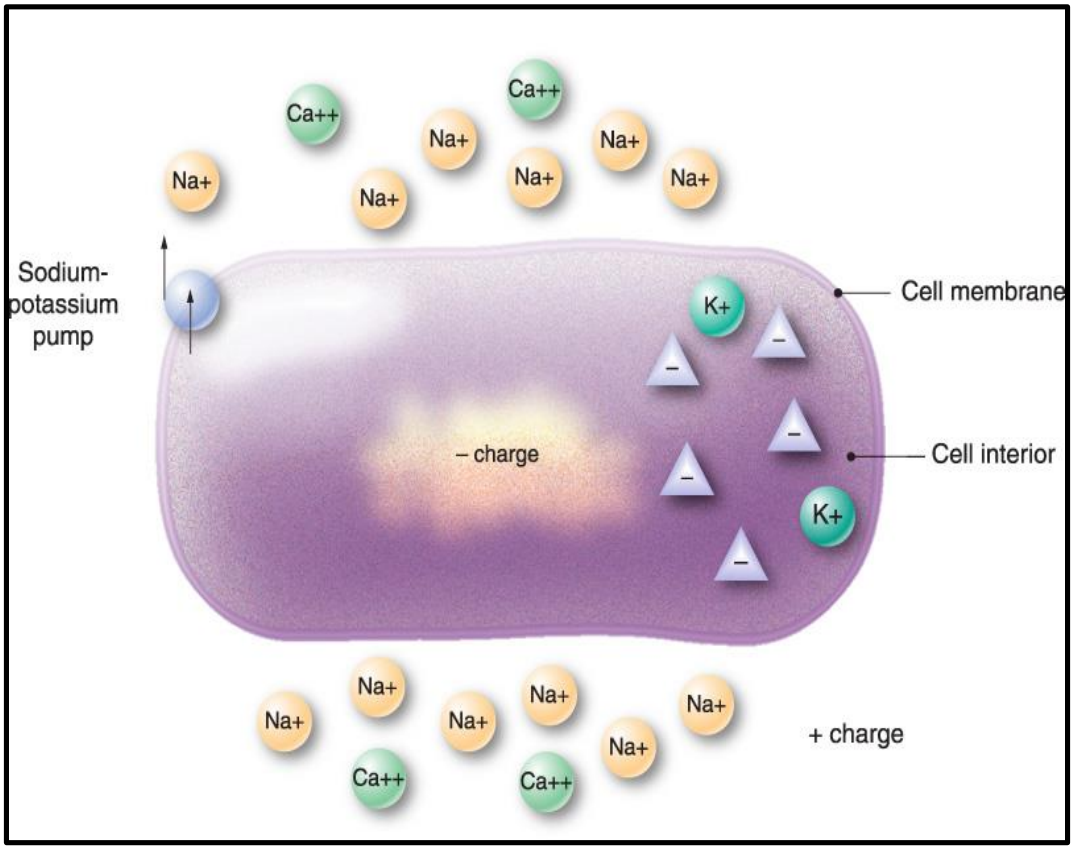


Key Properties of Myocardial Cells

- Automaticity
  - Can produce electrical activity without outside nerve stimulation
- Excitability
  - Ability to respond to an electrical stimulus
- Conductivity
  - Ability to transmit an electrical stimulus from cell to cell throughout myocardium
- Contractility
  - Ability of myocardial cell to contract when stimulated by an electrical impulse

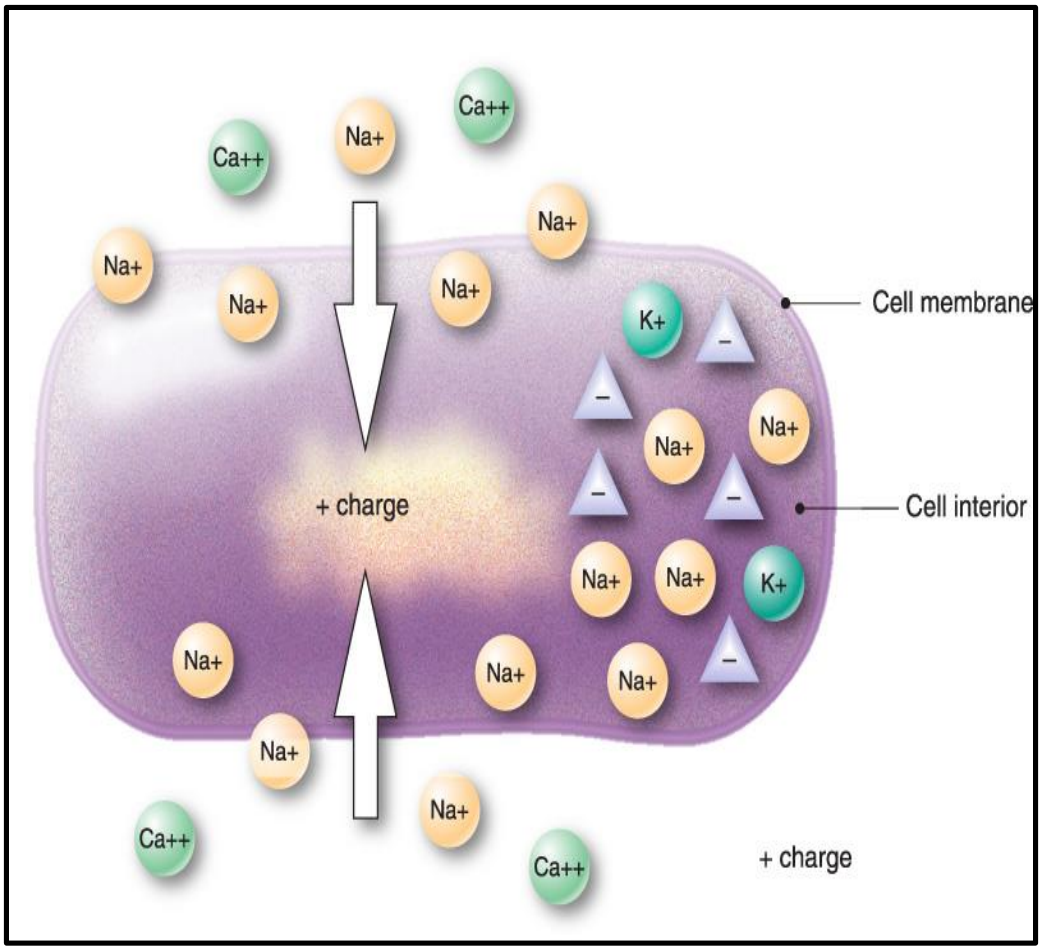
Polarized State

- Inside of myocardial cells more negatively charged in relationship to outside where it is more positively charged



Depolarization

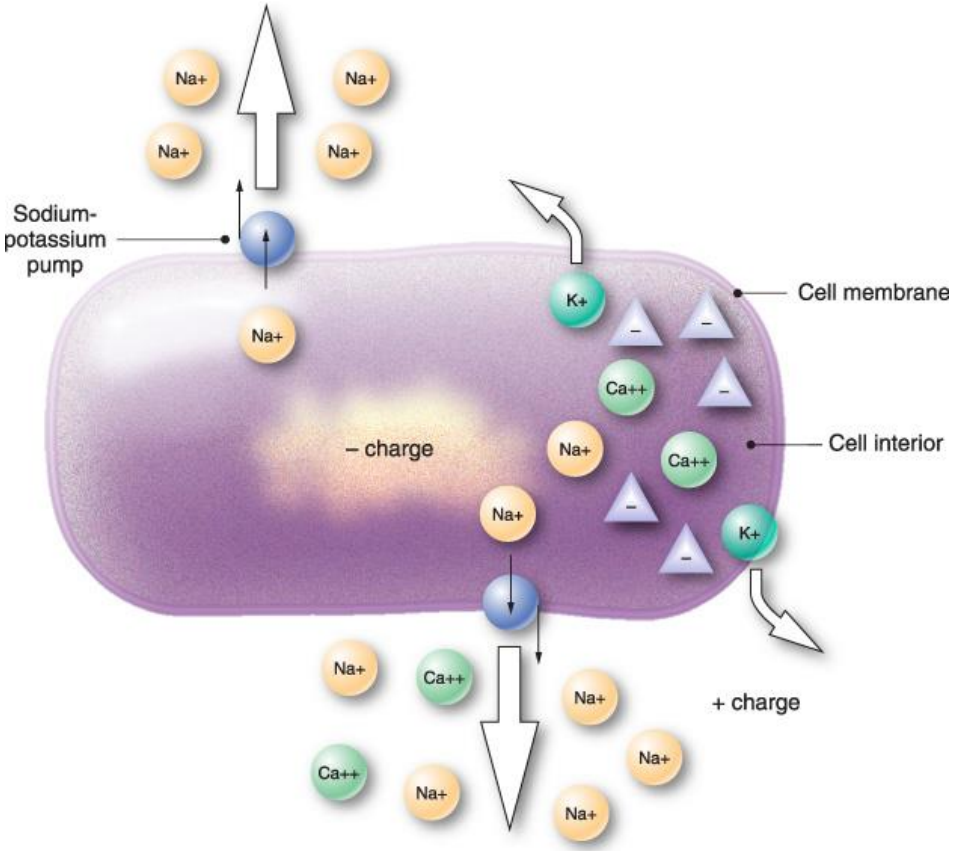
- Occurs when positively charged ions move inside cells causing interior to become positively charged
  - Change in electrical charge over time referred to as cell's action potential



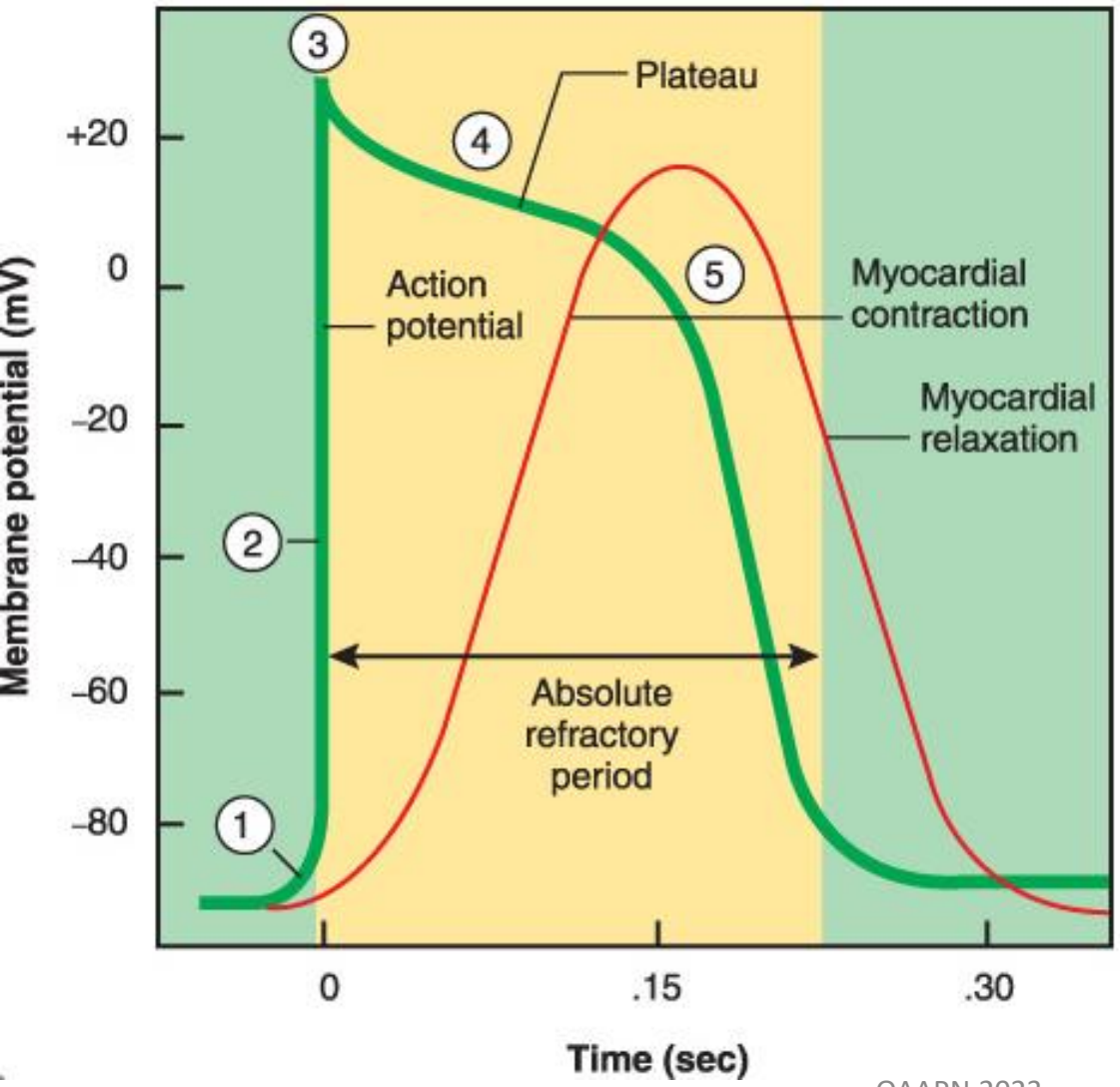
A

Repolarization

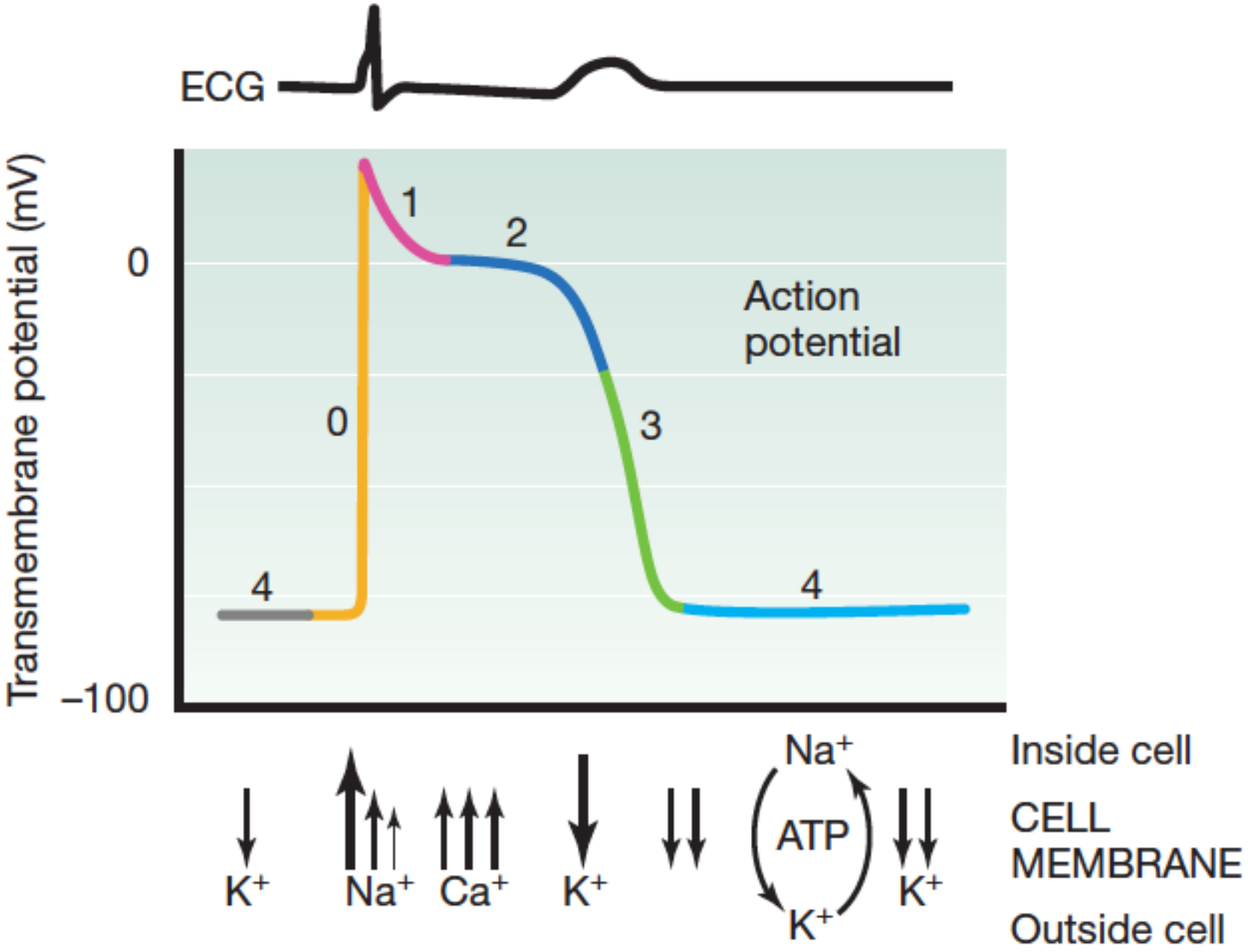
- Follows depolarization and occurs when:
  - Potassium leaves cell causing positive charge to lower
  - Sodium and calcium are removed by special transport systems

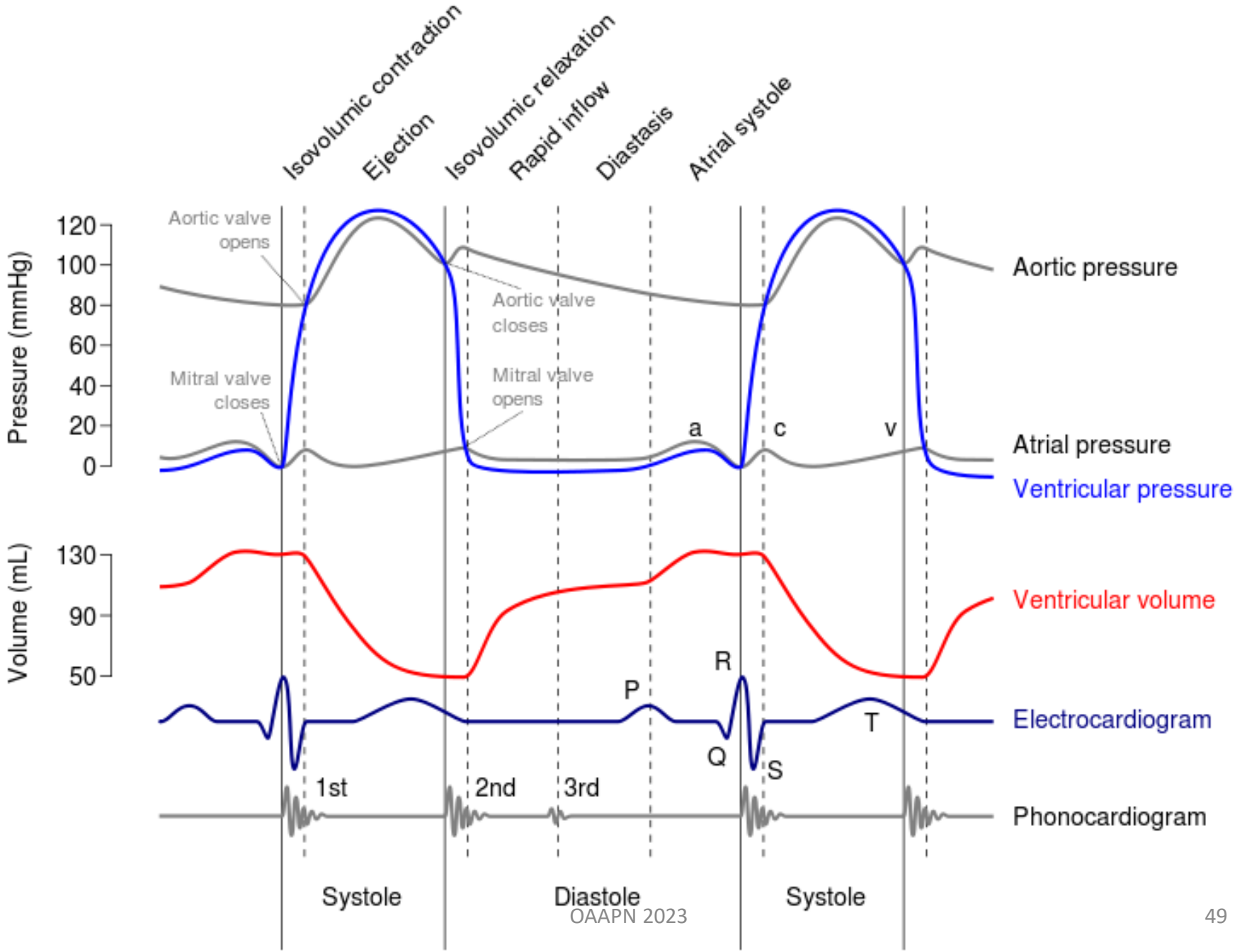


Refractory periods

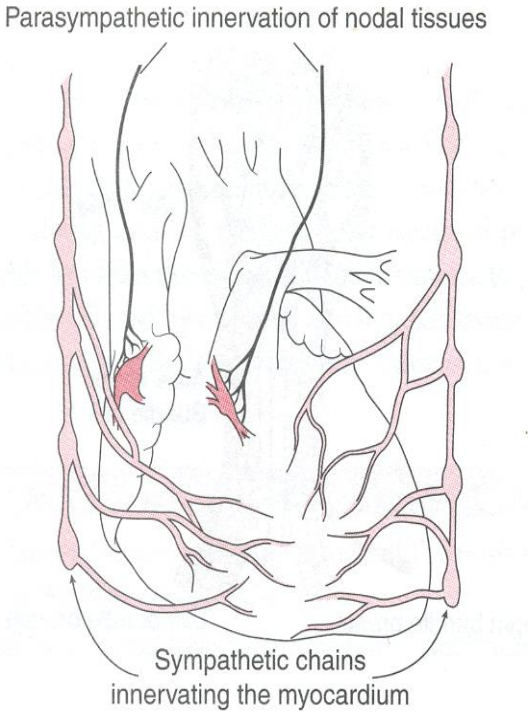


1. Voltage-gated sodium channels open.
2. Na^+ inflow depolarizes the membrane and triggers the opening of still more Na^+ channels, creating a positive feedback cycle and a rapidly rising membrane voltage.
3. Na^+ channels close when the cell depolarizes, and the voltage peaks at nearly +30 mV.
4. Ca^{2+} entering through slow calcium channels prolongs depolarization of membrane, creating a plateau. Plateau falls slightly because of some K^+ leakage, but most K^+ channels remain closed until end of plateau.
5. Ca^{2+} channels close and Ca^{2+} is transported out of cell. K^+ channels open, and rapid K^+ outflow returns membrane to its resting potential.


ECG
Transmembrane potential (mV)
0
–100
1
2
0
3
4
4
Action potential
K+
Na+
Ca+
K+
Na+
ATP
K+
K+
Inside cell
CELL MEMBRANE
Outside cell


Isovolumic contraction
Ejection
Isovolumic relaxation
Rapid inflow
Diastasis
Atrial systole
Pressure (mmHg)
120
100
80
60
40
20
0
Aortic valve opens
Aortic valve closes
Mitral valve closes
Mitral valve opens
a
c
v
Aortic pressure
Atrial pressure
Ventricular pressure
Volume (mL)
130
90
50
Ventricular volume
R
P
T
Q
S
Electrocardiogram
1st
2nd
3rd
Phonocardiogram
Systole
Diastole
Systole

Autonomic Nervous System

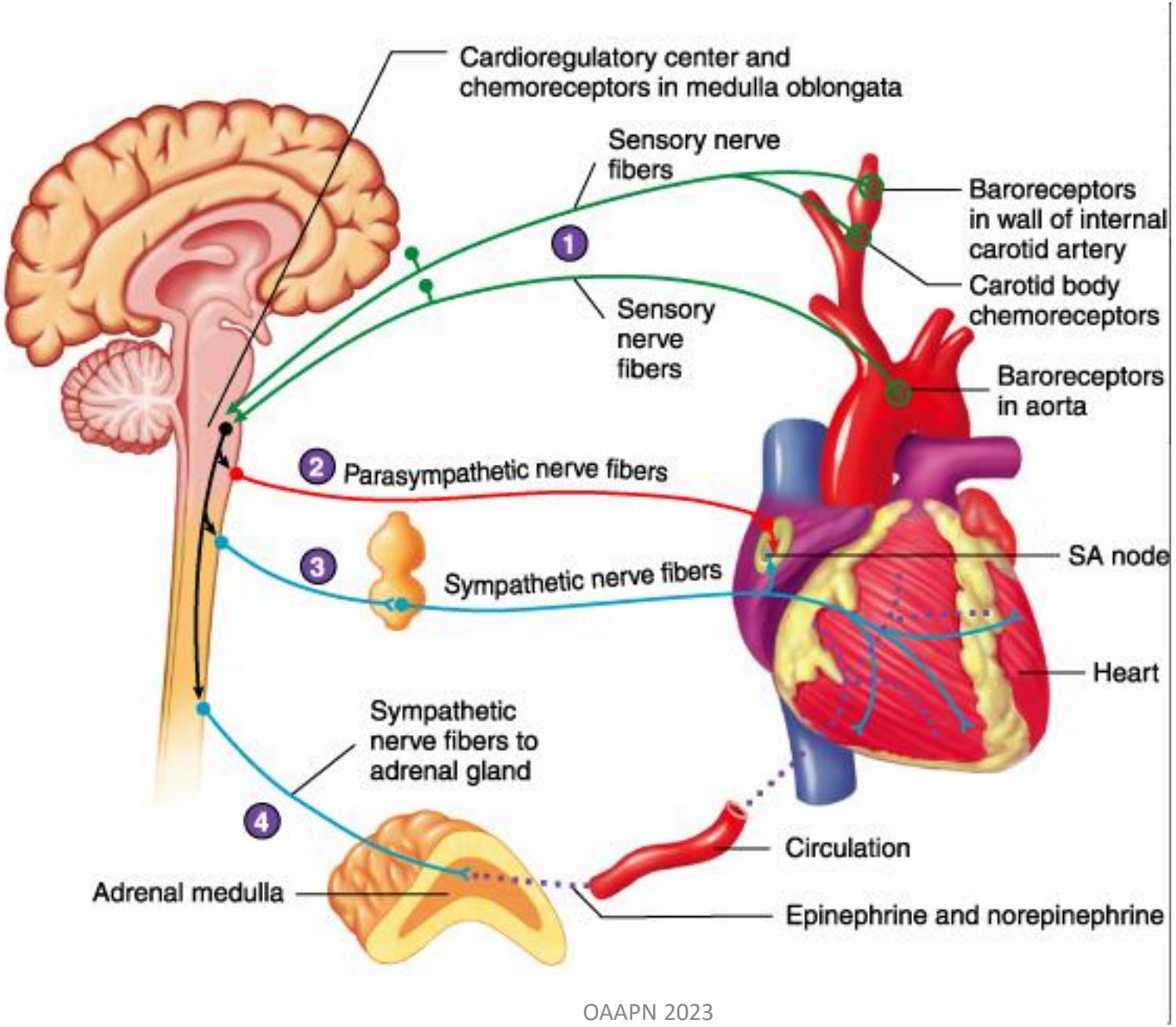


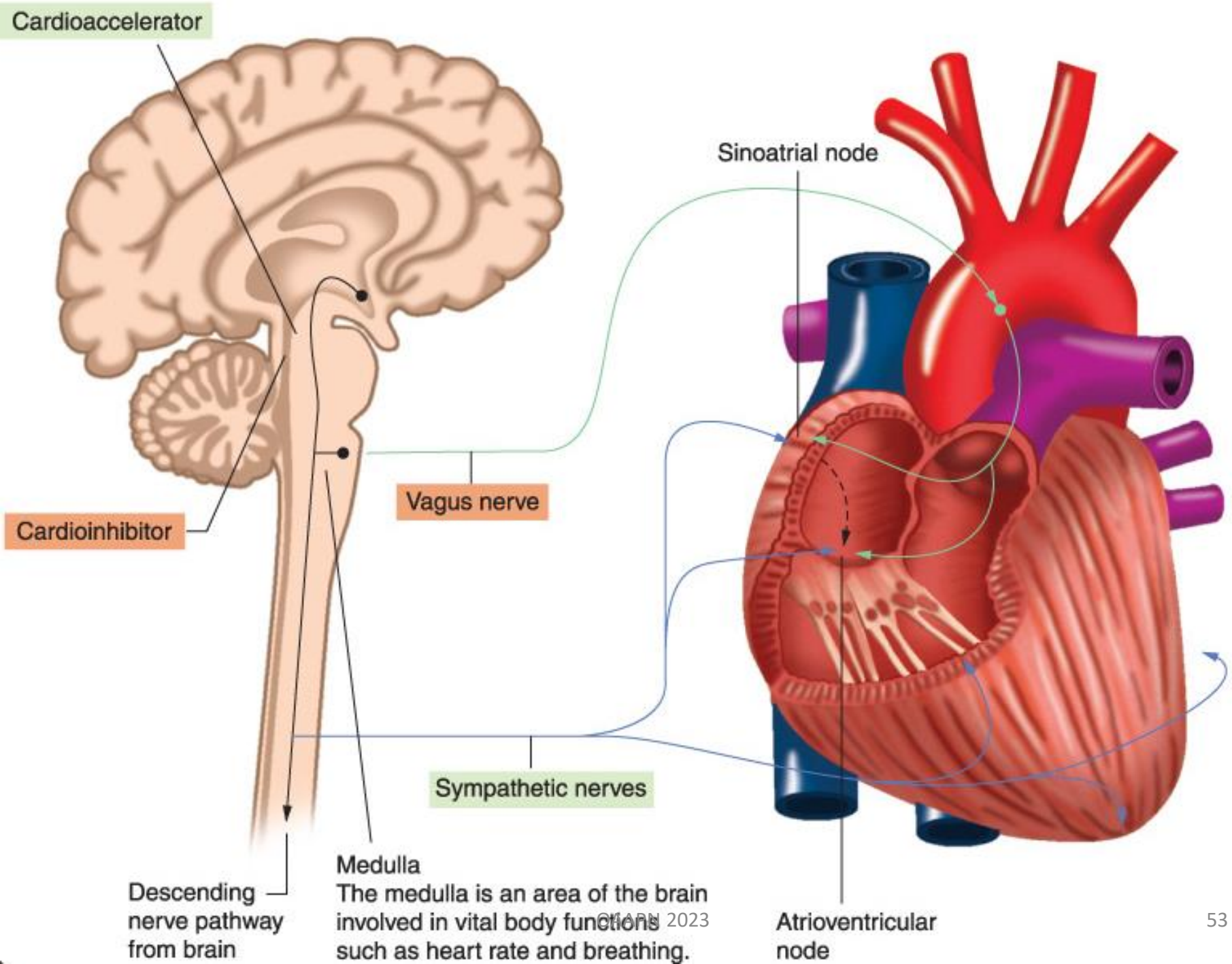
Electrophysiology of the Heart
Autonomic Nervous System control

- Sympathetic nerves: supply primarily ventricles, chemical mediators are hormones *norepinephrine and epinephrine*

  (Tachy arrhythmias)
- Parasympathetic: supply primarily atria, stimulation of vagus nerve causes the release of the hormone *acetylcholine*

  (*Brady arrhythmias)*

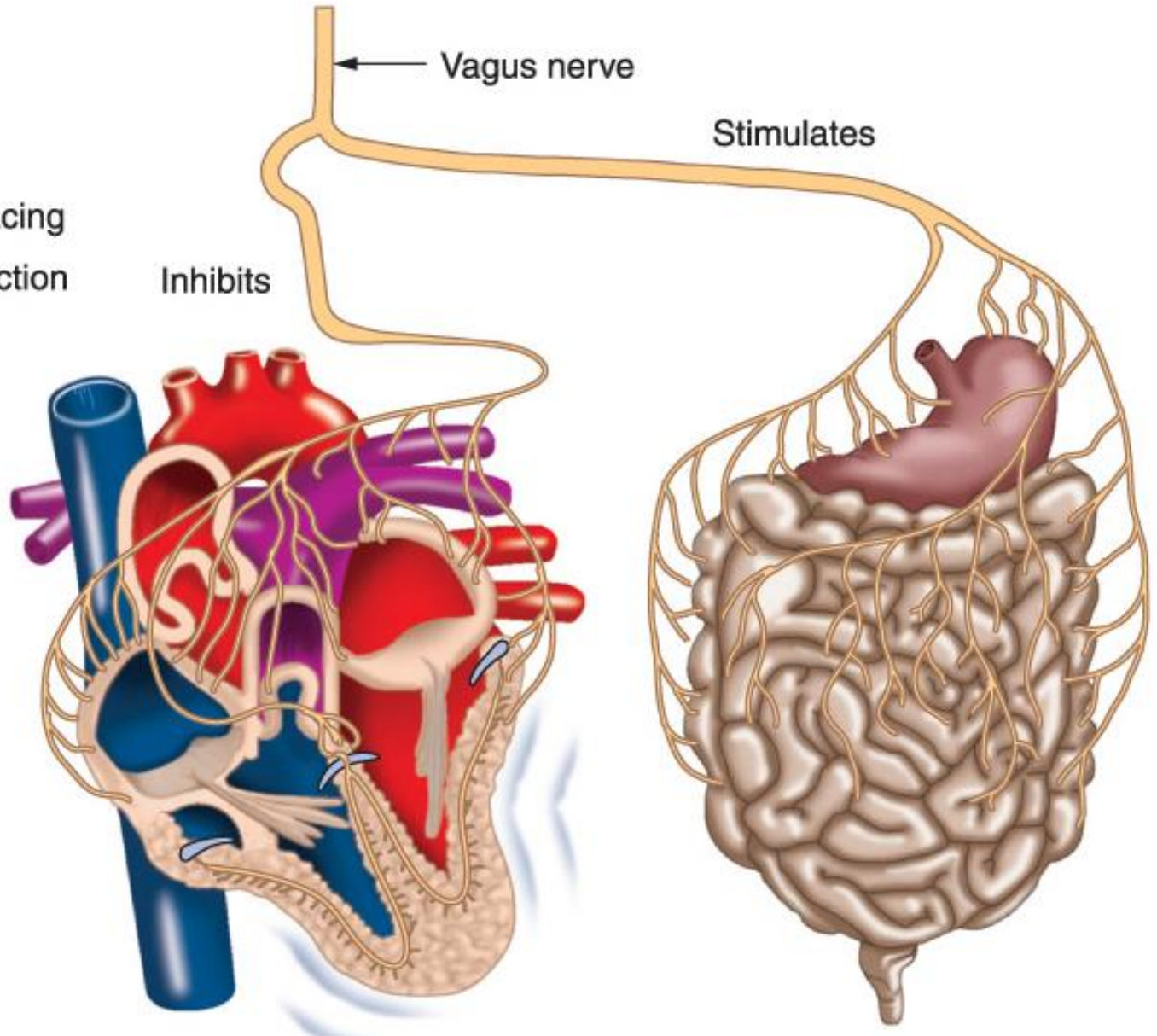

Cardioregulatory center and chemoreceptors in medulla oblongata
Sensory nerve fibers
1
Sensory nerve fibers
Baroreceptors in wall of internal carotid artery
Carotid body chemoreceptors
Baroreceptors in aorta
2
Parasympathetic nerve fibers
3
Sympathetic nerve fibers
SA node
Heart
Sympathetic nerve fibers to adrenal gland
4
Circulation
Adrenal medulla
Epinephrine and norepinephrine


Cardioaccelerator
Sinoatrial node
Vagus nerve
Cardioinhibitor
Sympathetic nerves
Descending nerve pathway from brain
Medulla
The medulla is an area of the brain involved in vital body functions such as heart rate and breathing.
Atrioventricular node

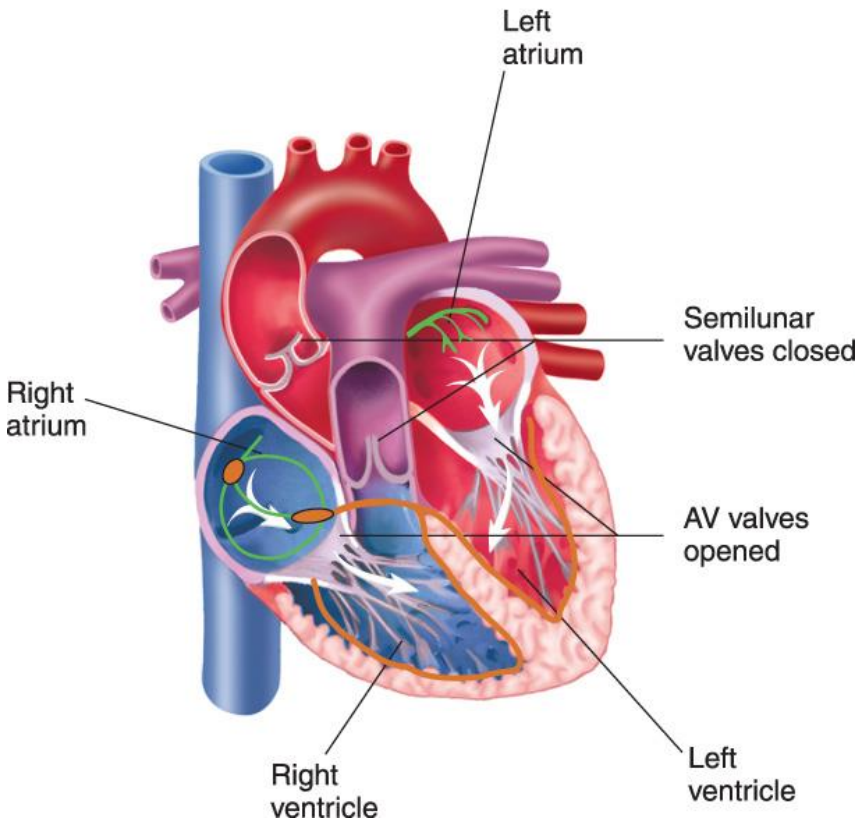
Parasympathetic system
Activates cholinergic receptors

Cardioinhibitor effects

- Rate of SA node pacing
- Speed of AV conduction

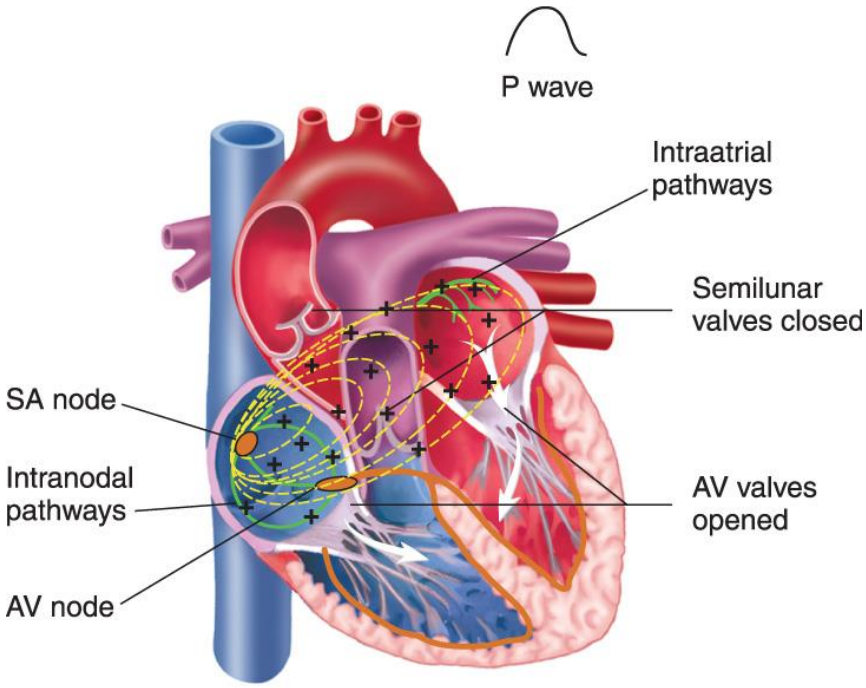


- Cardiac cycle begins with RA and LA receiving blood from systemic and pulmonary circulations
  - Rising pressure within atria forces tricuspid and mitral valves open

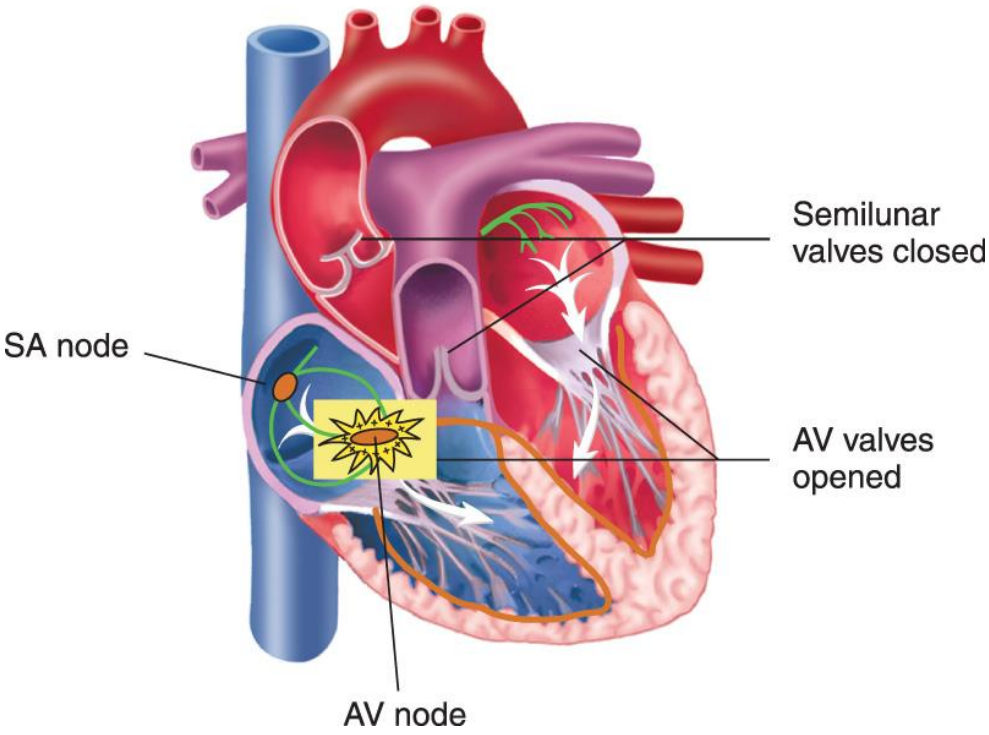


I

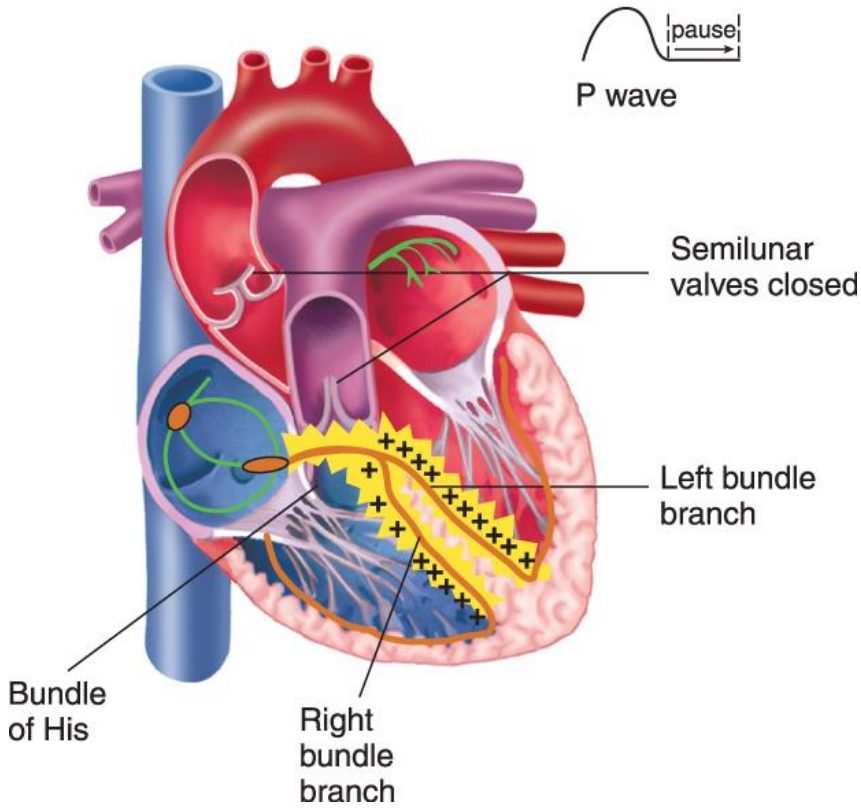
- Heartbeat initiated by an electrical impulse that arises from SA node
- Impulse travels through atria
  - generates a positive waveform on ECG and contraction of atria



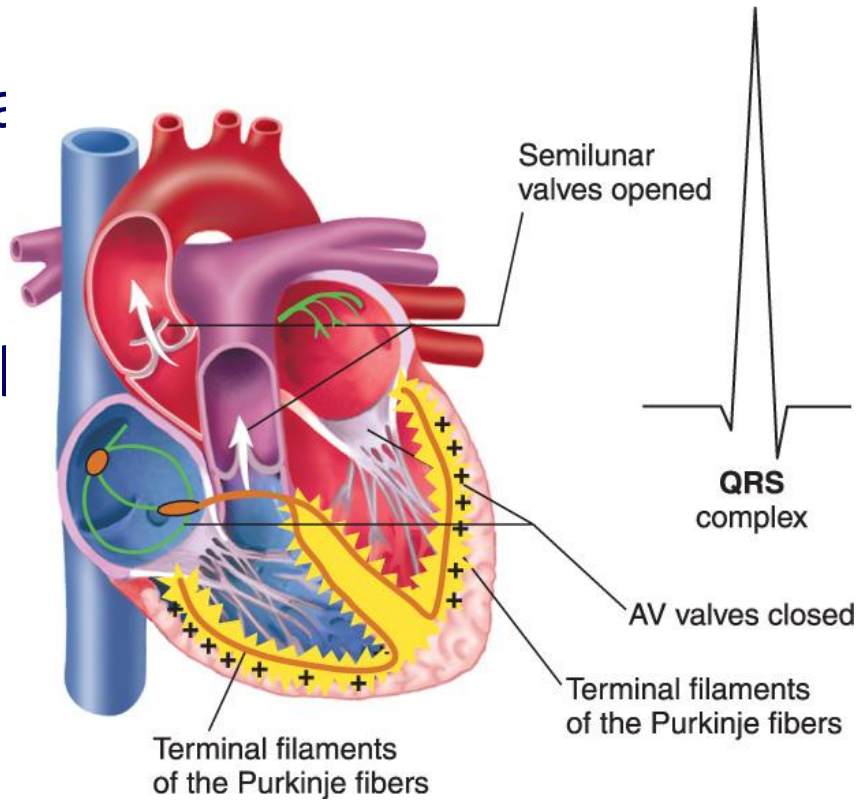
- Impulse slows as it passes through AV node from atria to ventricles
  - Allows atria time to finish filling ventricles



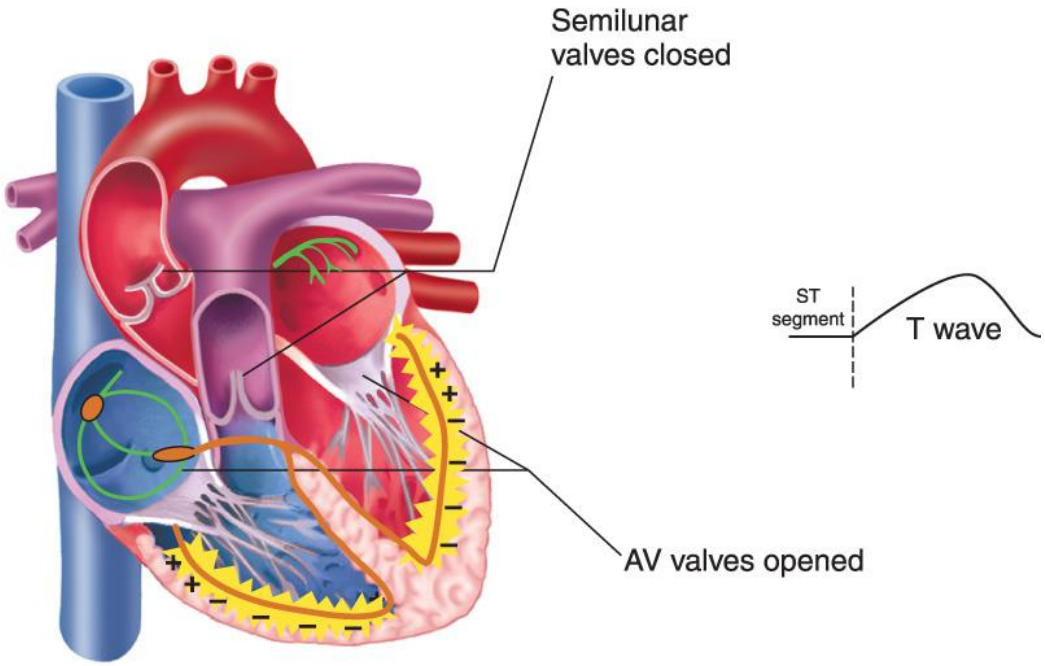
- Impulse then rapidly travels through His-Purkinje system
  - Seen as a flat line following P wave



- Depolarization of septum and ventricula walls generates QRS complex and contraction of ventricl

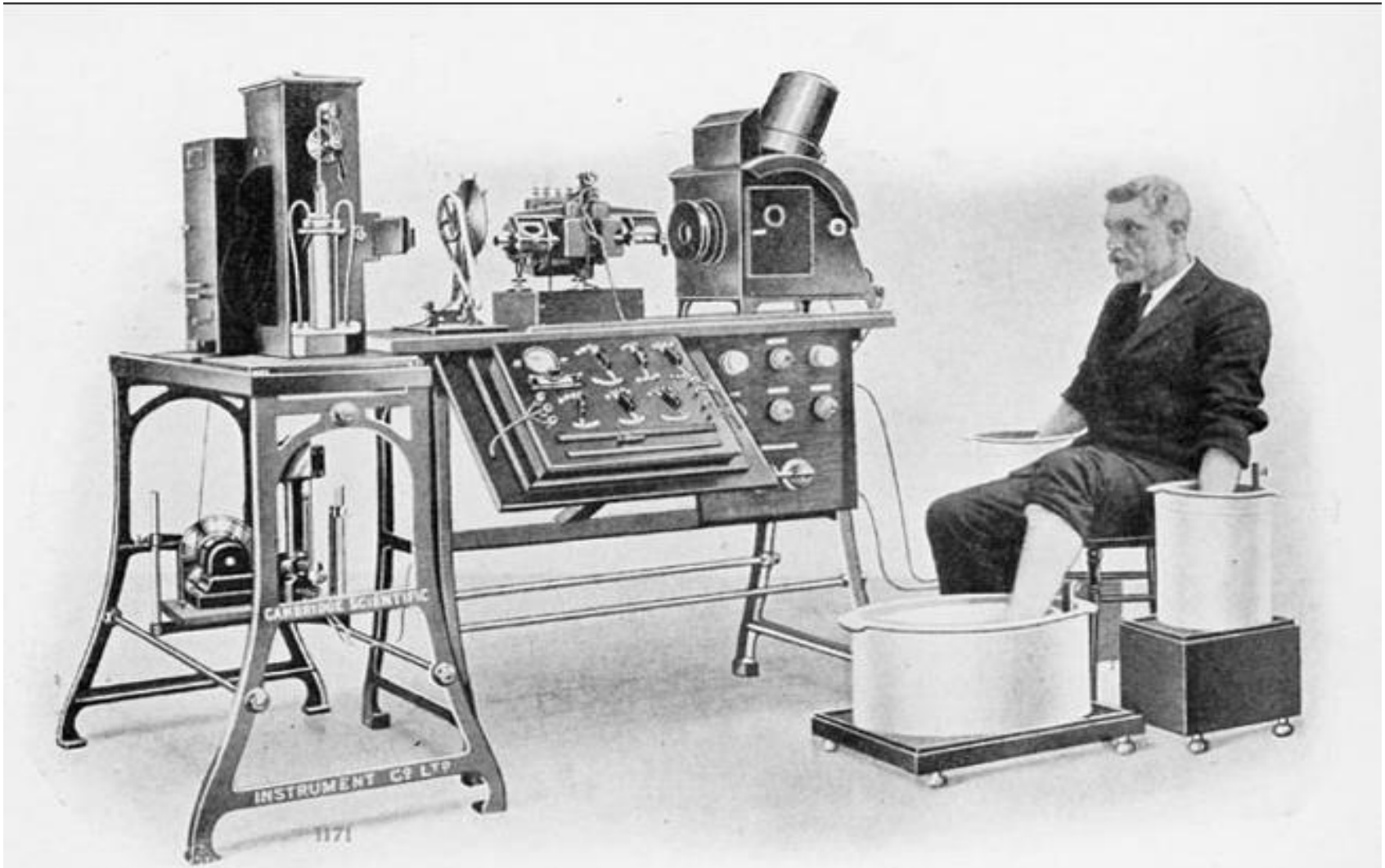


- Repolarization of ventricles is represented on ECG by ST segment and T wave



The Electrocardiogram

What is important to know



PHOTOGRAPH OF A COMPLETE ELECTROCARDIOGRAPH, SHOWING THE MANNER IN WHICH THE ELECTRODES ARE ATTACHED TO THE PATIENT, IN THIS CASE THE HANDS AND ONE FOOT BEING IMMERSED IN JARS OF SALT SOLUTION

Normal ECG

- ECG Paper

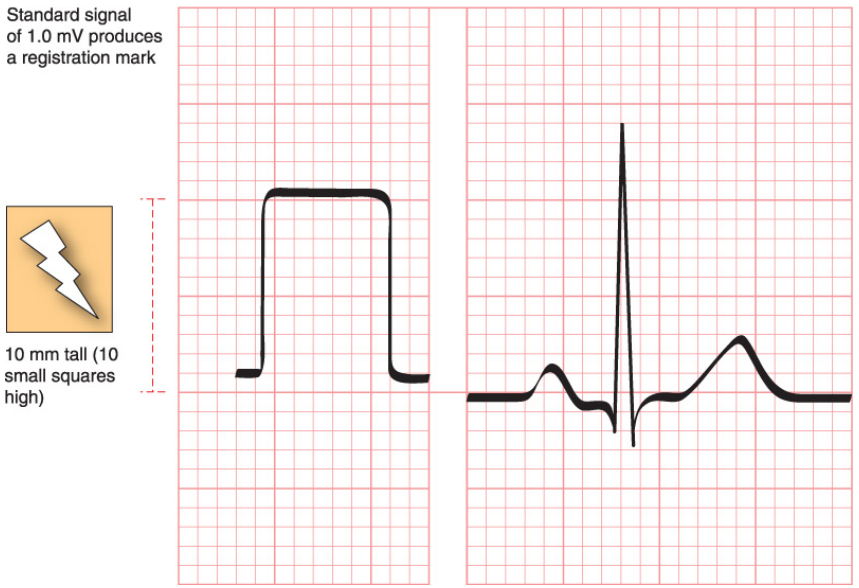
  Usually moves at a rate of 25mm/second

  There are horizontal lines, indicating time, five large boxes of 5mm each equal 25mm or 1 second of time

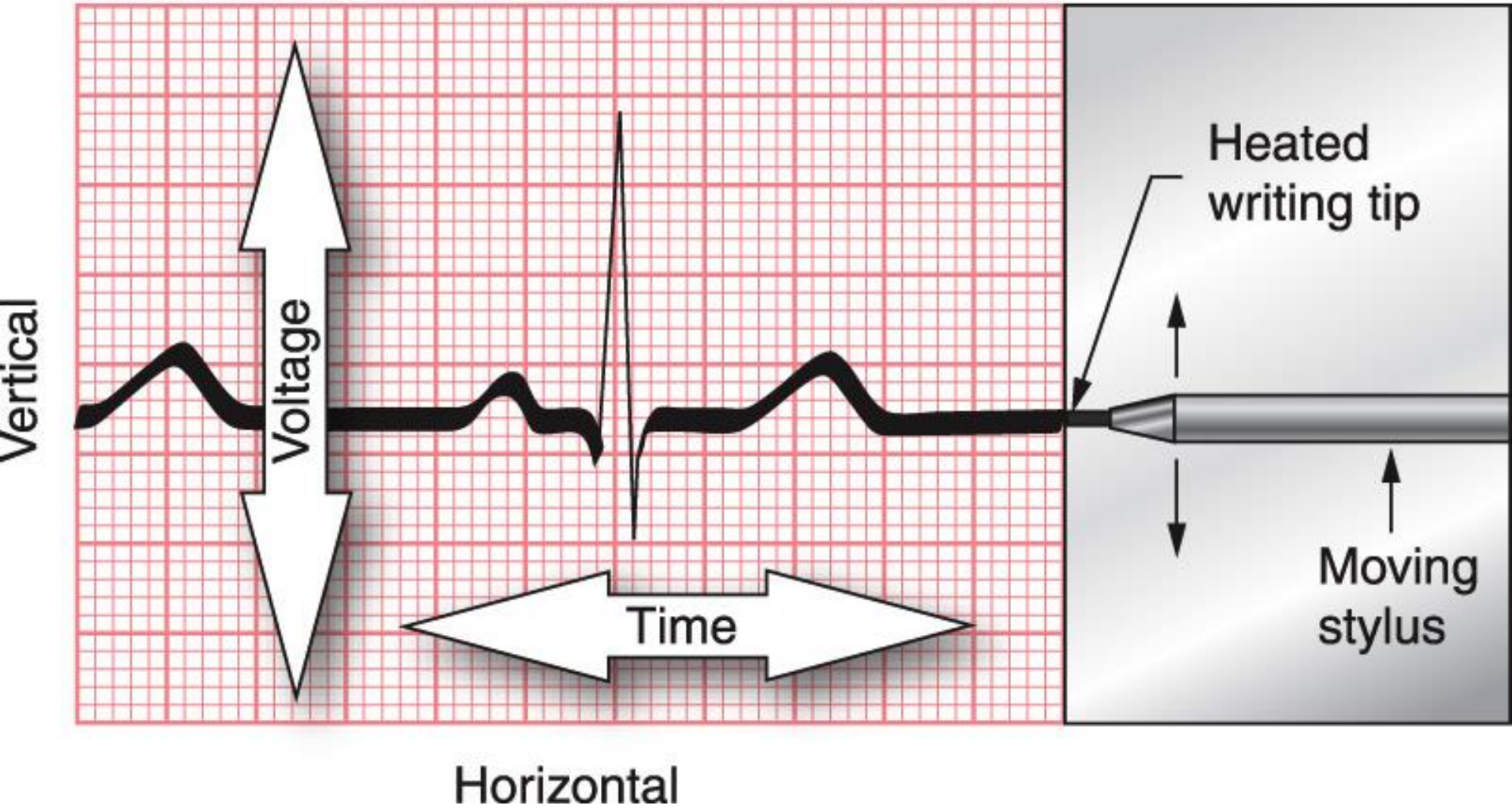
  There are vertical lines, indicating voltage, calibrated so that a 1mV standardization signal produces a deflection of exactly 10mm, (full standardization).

Calibration or Registration Mark

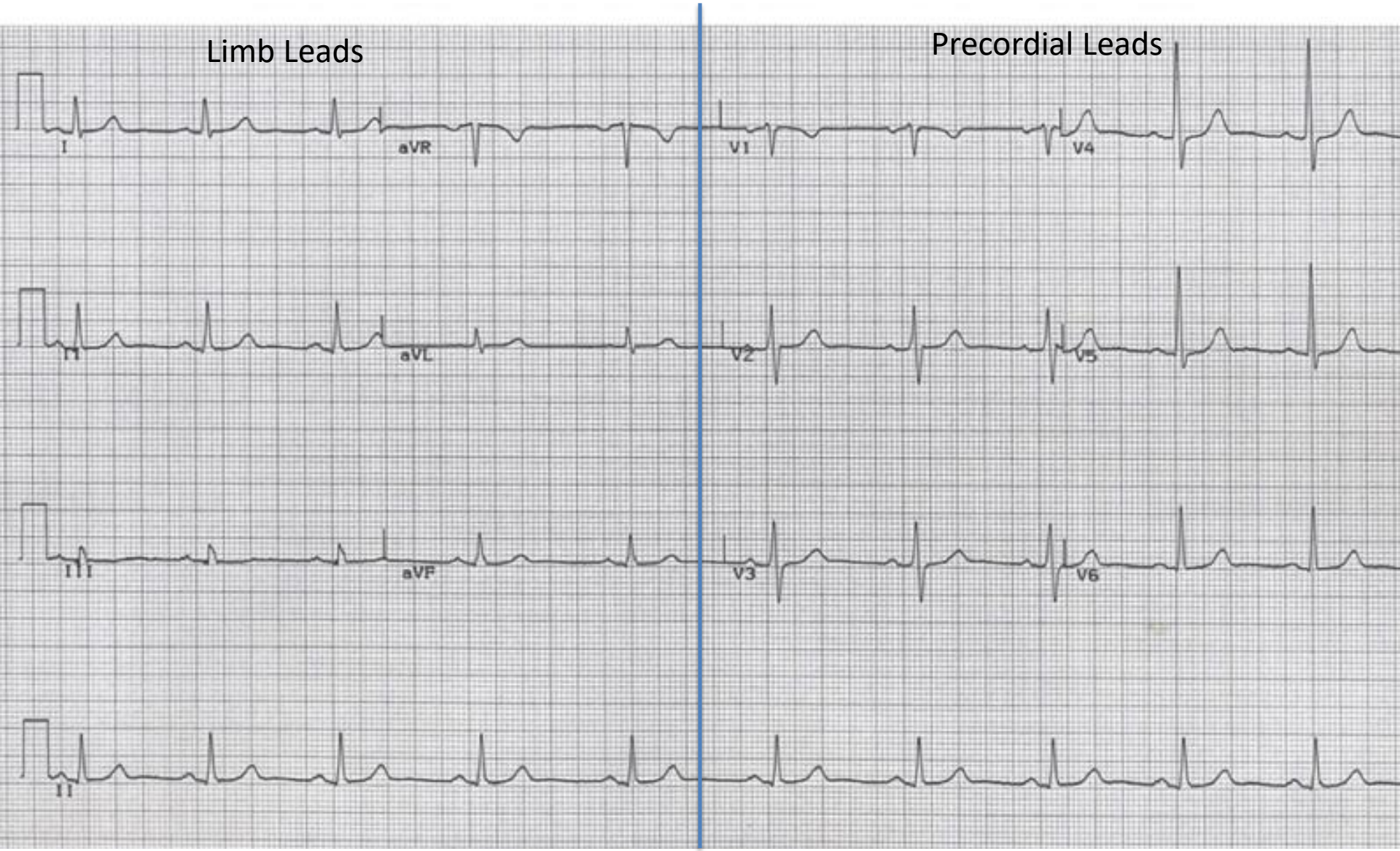
- Helps ensure ECG machine is properly calibrated
- Serves as reference point on ECG tracing

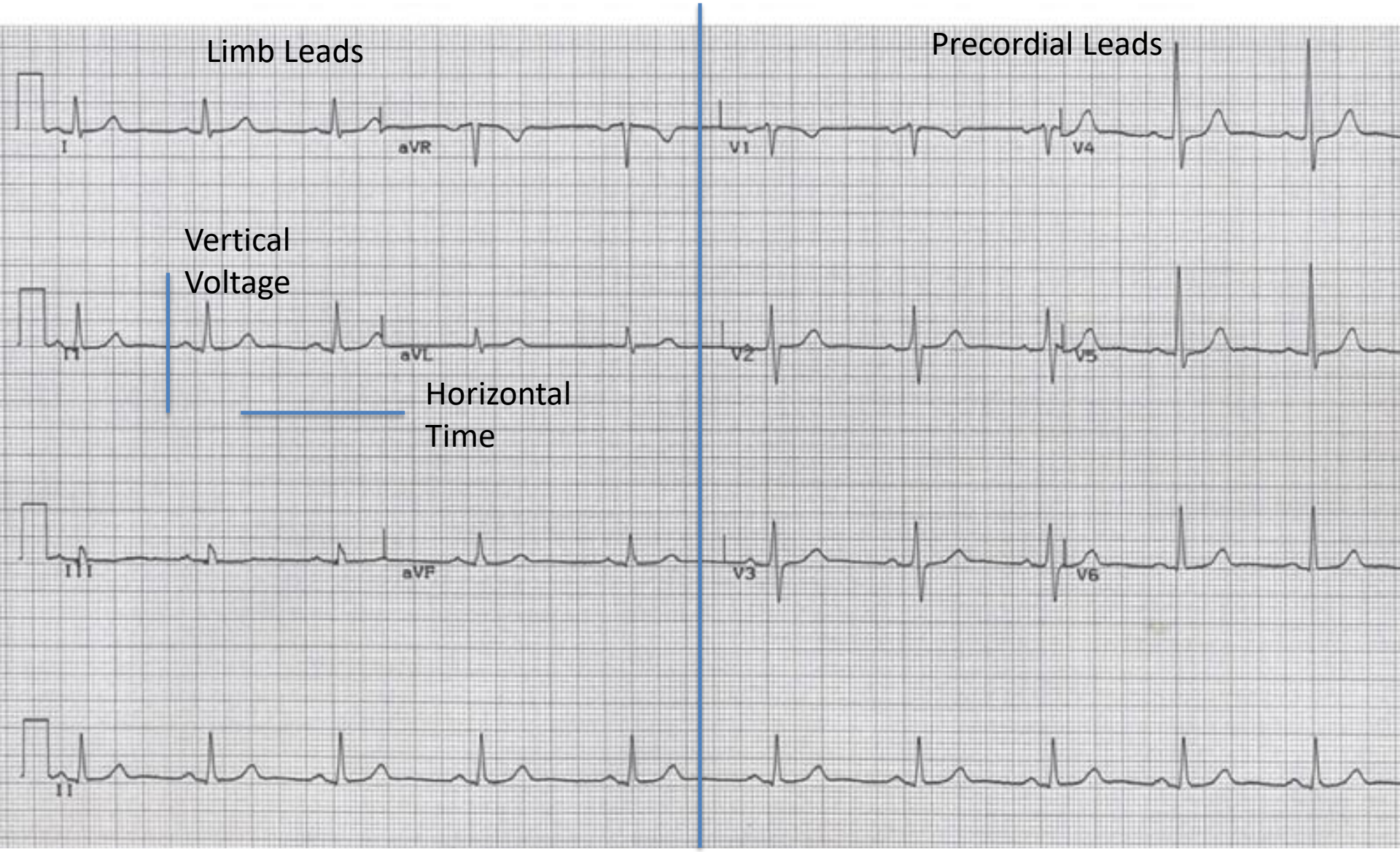


How things are measured

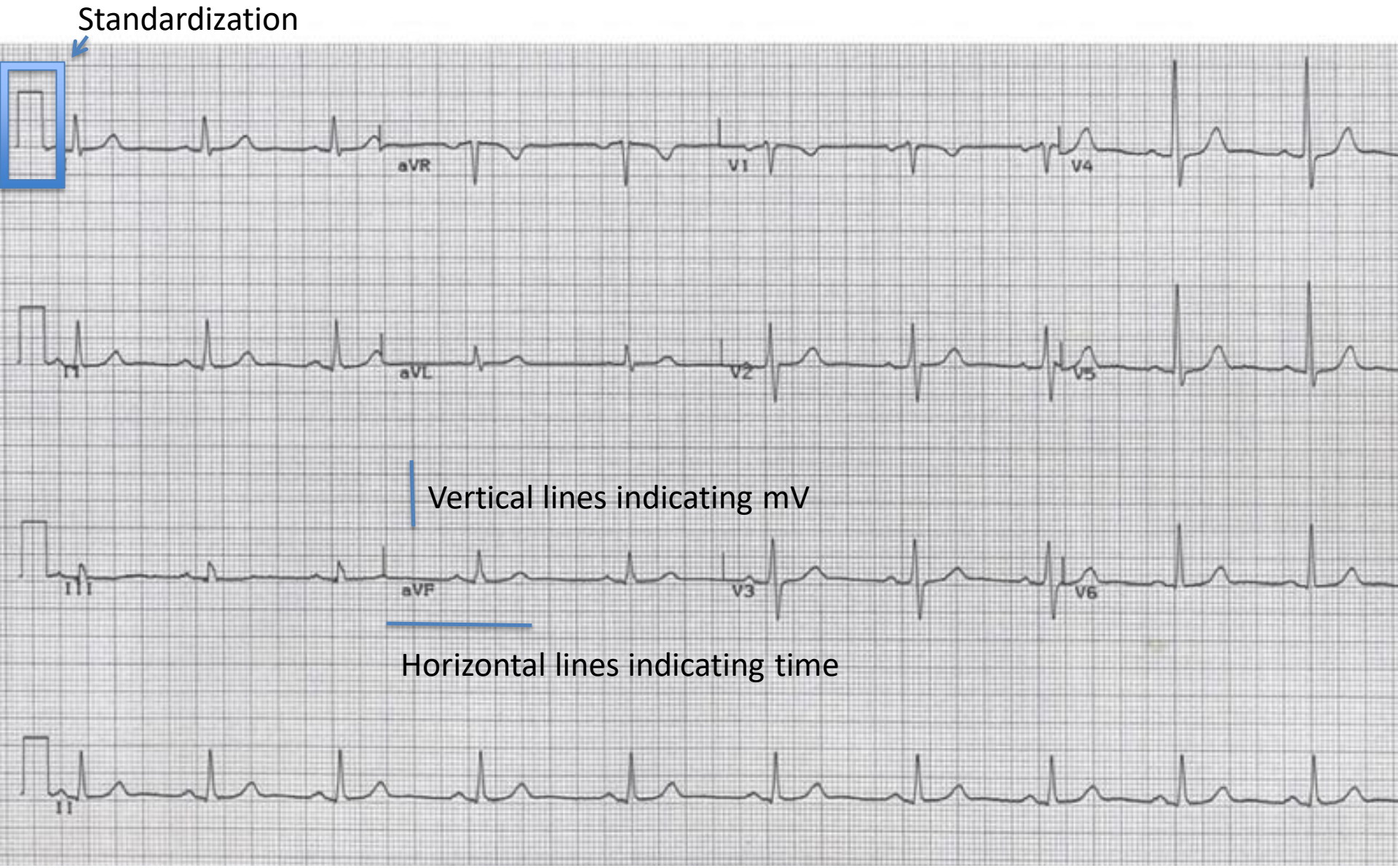


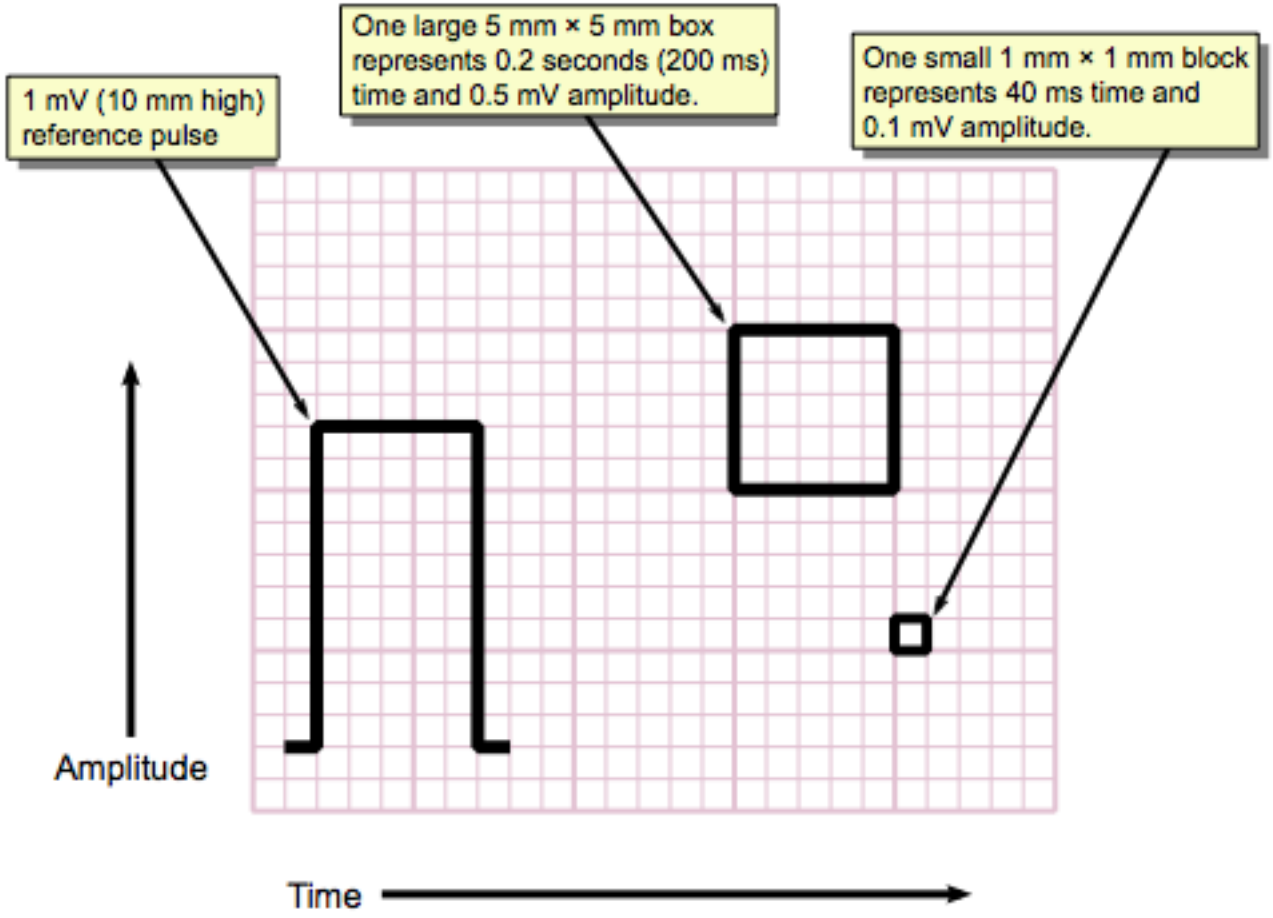

I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II

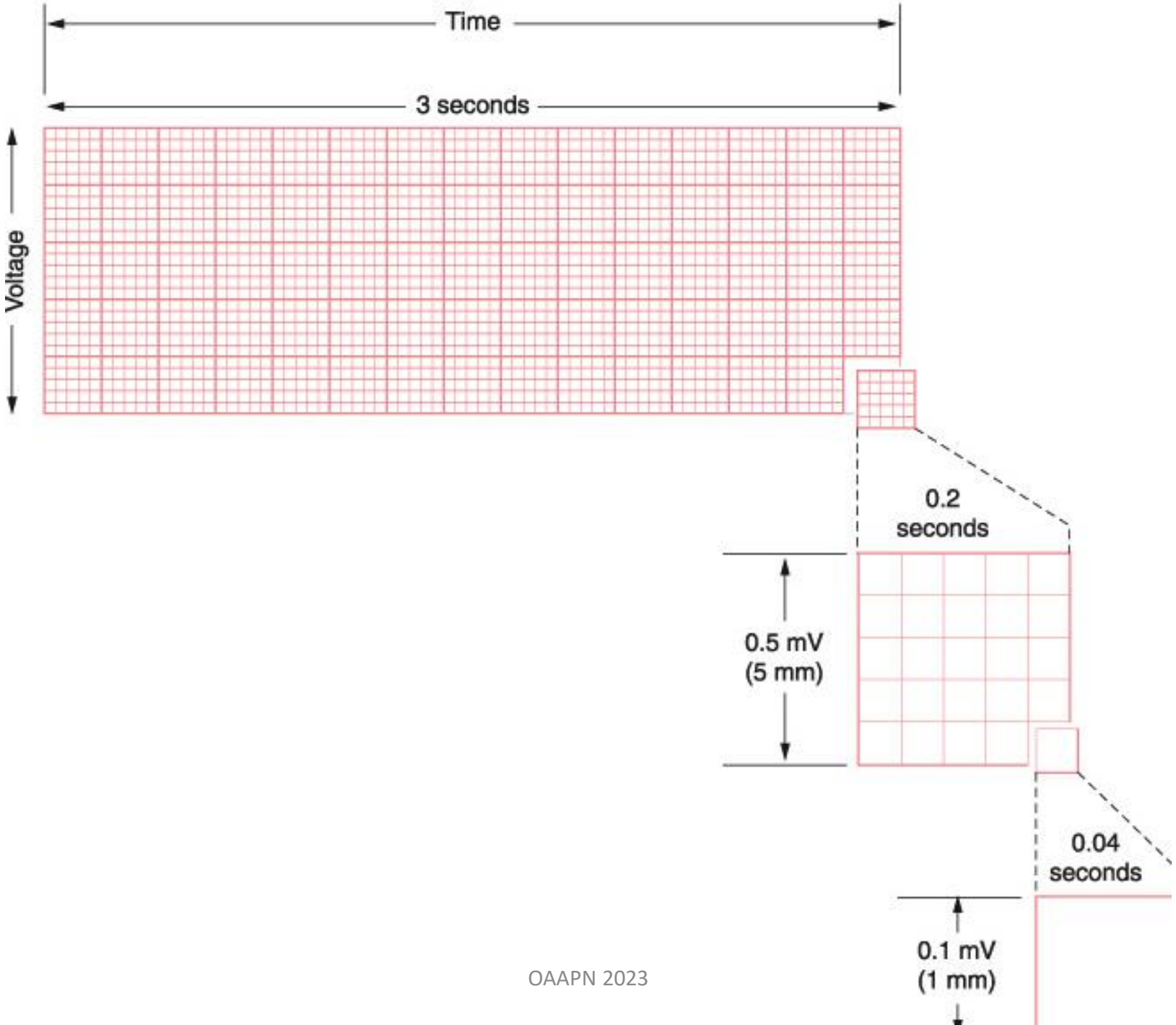

Limb Leads
Precordial Leads
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II


Limb Leads
Precordial Leads
Vertical
Voltage
Horizontal
Time
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II

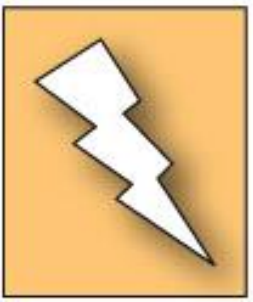
Normal EKG


Standardization
aVR
V1
V4
aVL
V2
V5
Vertical lines indicating mV
aVF
V3
V6
Horizontal lines indicating time
II


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


Time
3 seconds
Voltage
0.2
seconds
0.5 mV
(5 mm)
0.04
seconds
0.1 mV
(1 mm)

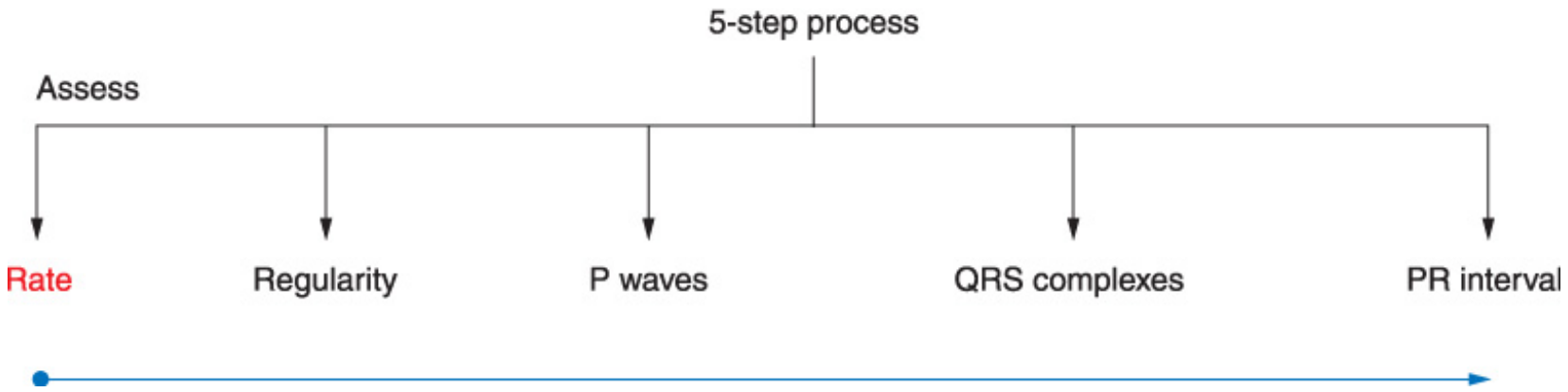
Standard signal of 1.0 mV produces a registration mark



10 mm tall (10 small squares high)

ECG Analysis

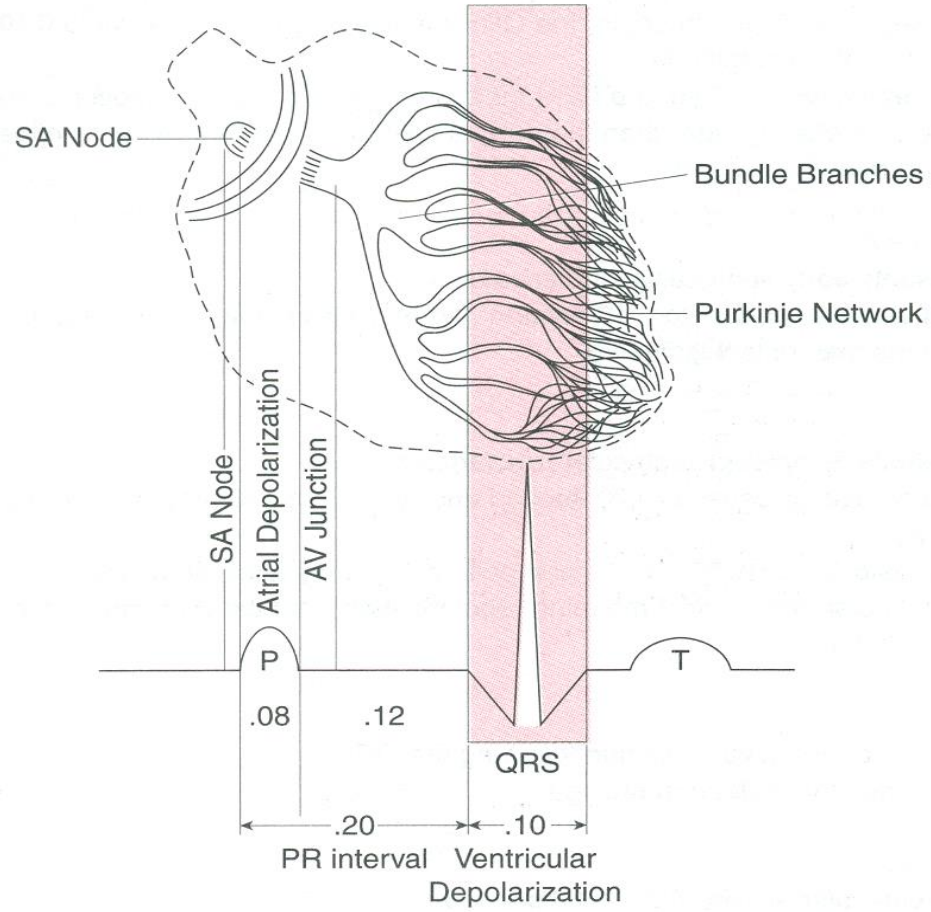
- Five Step Process is a logical and systematic process for analyzing ECG tracings



Dysrhythmias

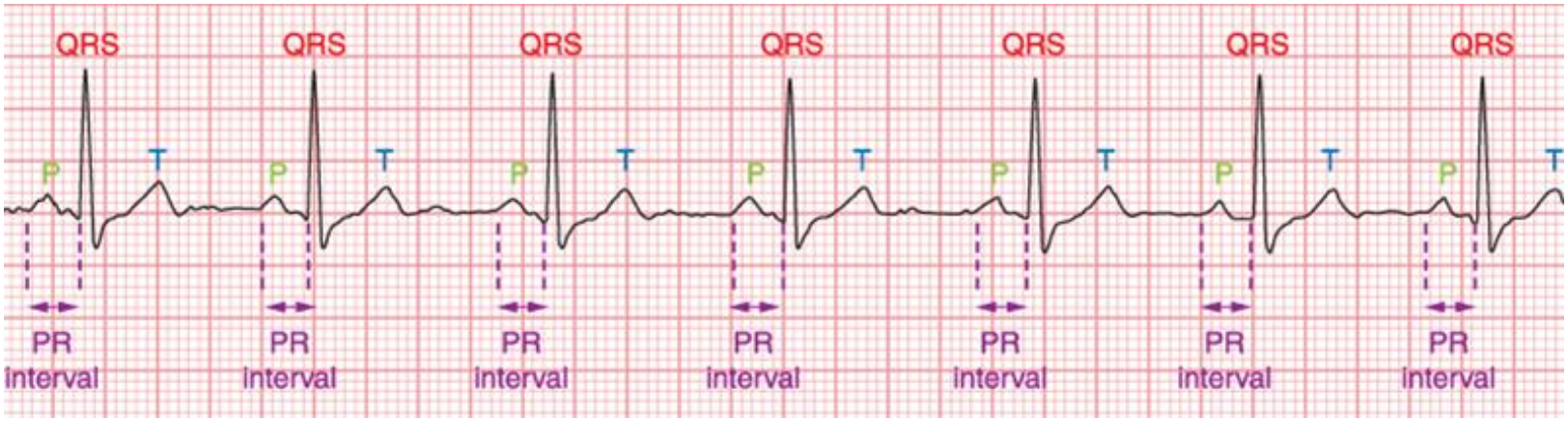
- Irregularities in heart rate or rhythm
  - Some are of little significance whereas others are life threatening

Relationship of conduction to ECG measurement



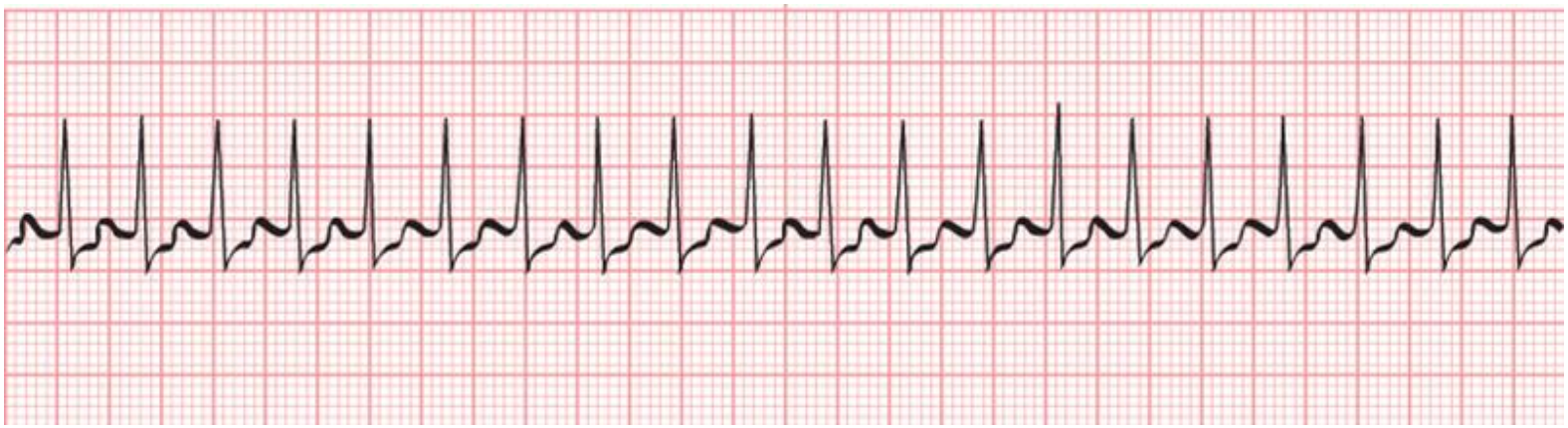
Normal Sinus Rhythm Characteristics

- **Rate:** 60 - 100 BPM
- **Rhythm:** Regular
- **P waves:** Upright and round, one preceding each QRS complex
- **QRS complexes:** Narrow, 0.06 - 0.12 seconds in duration
- **PR Interval:** 0.12 - 0.20 seconds in duration
- **T waves:** Upright and slightly asymmetrical



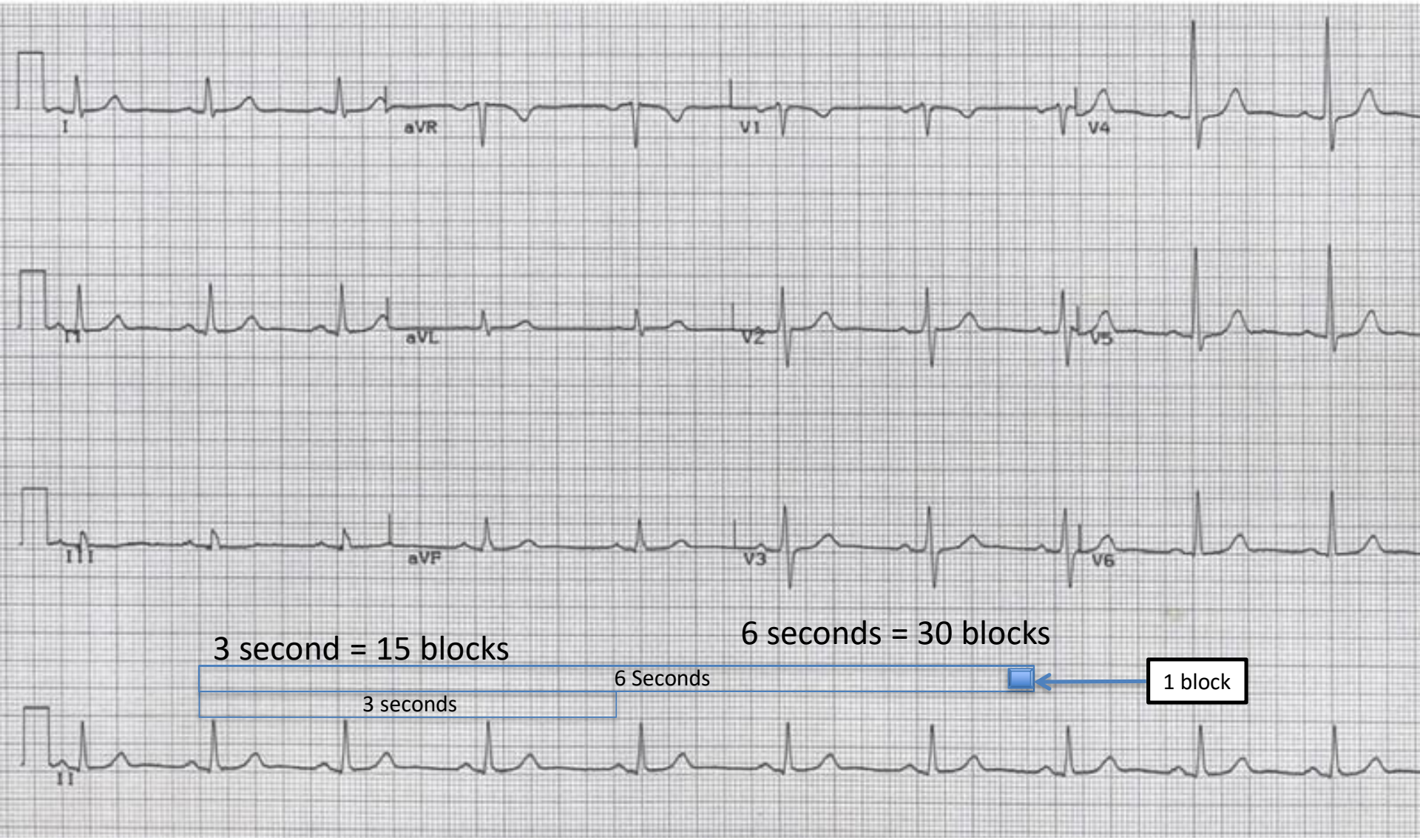
Determining Heart Rate

- First step in analyzing an ECG rhythm
- Begin by quickly checking ECG monitor or tracing to see if rate is slow, normal or fast



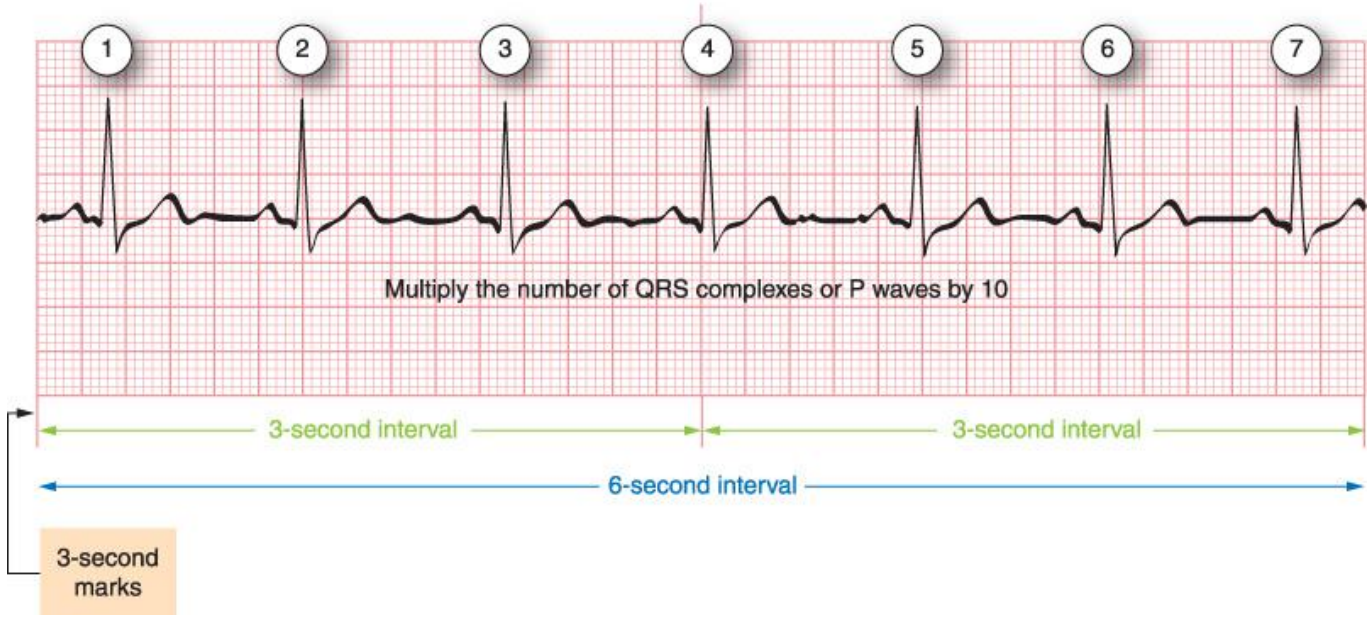
Calculating Heart Rate

- Several methods can be used including:
  - 6-Second Interval x 10 Method
  - 300, 150, 100, 75, 60, 50 Method
  - 1500 Method
  - Rate Calculator


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II
3 second = 15 blocks
6 seconds = 30 blocks
6 Seconds
3 seconds
1 block

6-Second Interval x 10 Method

- Quick and easy and does not require tools or devices
- Not as accurate as other methods
- Multiply by 10 the number of QRS complexes found in a six second portion of ECG tracing



Practice Makes Perfect

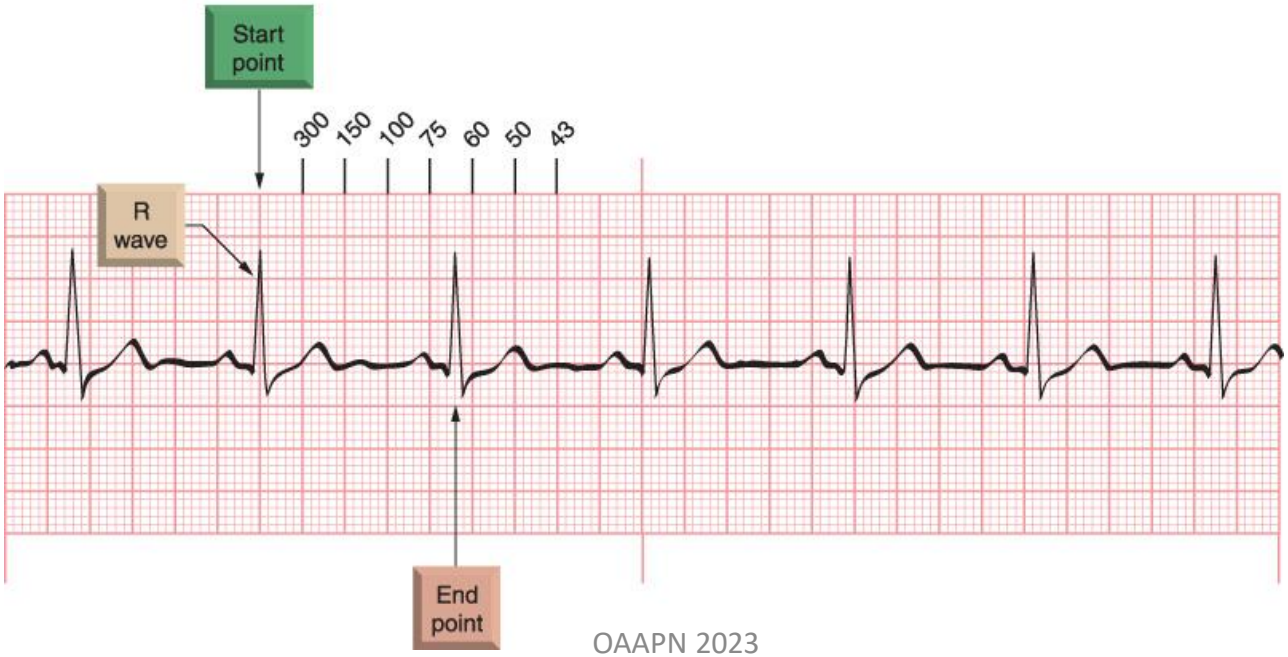
- Determine the heart rate using the 6-second interval x 10 method

Practice Makes Perfect

- Determine the heart rate using the 6-second interval x 10 method

300, 150, 100, 75, 60, 50 Method

- If the second R wave does not fall on a bold line the heart rate is approximated
  - Example: if it falls between the 4th and 5th bold line the heart rate is between 60 and 75 BPM

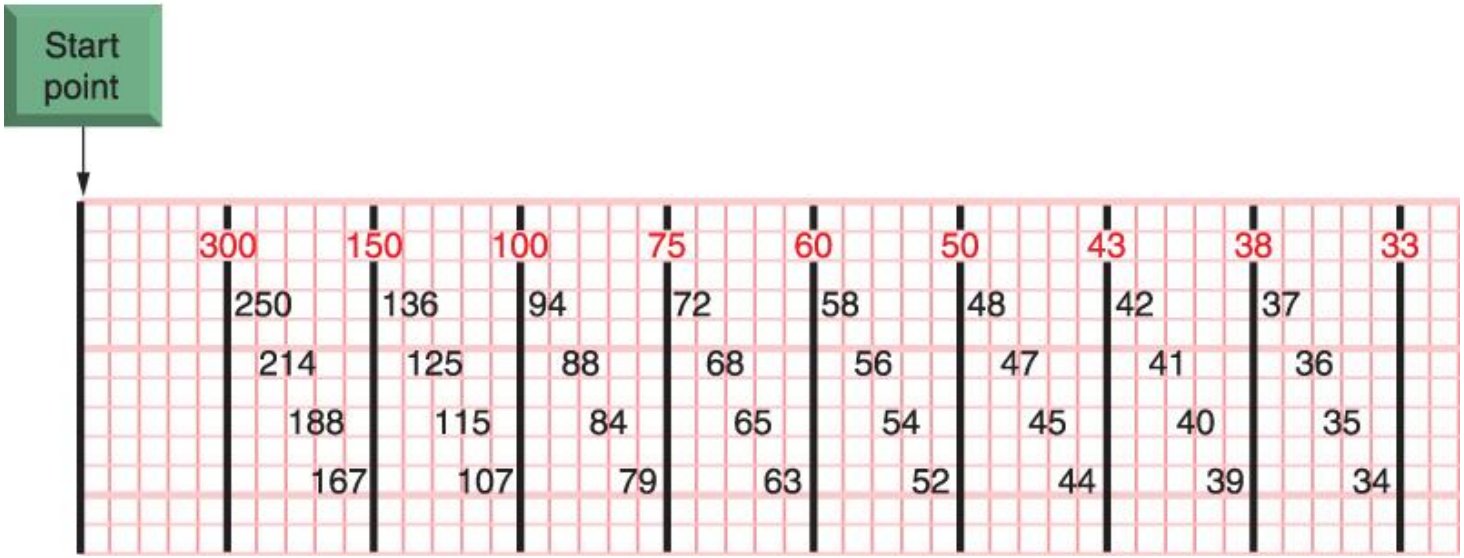


300, 150, 100, 75, 60, 50 Method

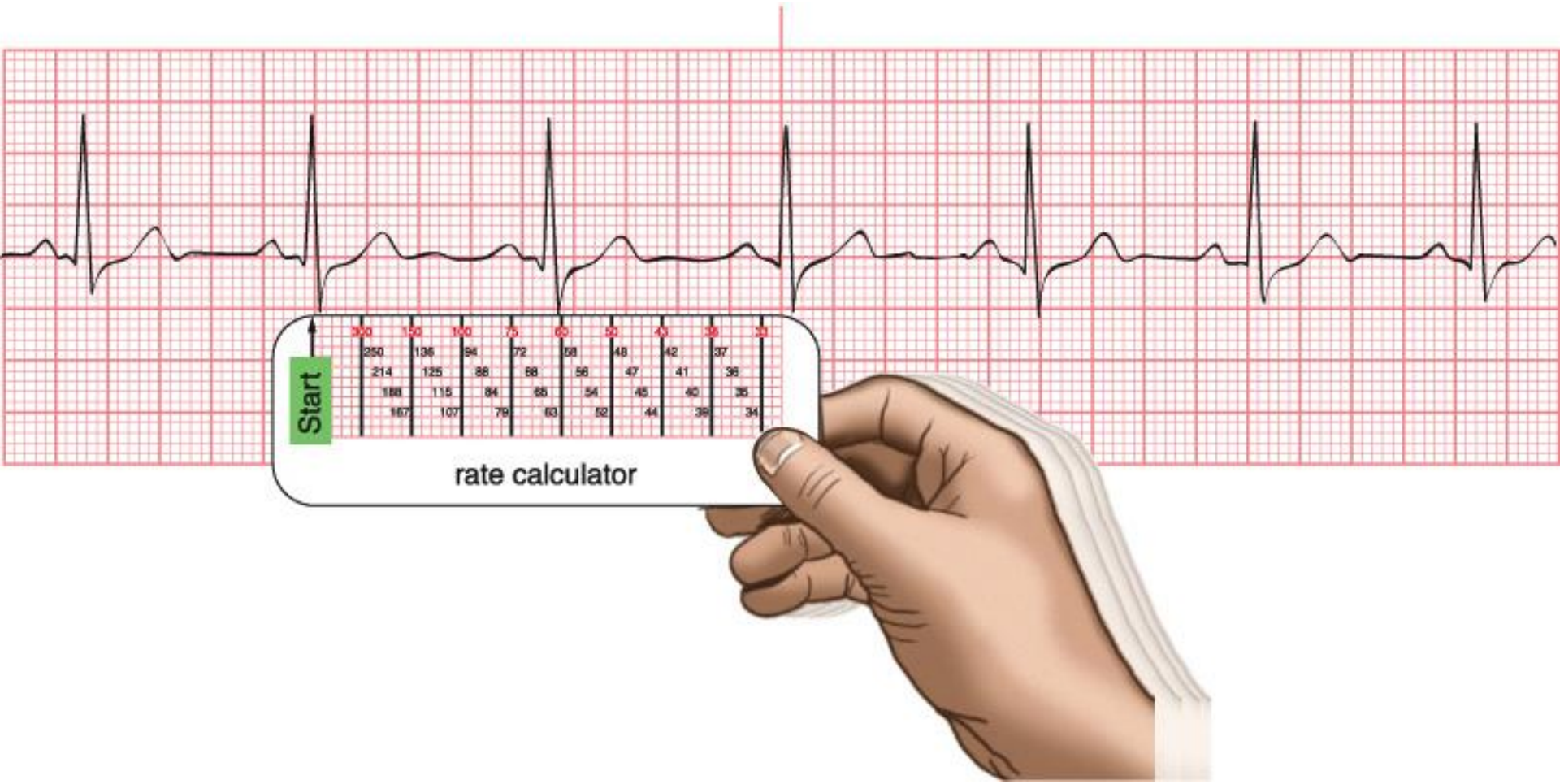
- Quick, fairly accurate, requires no special tools, or calculations
- Cannot be used with irregular rhythms
- Find an R wave located on a bold line. Then find the next consecutive R wave. Bold line it falls on (or is closest to) represents the heart rate.

300, 150, 100, 75, 60, 50 Method

- If the second R wave falls in between two bold lines the heart rate can be more precisely determined using the identified values for each thin line

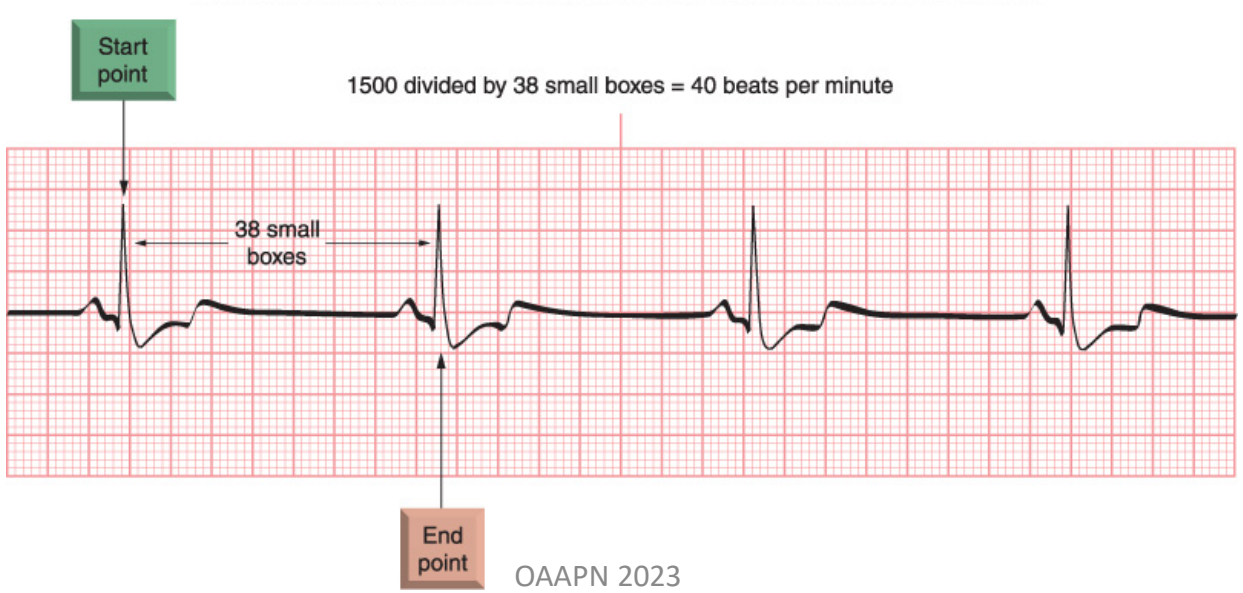


Rate rulers



1500 Method

- Most accurate and requires no special tools but math calculation must be done to determine heart rate
- Cannot be used with irregular rhythms
- Count the number of small squares between two consecutive R waves and divide 1500 by that number



Practice Makes Perfect

- Determine the heart rate using the 300, 150, 100, 75, 60, 50 method

Practice Makes Perfect

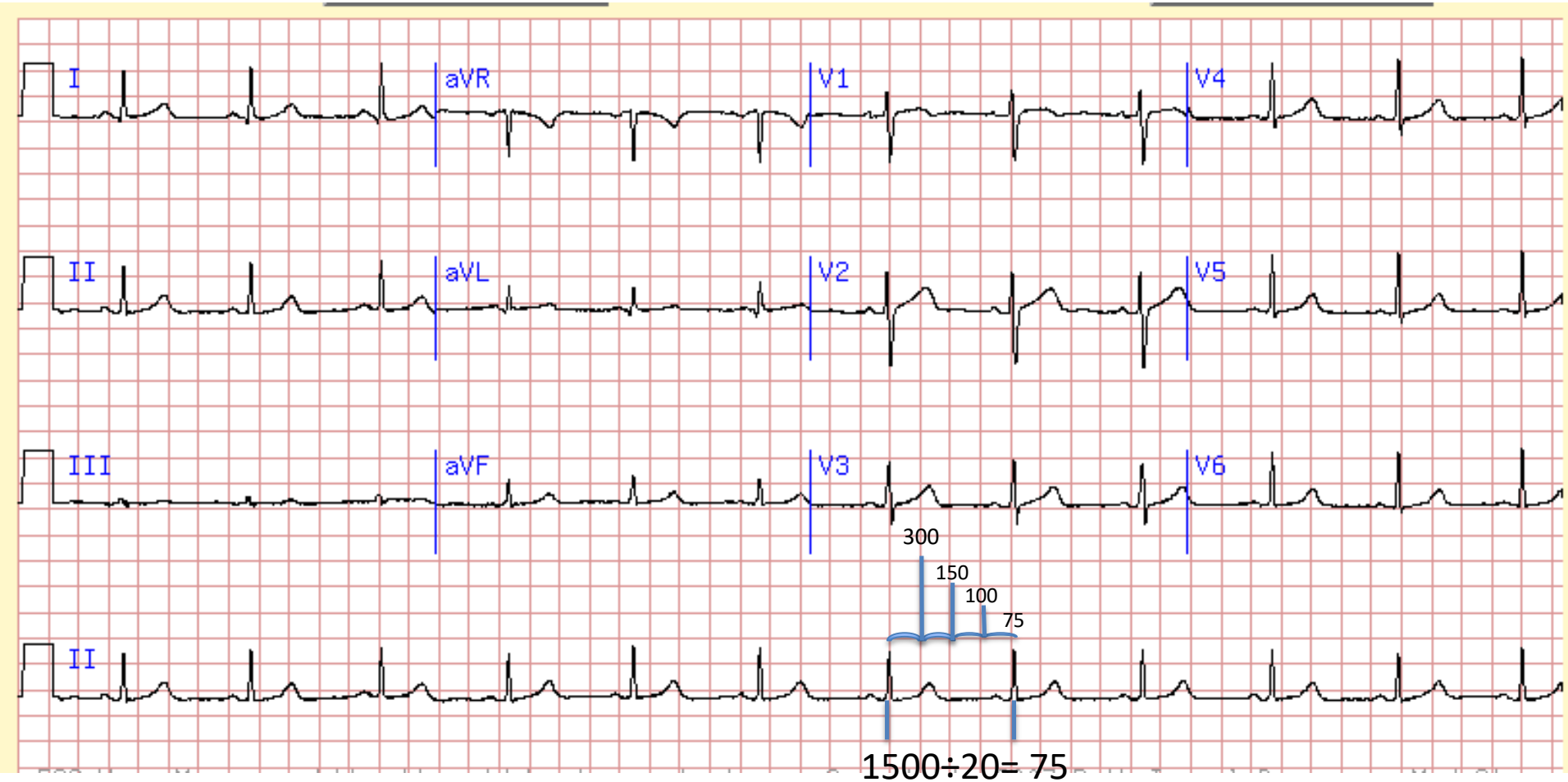
- Determine the heart rate using the 300, 150, 100, 75, 60, 50 method

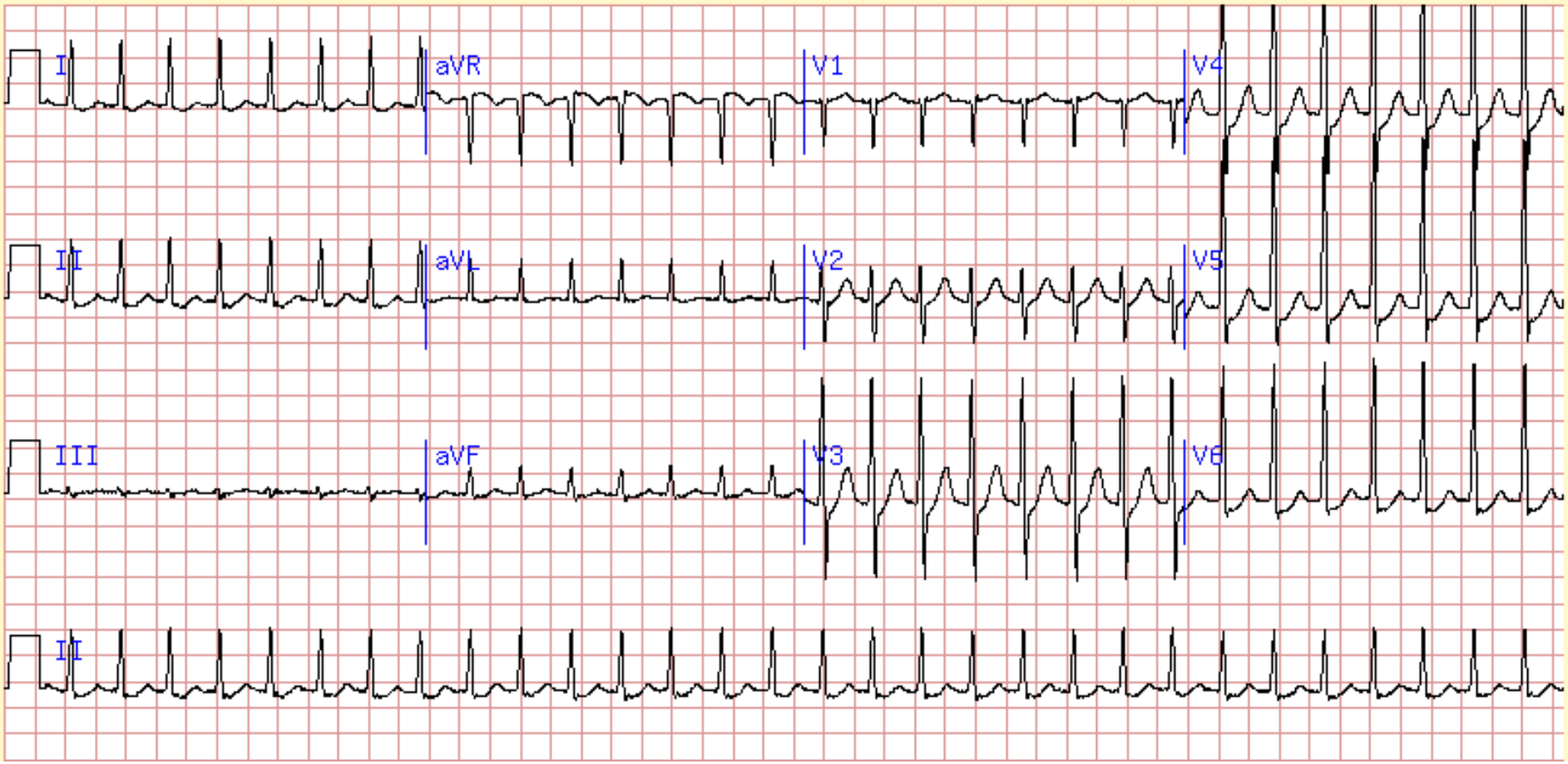
Practice Makes Perfect

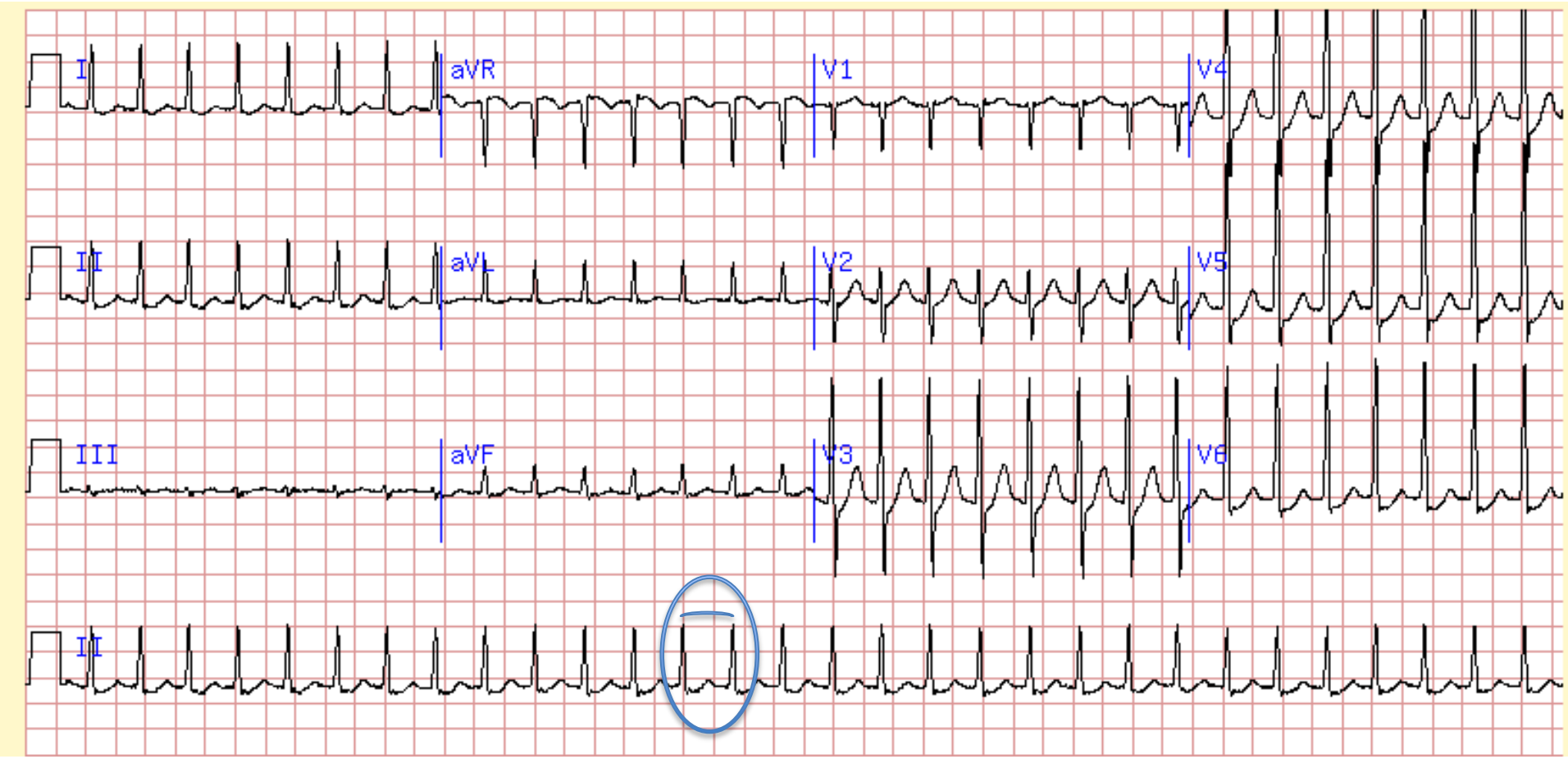
- Determine the heart rate using the 1500 method

Practice Makes Perfect

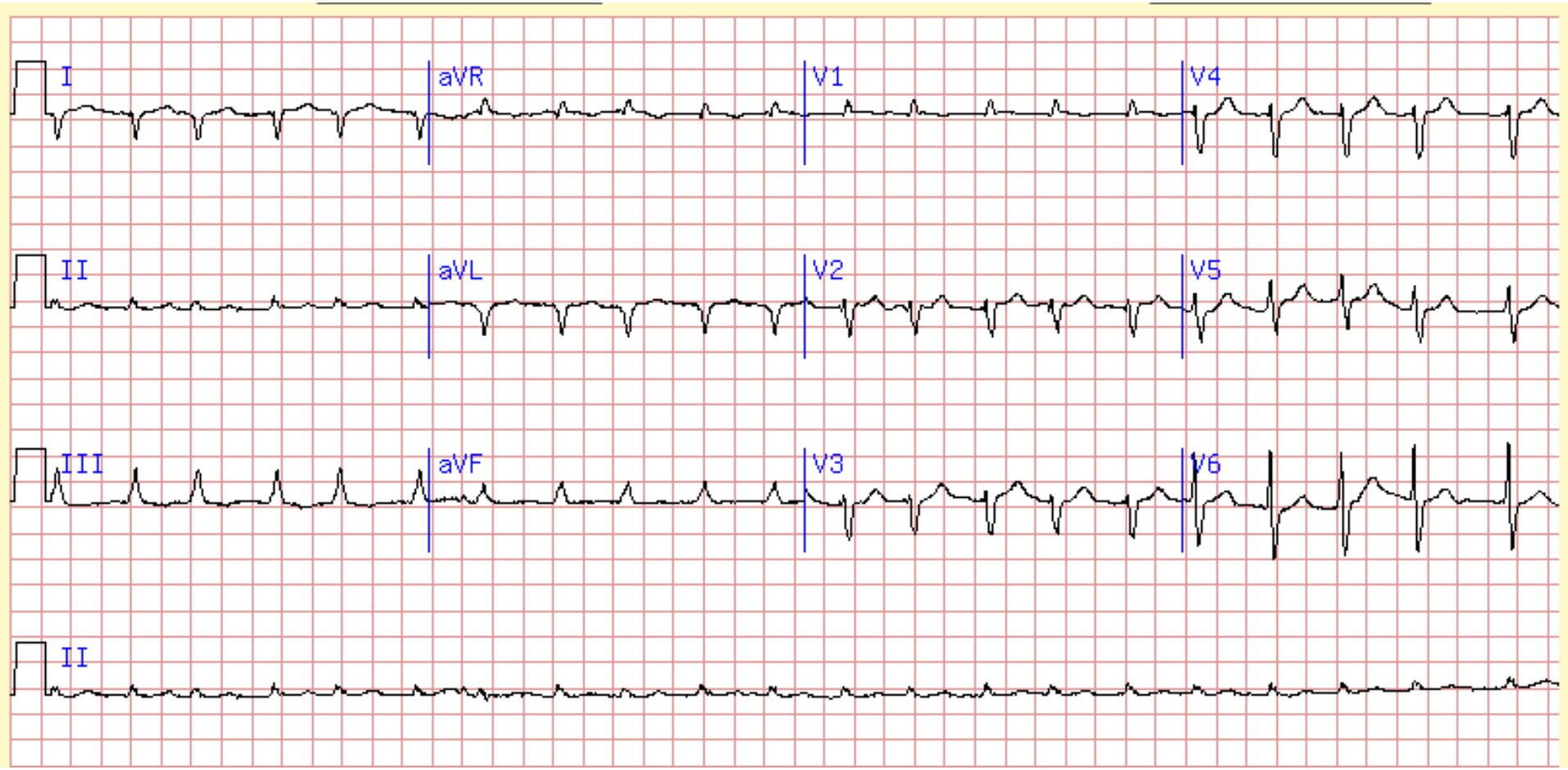
- Determine the heart rate using the 1500 method

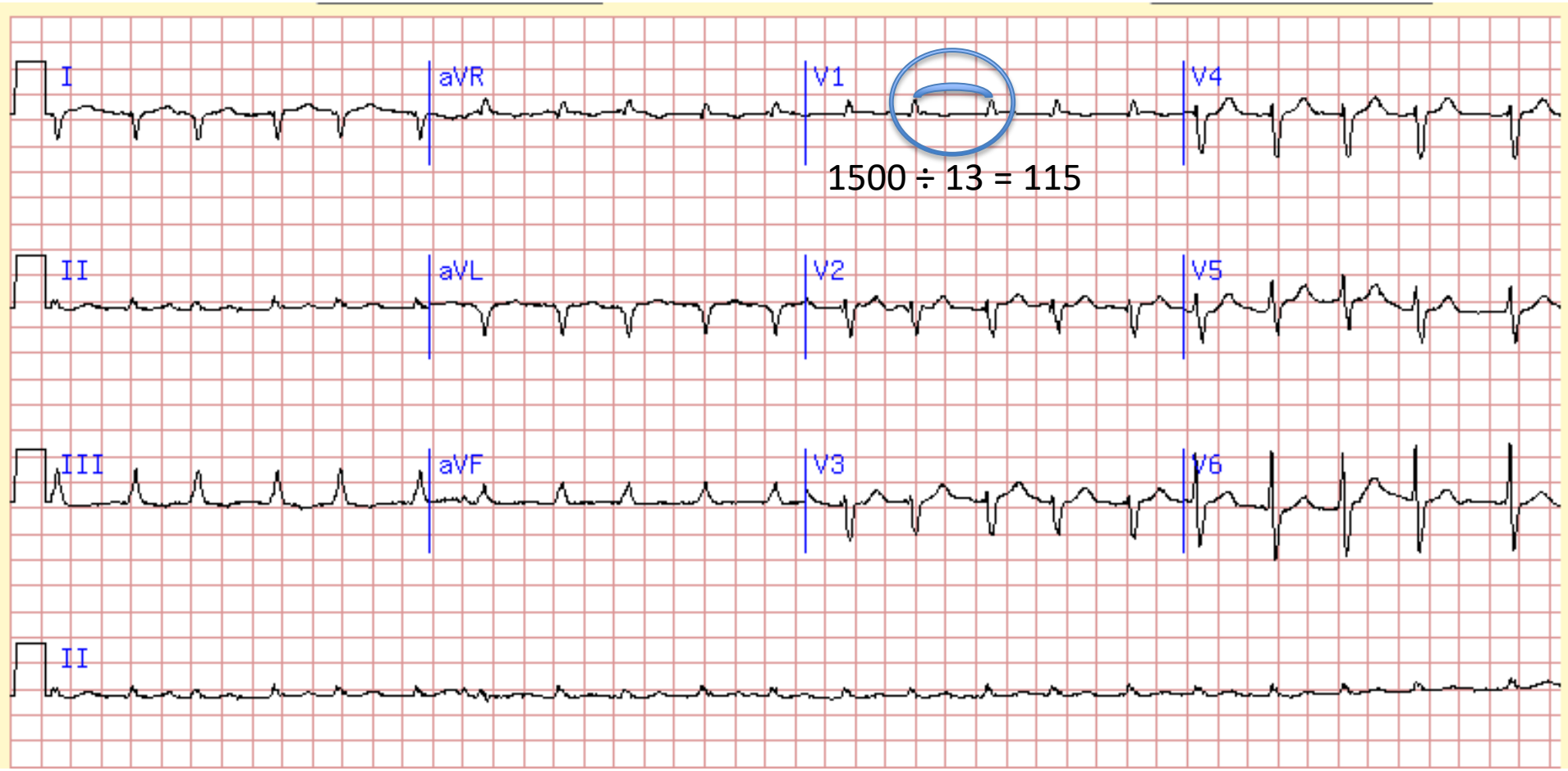

I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
300
150
100
75
II
1500÷20= 75

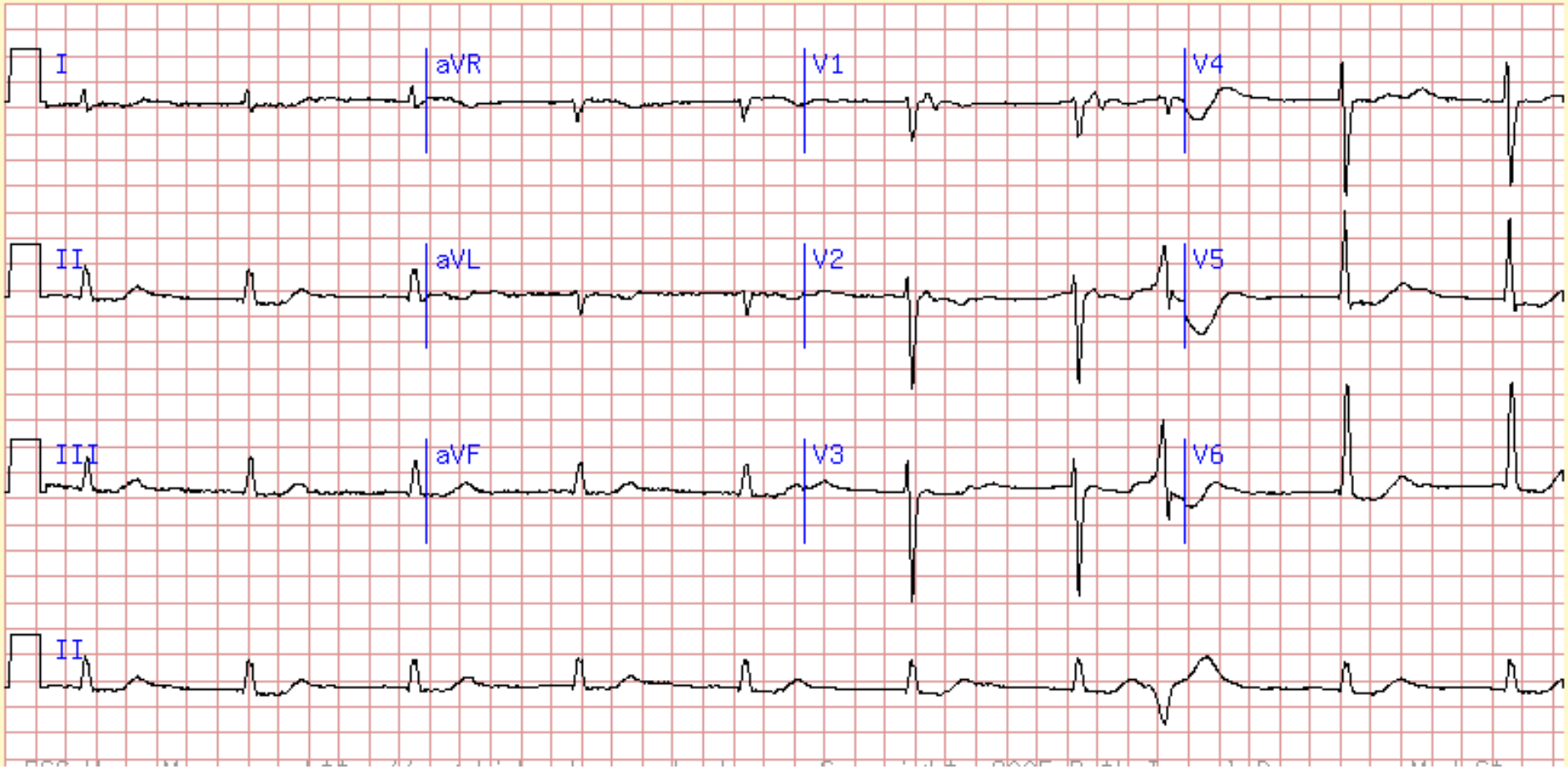

I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II

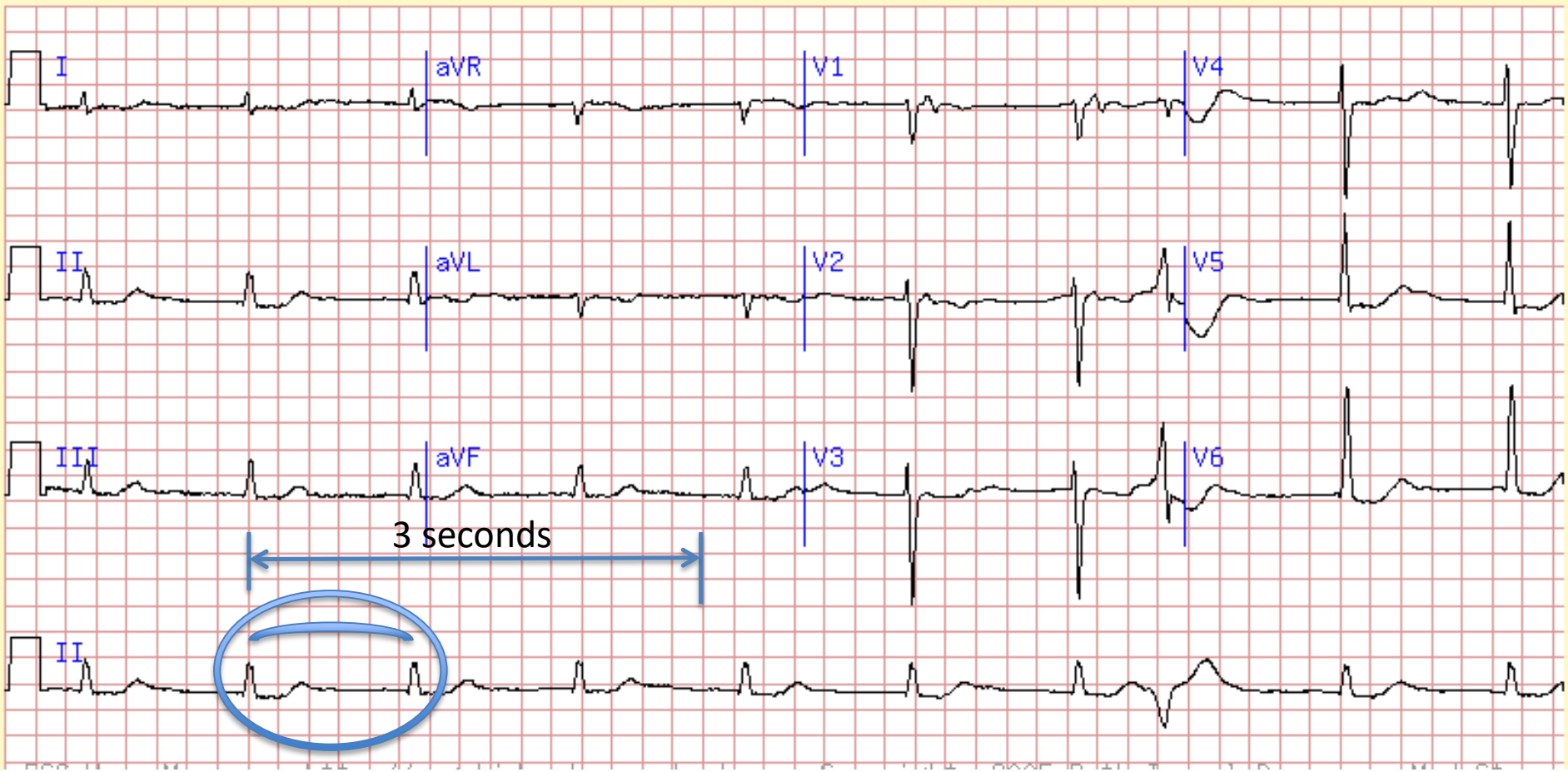


1500 ÷ 8 = 187

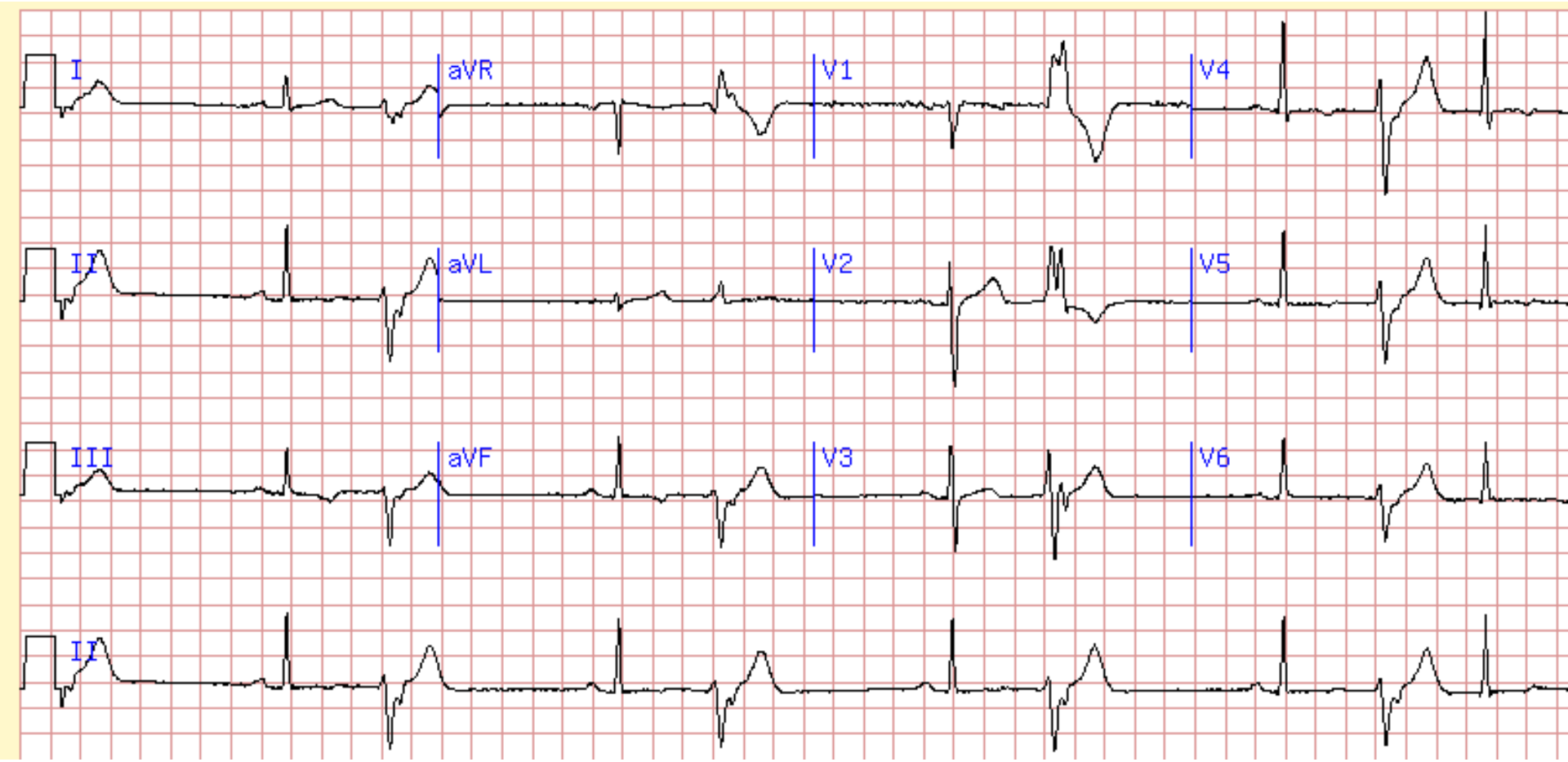

I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II

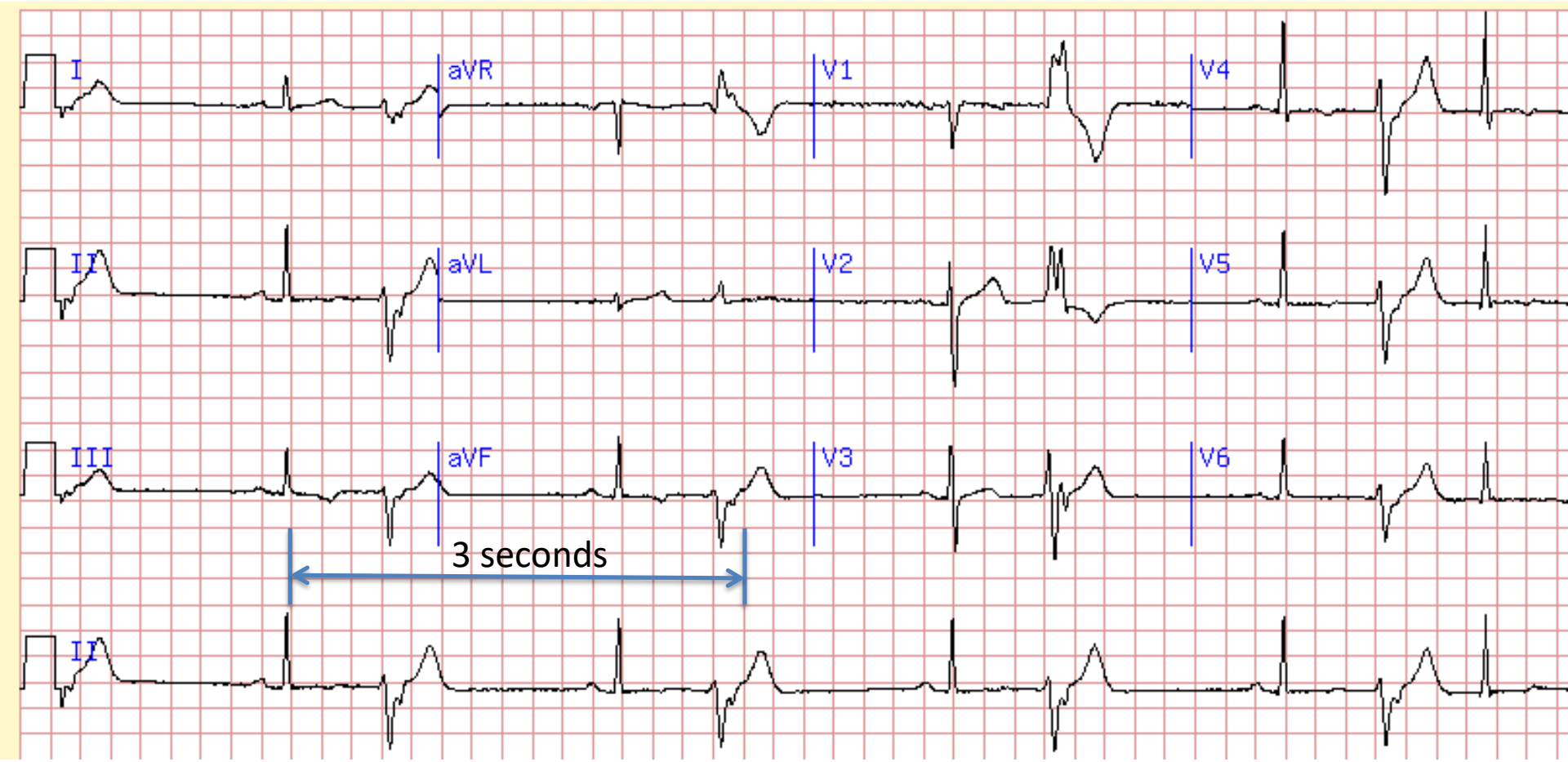

I
aVR
V1
V4
1500 ÷ 13 = 115
II
aVL
V2
V5
III
aVF
V3
V6
II


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



1500 ÷ 23 = 53

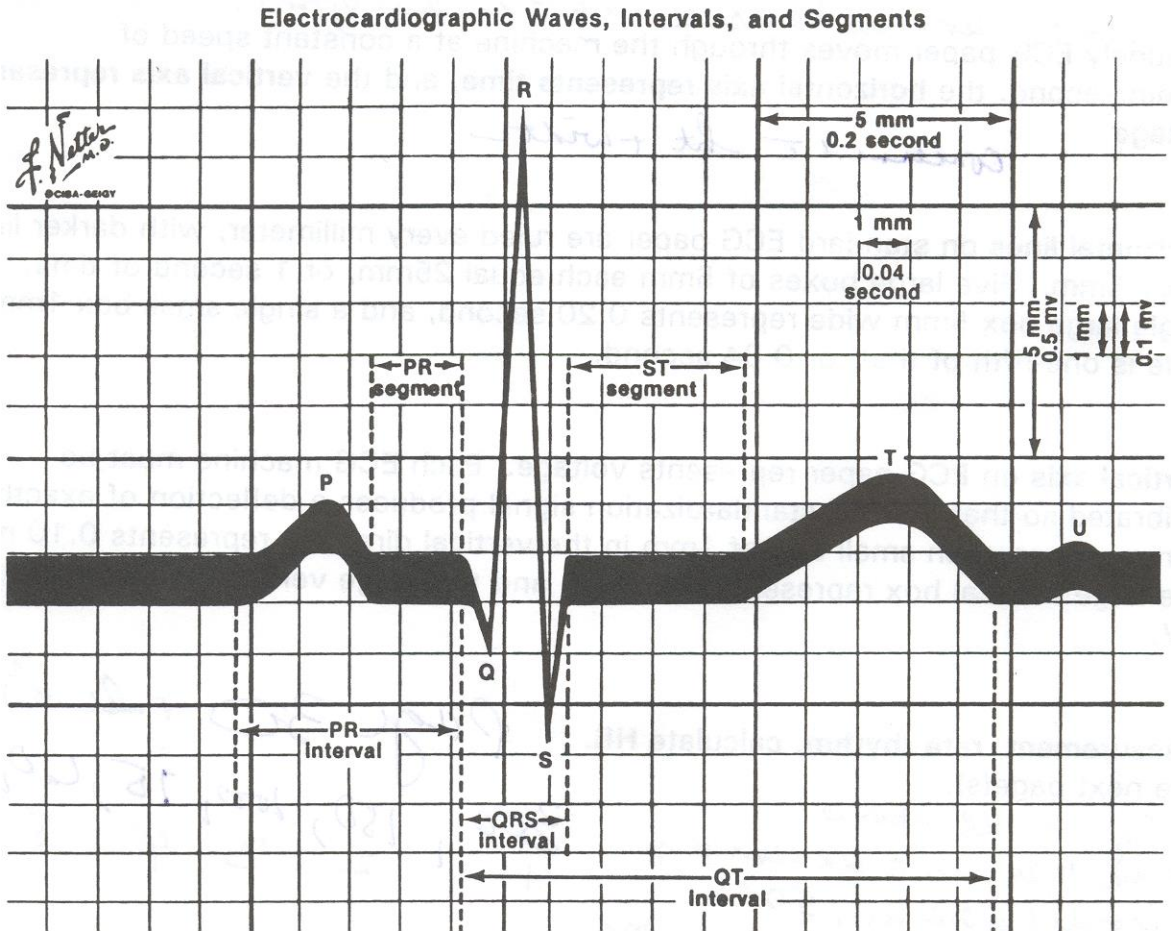

I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II

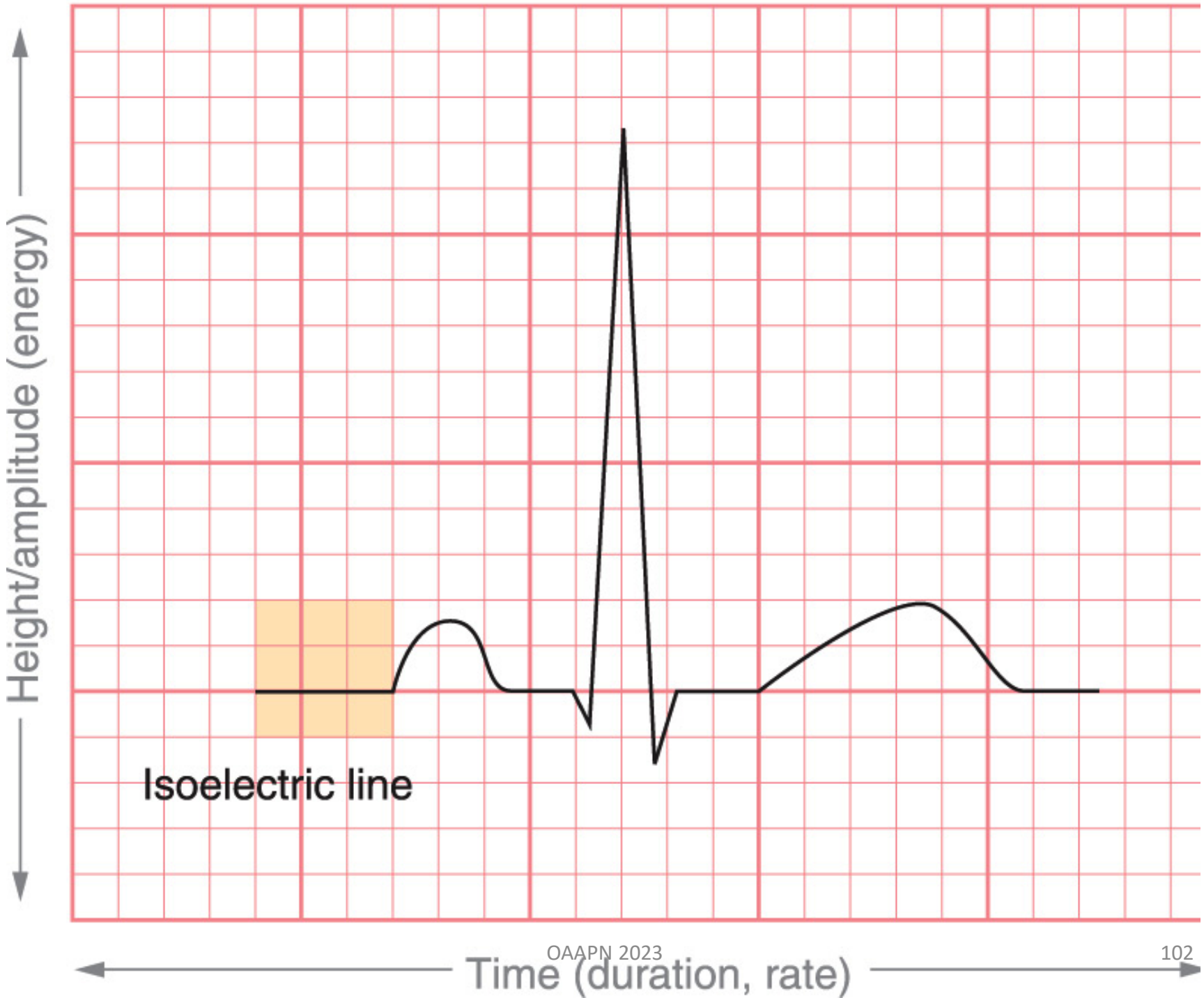


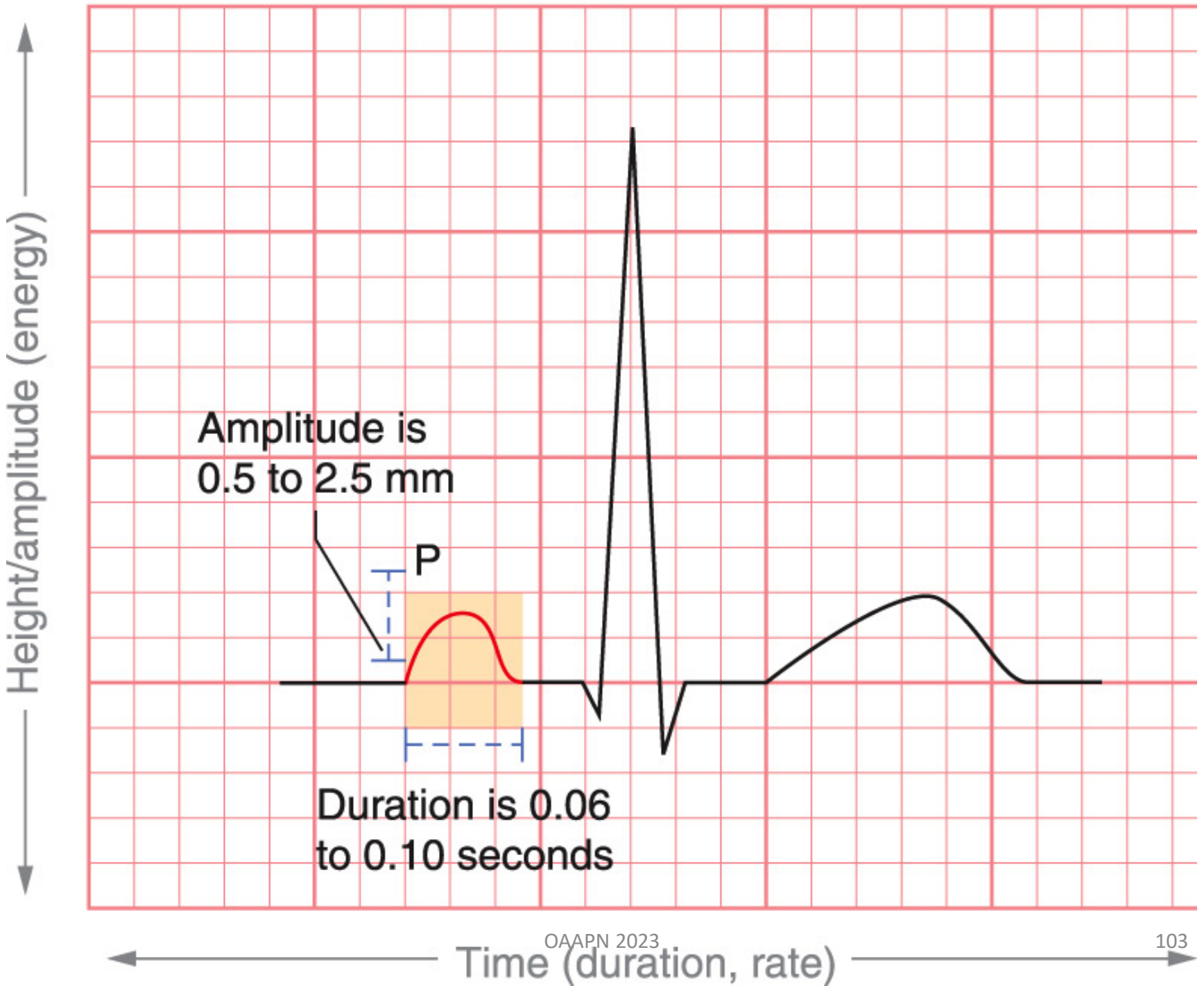
4 X 20 = 80

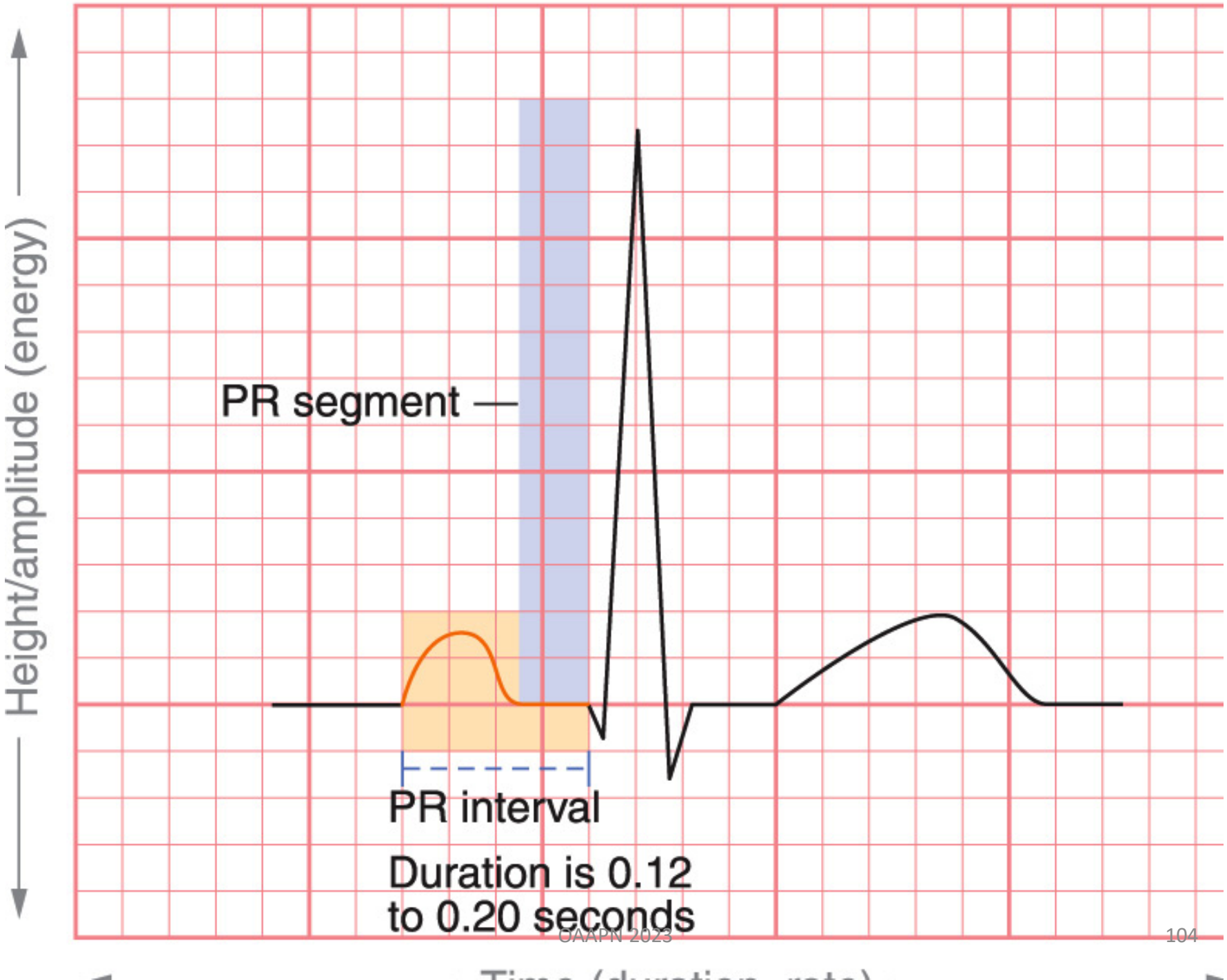
Only 2 out of the 4 is generating a pulse

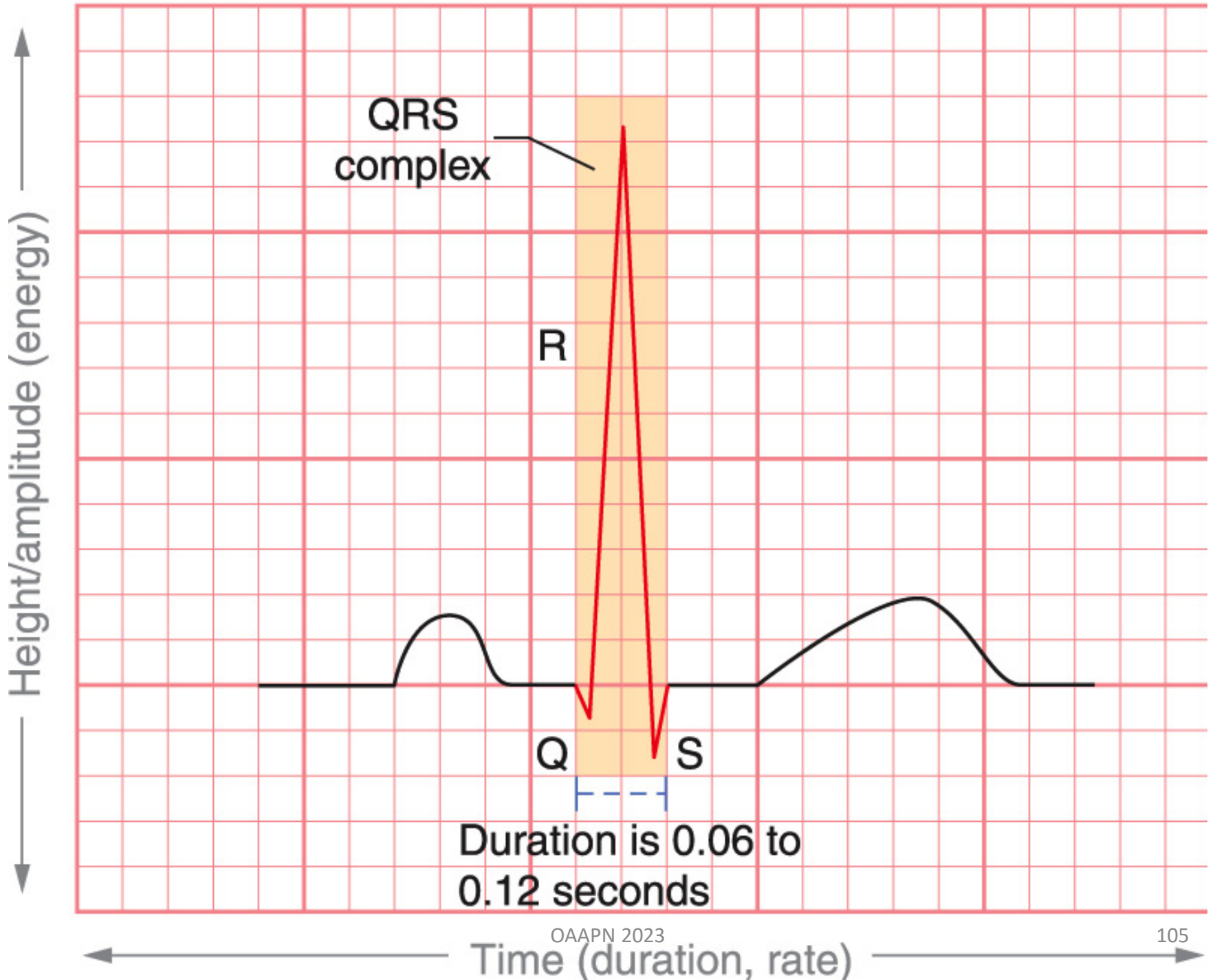
ECG Paper

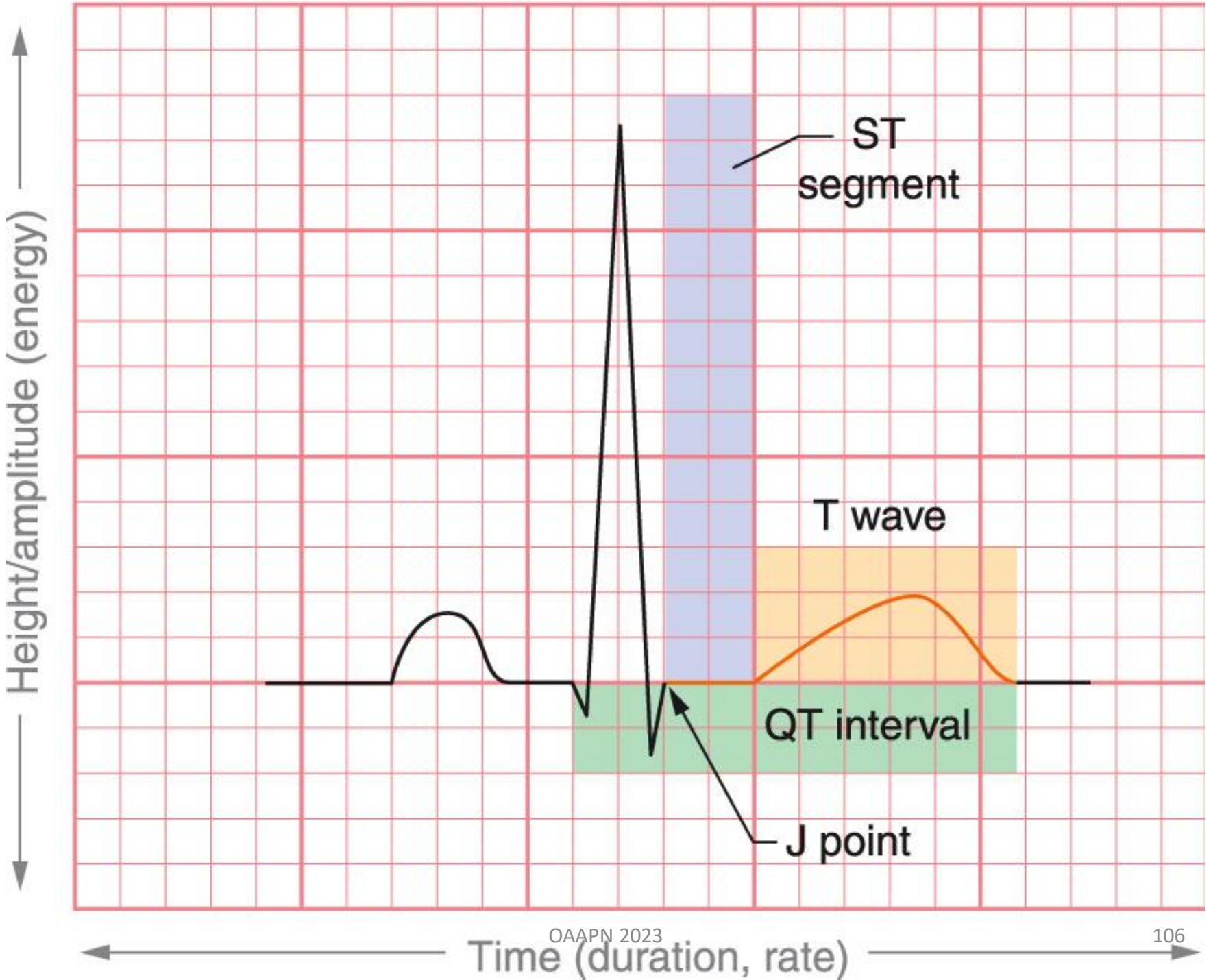

Electrocardiographic Waves, Intervals, and Segments
R
5 mm
0.2 second
1 mm
0.04
second
5 mm
0.5 mv
1 mm
0.1 mv
PR
segment
ST
segment
T
P
U
Q
S
PR
Interval
QRS
interval
QT
Interval

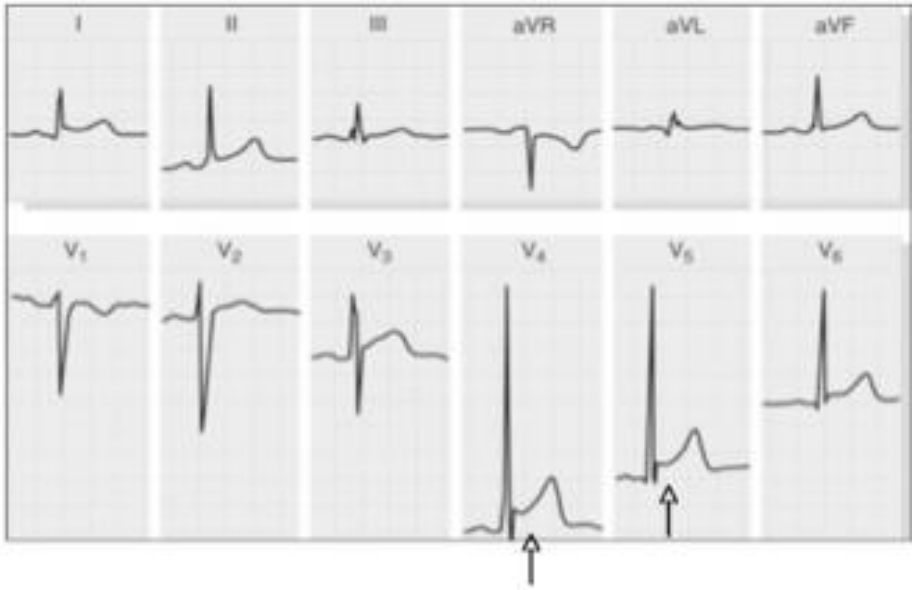

Height/amplitude (energy)
Isoelectric line
Time (duration, rate)


Height/amplitude (energy)
Amplitude is
0.5 to 2.5 mm
P
Duration is 0.06
to 0.10 seconds
Time (duration, rate)

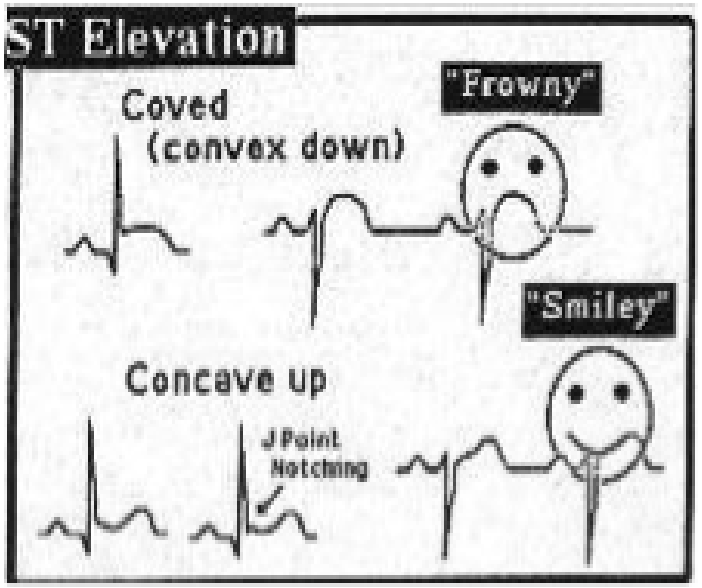

Height/amplitude (energy)
PR segment
PR interval
Duration is 0.12
to 0.20 seconds


QRS
complex
R
Q
S
Duration is 0.06 to
0.12 seconds
Height/amplitude (energy)
Time (duration, rate)


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

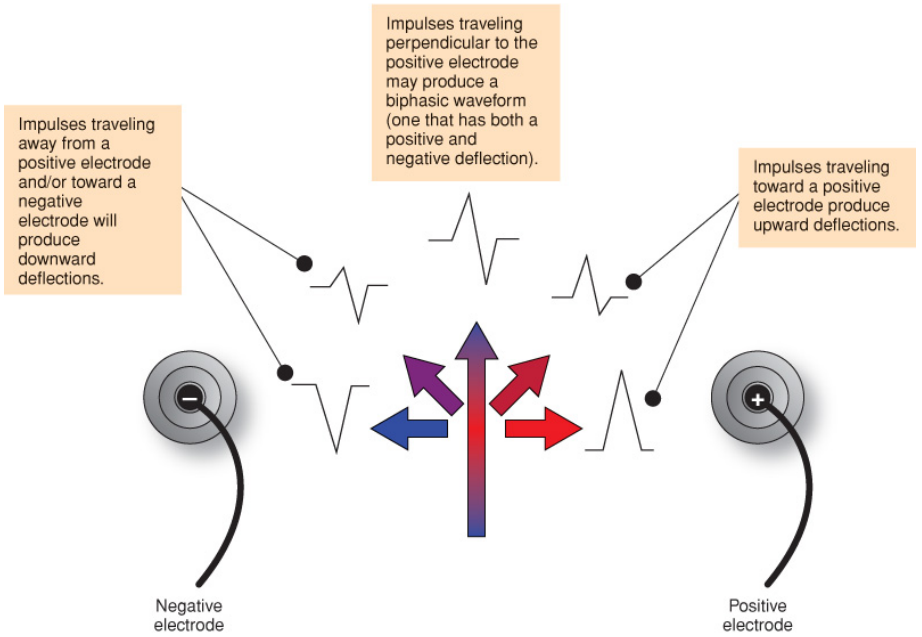


J point elevation, notching of the QRS downstroke, conave, mid-precordial, no evidence of reciprocal changes

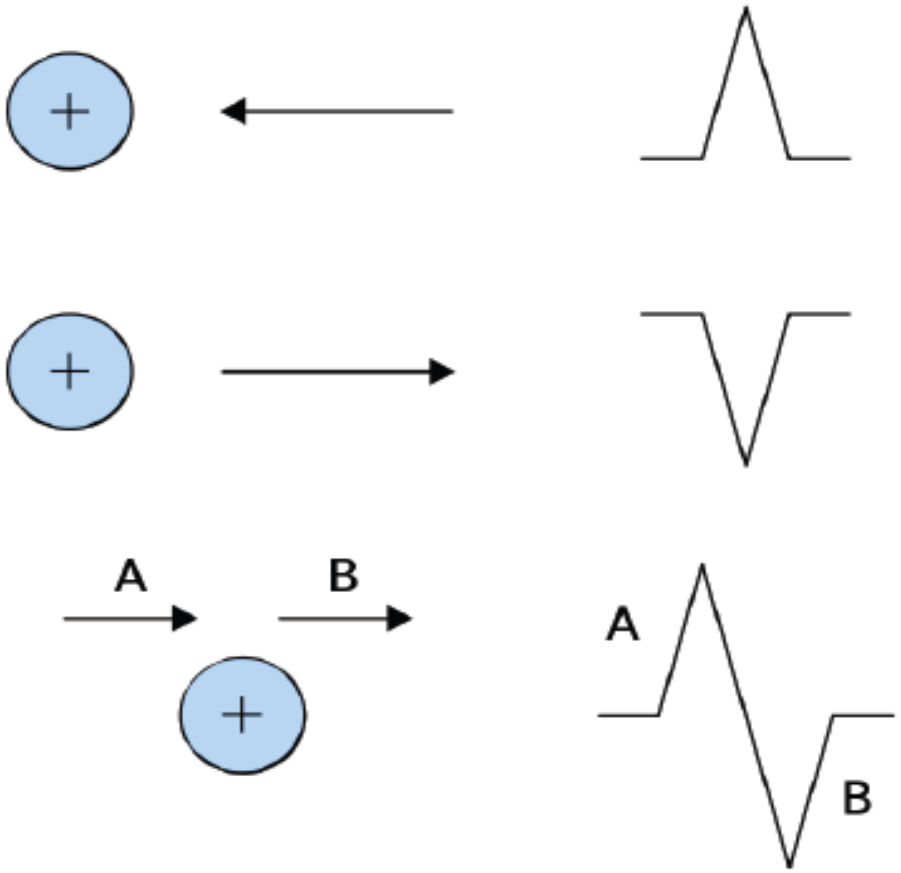


ECG Leads

- Direction an ECG waveform takes depends on whether electrical currents are traveling toward or away from a positive electrode



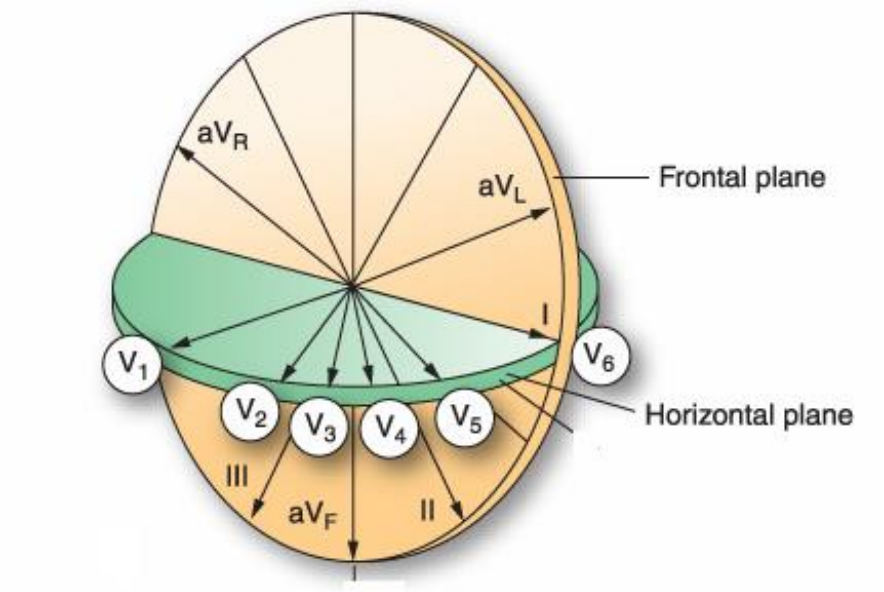
I

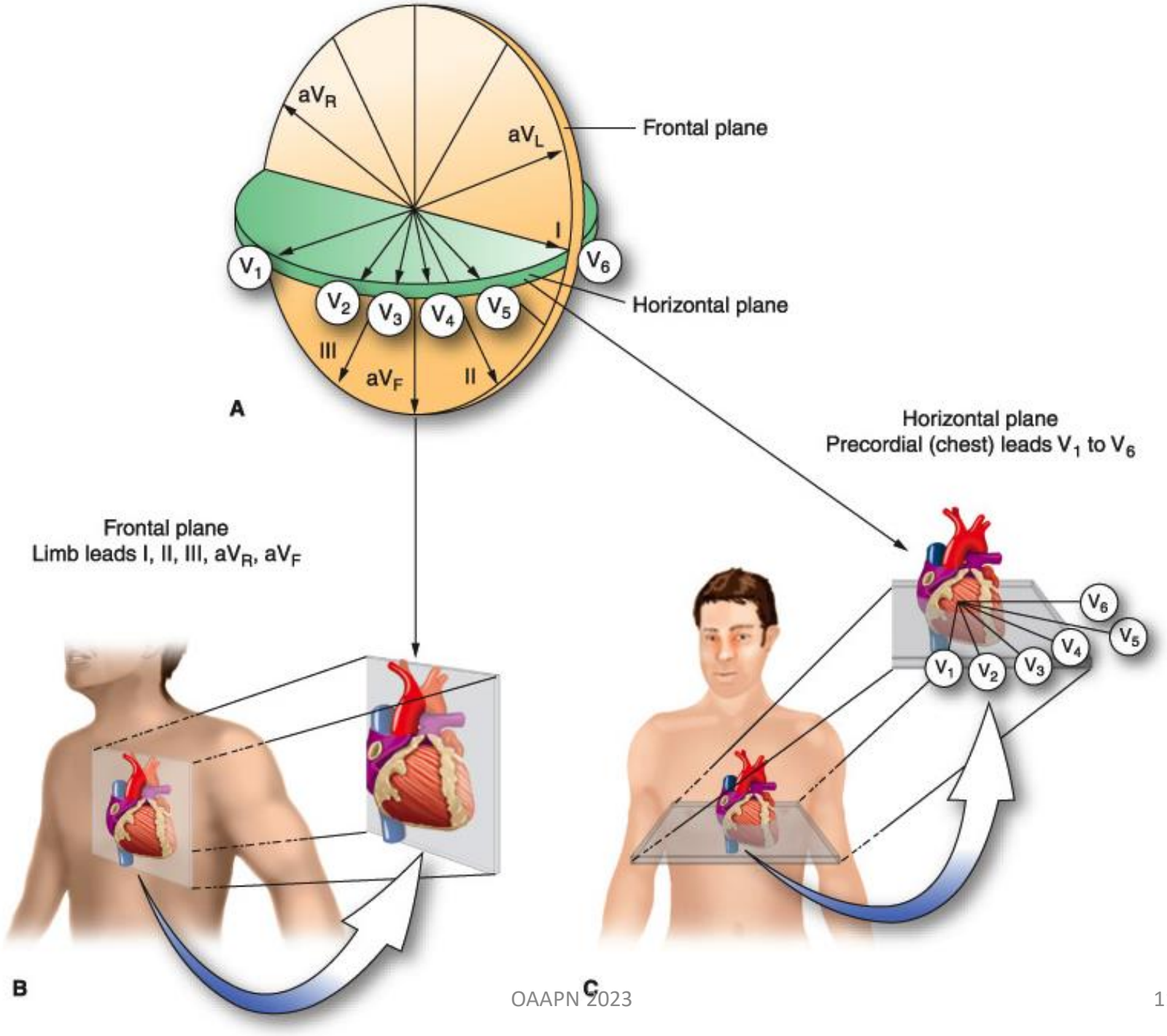


Graphic showing the relationship between positive electrodes, depolarization wavefronts (or mean electrical vectors), and complexes displayed on the ECG.

ECG Leads

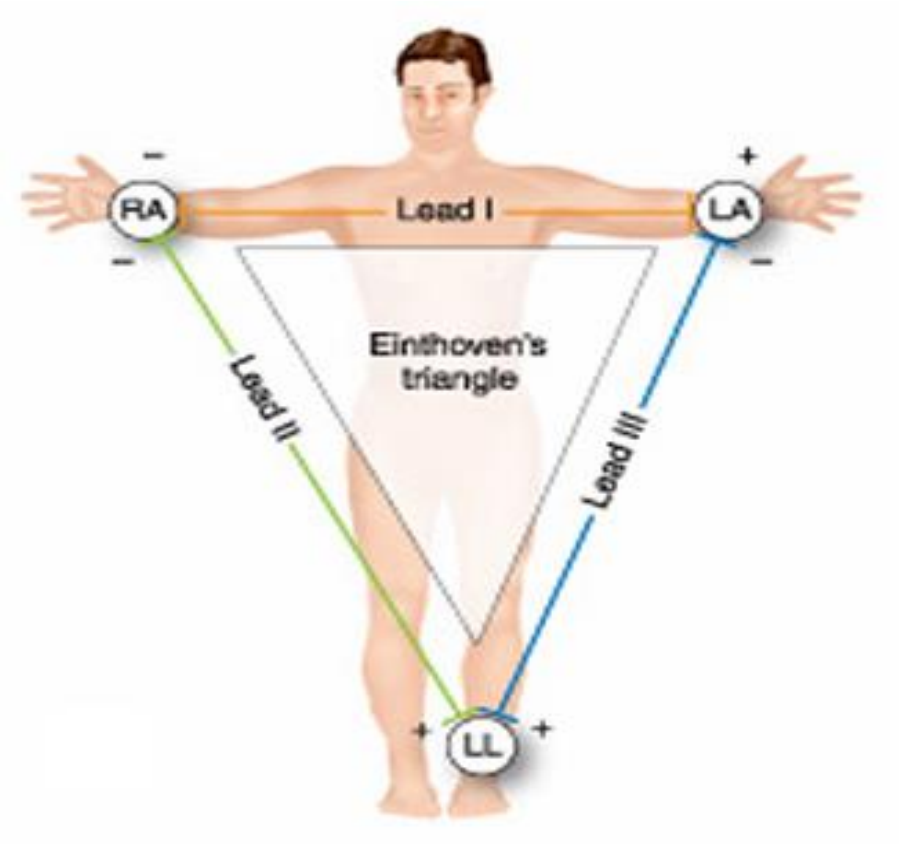
- Planes provide a cross-sectional view of heart
  - Frontal plane
  - Horizontal plane




aVR
aVL
Frontal plane
I
V1
V6
V2
V3
V4
V5
Horizontal plane
III
aVF
II
A
Horizontal plane
Precordial (chest) leads V1 to V6
Frontal plane
Limb leads I, II, III, aVR, aVF
V6
V5
V4
V1
V2
V3
B
C

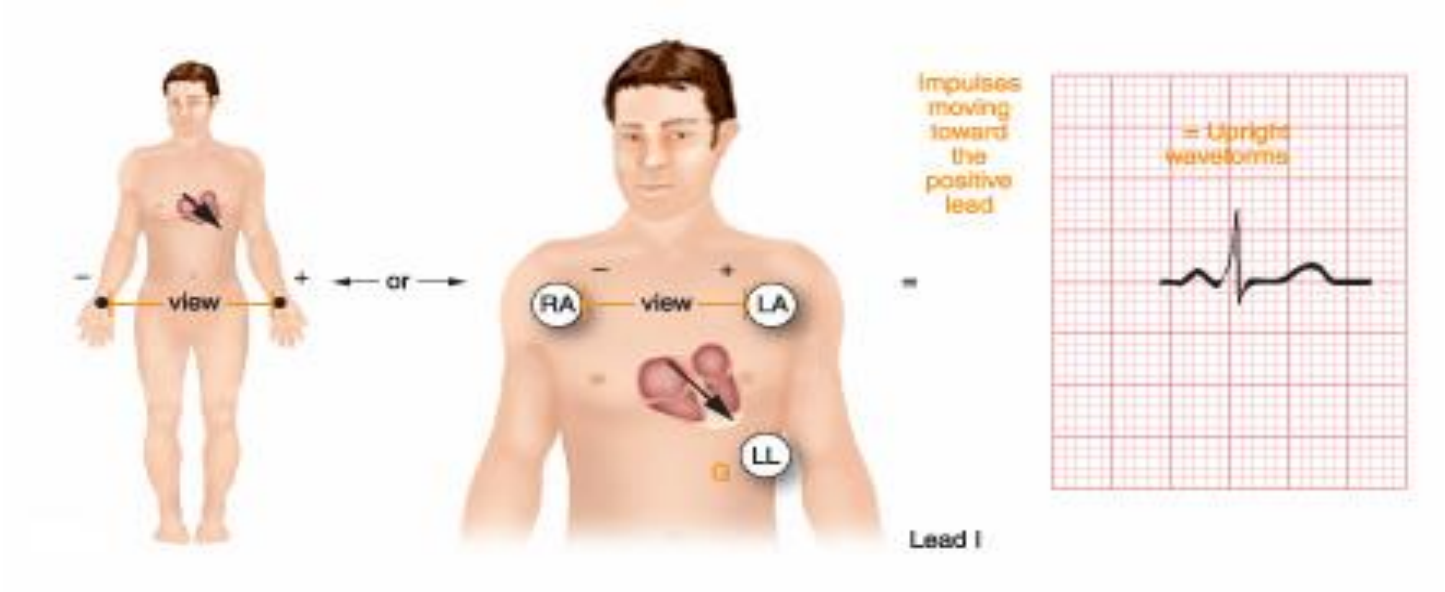
Bipolar Leads

- Record difference in electrical potential between a positive and negative electrode
- Uses a third electrode called a ground
- Include leads I, II and III



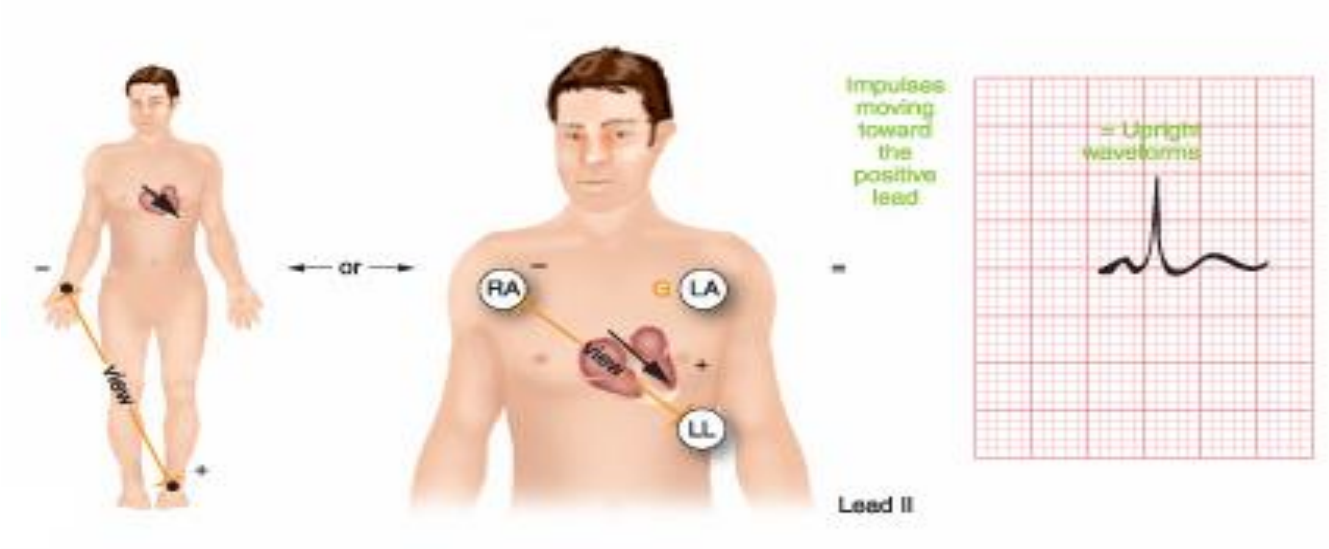
I

Limb Leads - Lead I



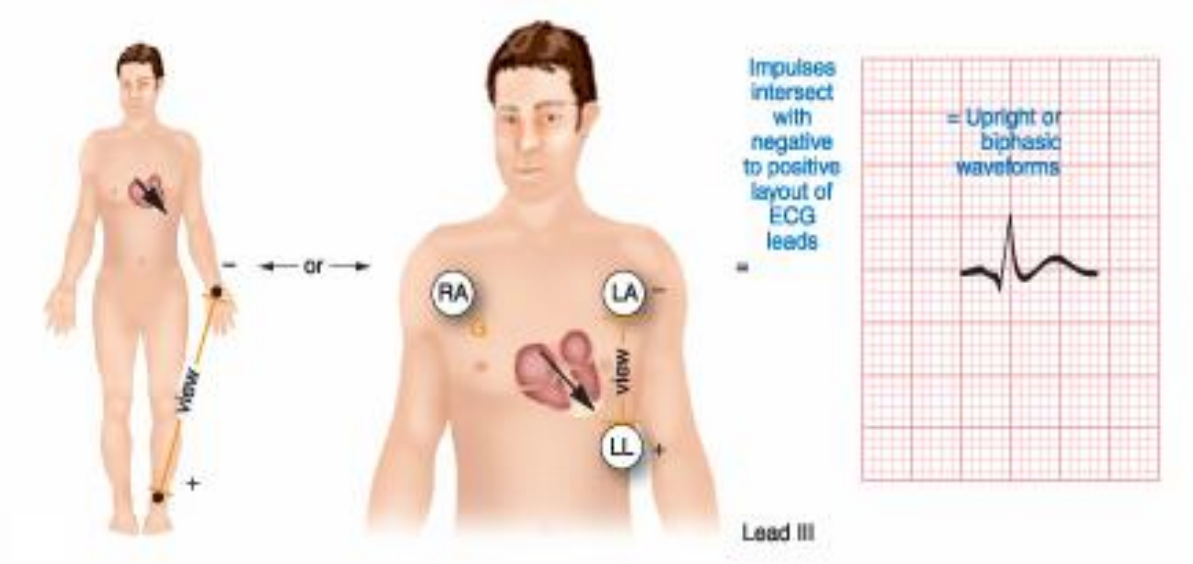
- Positive electrode - left arm (or under left clavicle)
- Negative electrode - right arm (or below right clavicle)
- Ground electrode - left leg (or left side of chest in midclavicular line just beneath last rib)
- Waveforms are positive

Limb Leads - Lead II



- Positive electrode - left leg (or on left side of chest in midclavicular line just beneath last rib)
- Negative electrode - right arm (or below right clavicle)
- Ground electrode - left arm (or below left clavicle)
- Waveforms are positive

Limb Leads - Lead III



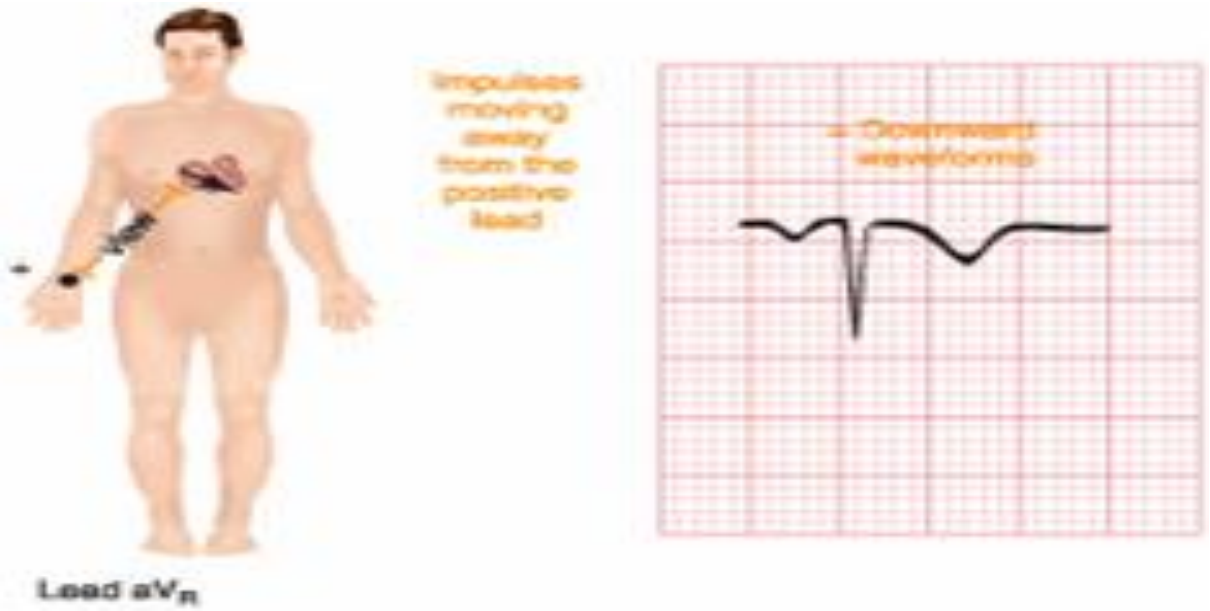
- Positive electrode - left leg (or left side of the chest in midclavicular line just beneath last rib)
- Negative electrode - left arm (or below left clavicle)
- Ground electrode - right arm (or below right clavicle)
- Waveforms are positive or biphasic

Limb Leads - Augmented Leads

- Includes aV_R, aV_L and aV_F
- Unipolar
- Enhanced by ECG machine because waveforms produced by these leads are normally small

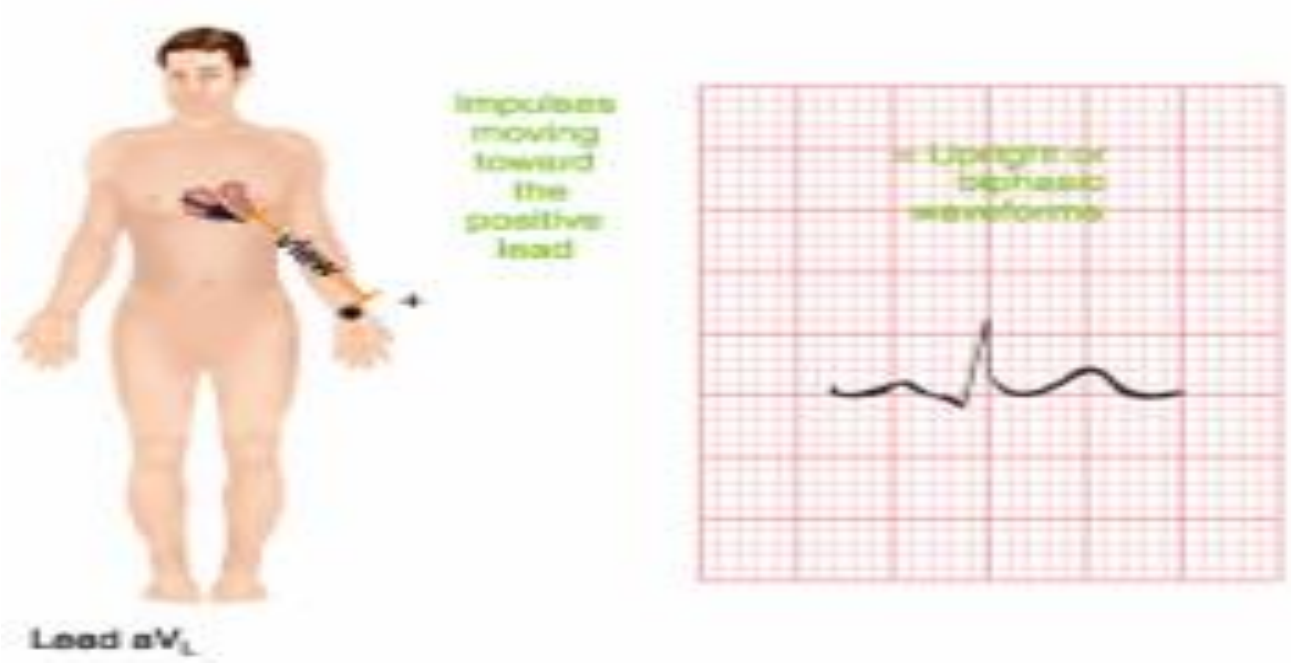
I

Limb Leads - Lead aV_R



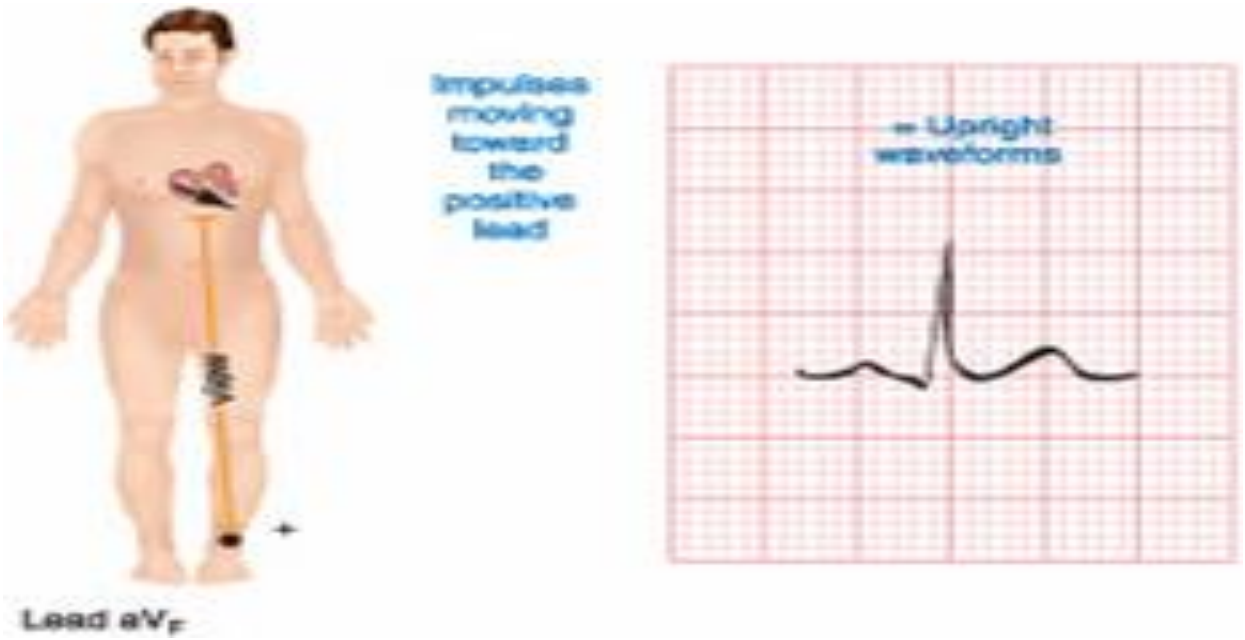
- Positive electrode placed on right arm
- Waveforms have negative deflection

Limb Leads - Lead aV_L



- Positive electrode placed on left arm
- Waveforms have positive deflection

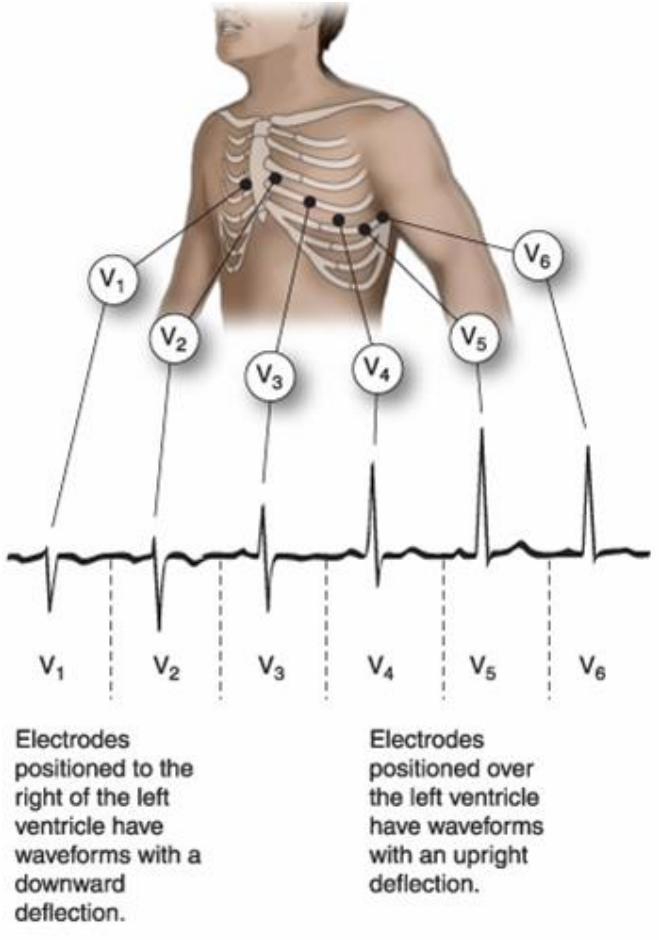
Limb Leads - Lead aV_F



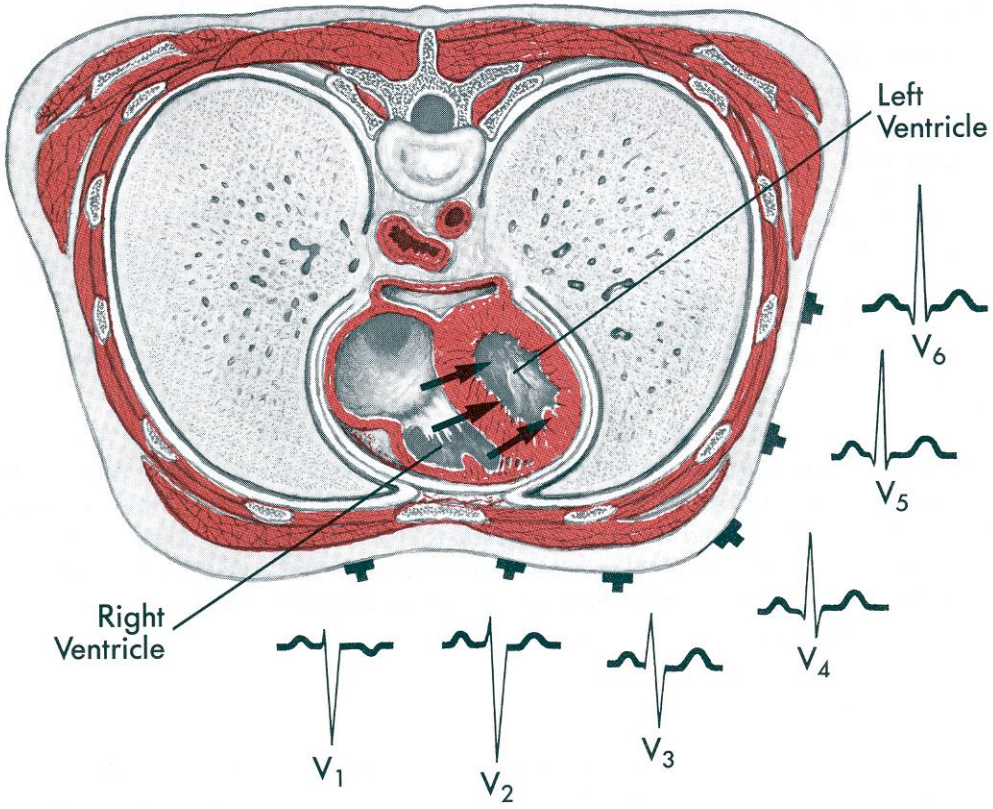
- Positive electrode located on left leg
- Waveforms have a positive deflection

Precordial Leads

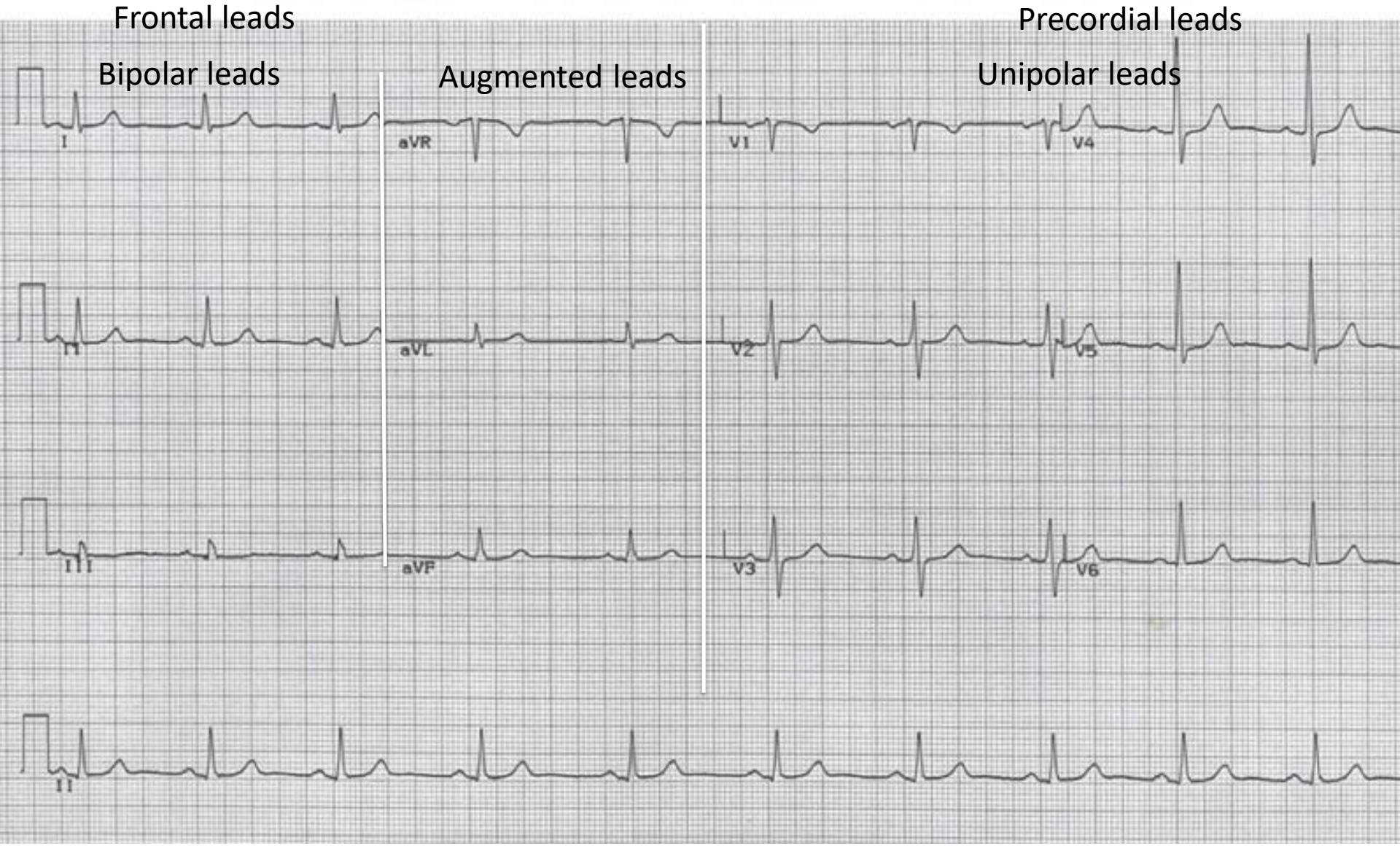
- Includes leads V_1, V_2, V_3, V_4, V_5 and V_6
- Positioned in order across the chest
- Unipolar
  - Opposing pole is center of heart as calculated by ECG



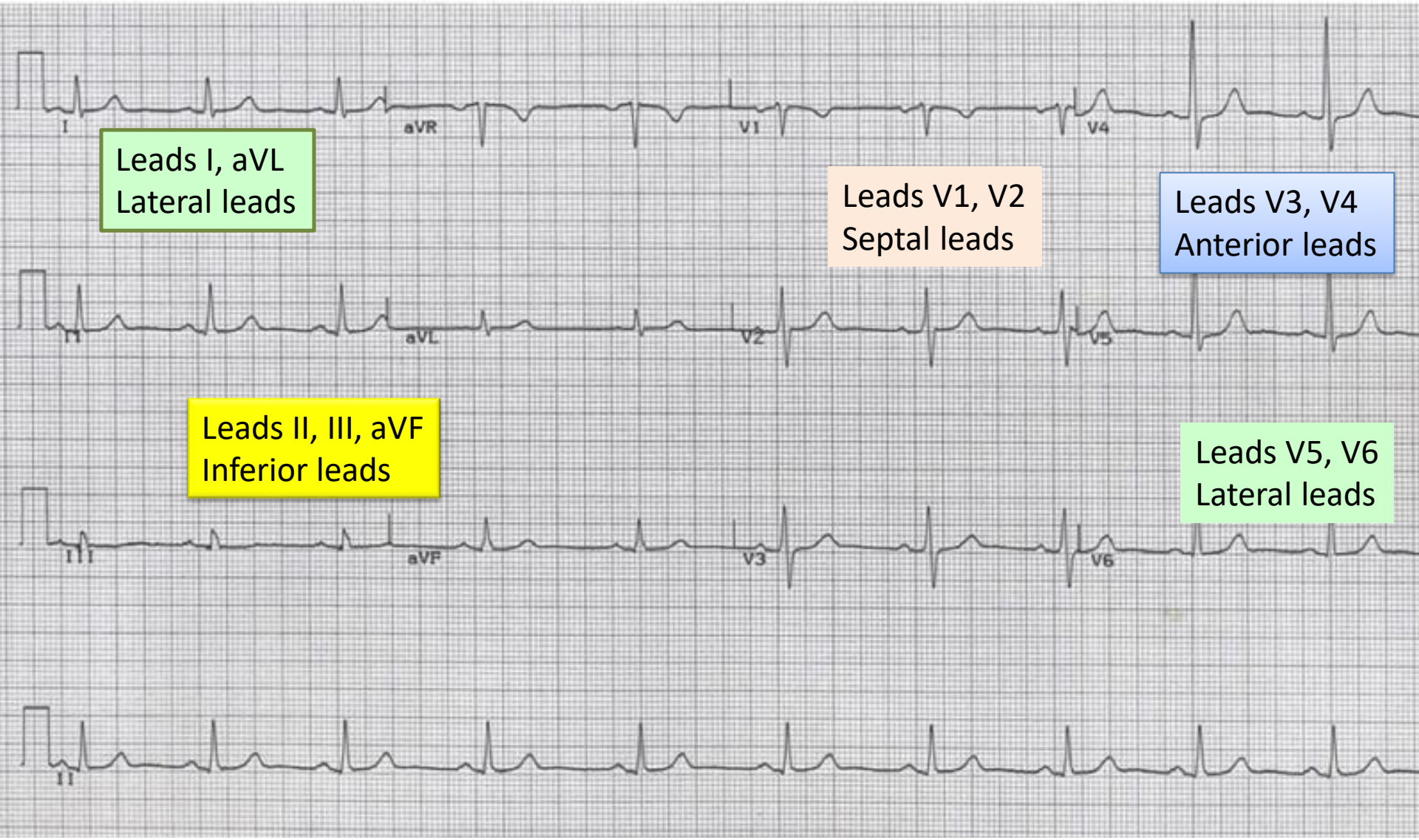
Precordial or Horizontal leads



Essential parts of the ECG



Normal EKG



Leads I, aVL
Lateral leads

Leads V1, V2
Septal leads

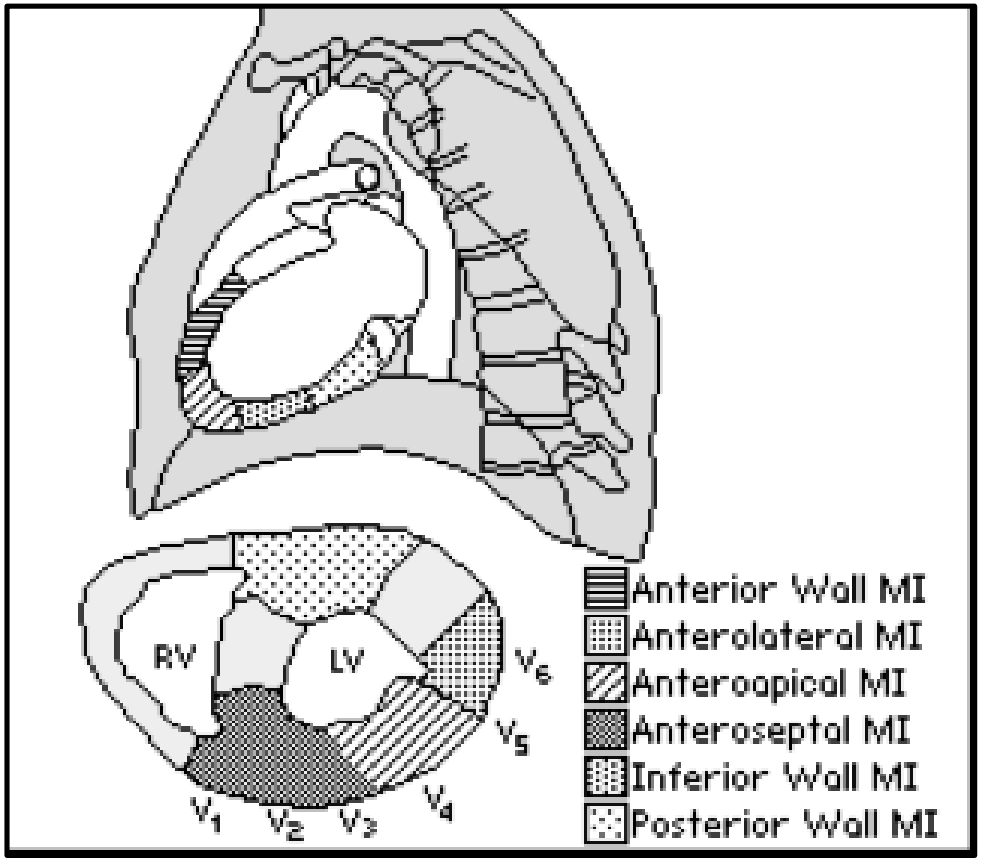
Leads V3, V4
Anterior leads

Leads II, III, aVF
Inferior leads

Leads V5, V6
Lateral leads

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

Diagram showing the contiguous leads in the same color


RV
LV
V1
V2
V3
V4
V5
V6
Anterior Wall MI
Anterolateral MI
Anteroapical MI
Anteroseptal MI
Inferior Wall MI
Posterior Wall MI