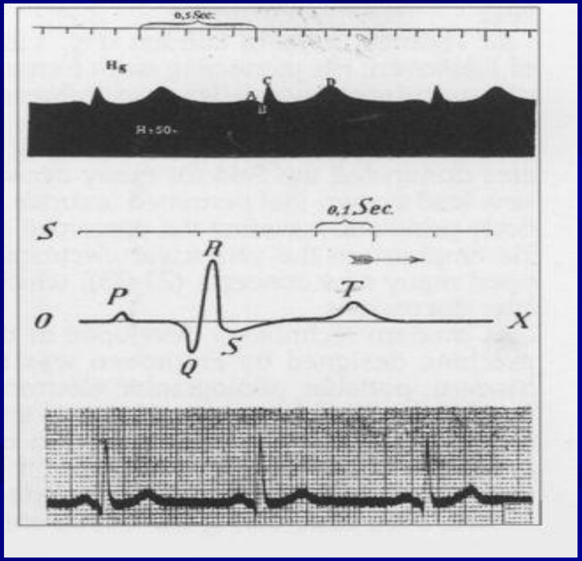
EKG Basics



Outline

1. Heart properties
2. **Review of the conduction system**
3. **EKG leads**
4. **EKG waveforms and intervals**
5. **Determining heart rate**
6. **Determining heart rhythm**
7. **Determining QRS axis**
8. **Determining characteristics of the ECG elements (waves, intervals)**

Heart properties

1. Automatism – capacity to produce electrical impulses (special myocardial cells),
2. Conduction – capacity to conduct the electrical impulses (the heart conductive system),
3. Excitability – capacity to get activated, *depolarized*, under the electrical impulse (myocardial cells),
4. Contractility – capacity of the myocardial cells to contract as a response to their depolarization
5. Refractivity – capacity of the myocardial cells to be non-responsive to electrical impulses, coming in the refractory pause

How the heart work?

- First in the heart is produced an electric impulse. There are special cells (called “pacemaking”) which are producing and conducting electrical impulses.

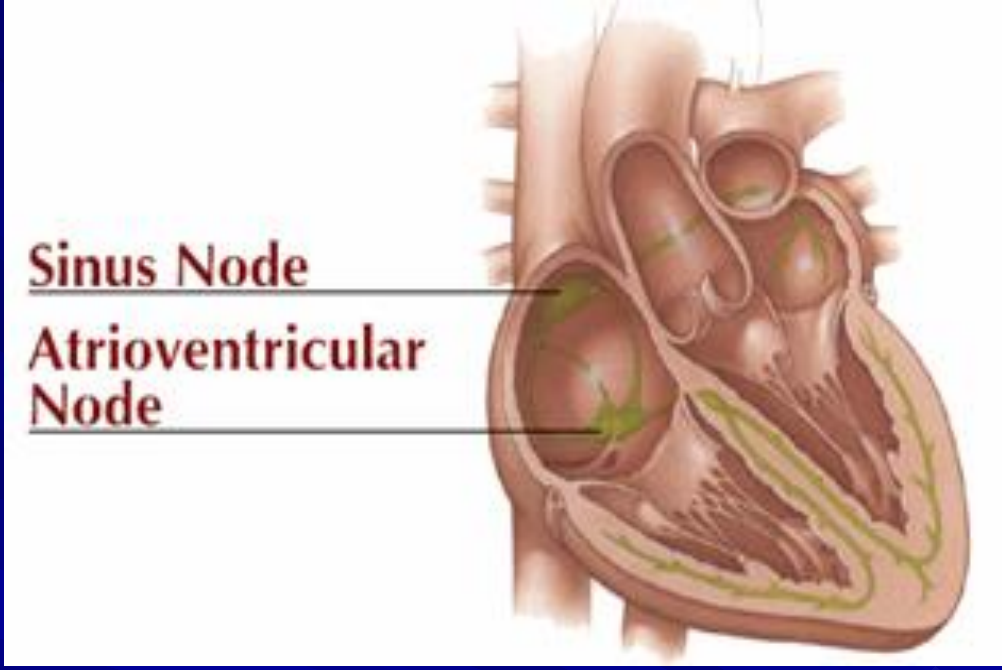
- The electric impulse is transmitted through the ***conductive system*** to the myocytes – and the myocytes begin to depolarize.

- The depolarization of the myocytes are causing their contraction.

Conduction heart system

SA Node – the mean "pacemaker" of the heart (produces 60-100 impulses per min)

- Is placed in right atrium:
  - a branch from SA node is sent to left atria
  - the wave front travels through the right and left atria in a centrifugal manner.



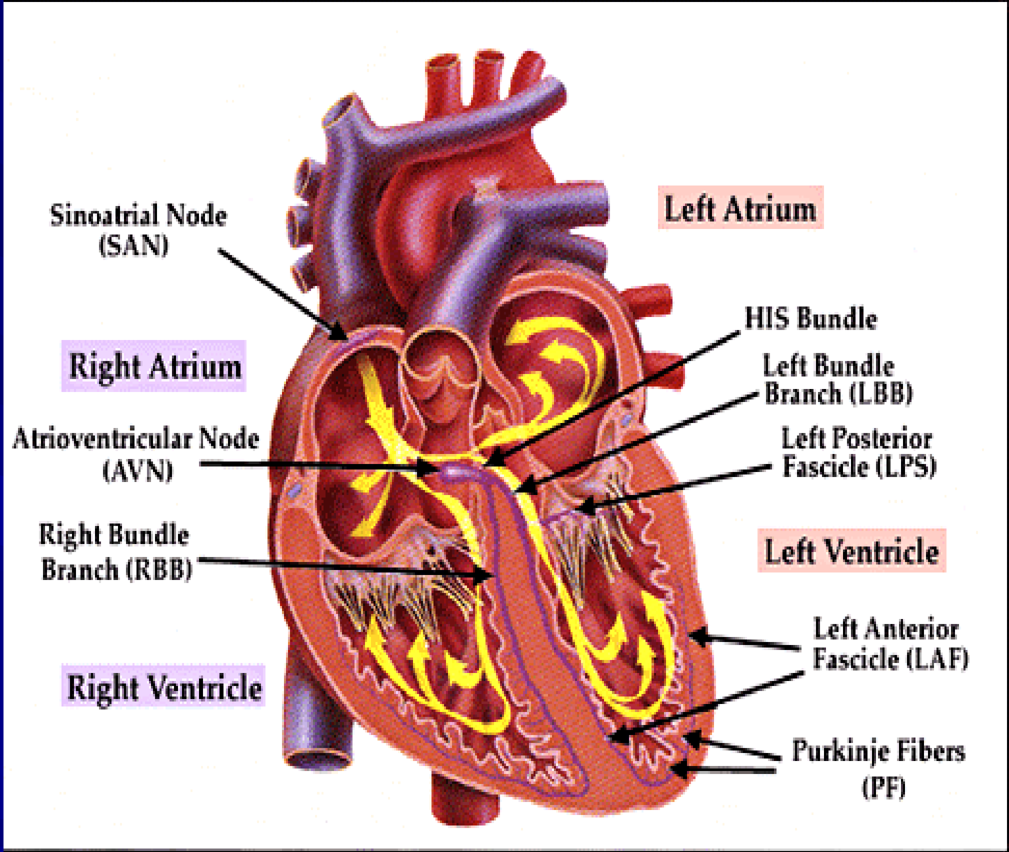
AV Node – junction of the atria and ventricles (40-60 impulses pm)

- is delaying the impulse, allowing for a sequential contraction of the ventricles after the atria.
- sends the signal to the ventricles via the "bundle of His"

Conduction heart system

Bundle of His has 2 branches – left and right -LBB and RBB (20-40 imp pm).

- The Left bundle divides into an anterior and posterior branch.
- More distally the bundles ramify into Purkinje fibers, that diverge to the inner sides of the ventricular walls.
- the electrical impulses with the slowest rate could be produced by the cells in the His bundle (20-40 per min) and Purchinje fibers (10-15 per min).



Cardiac Conduction System

Propagation on ventricular wall

- From the inner side of the ventricular wall, the many activation sites cause the formation of a wavefront which propagates through the ventricular mass toward the outer wall.

- This process results from cell-to-cell activation.

Depolarization of the myocytes

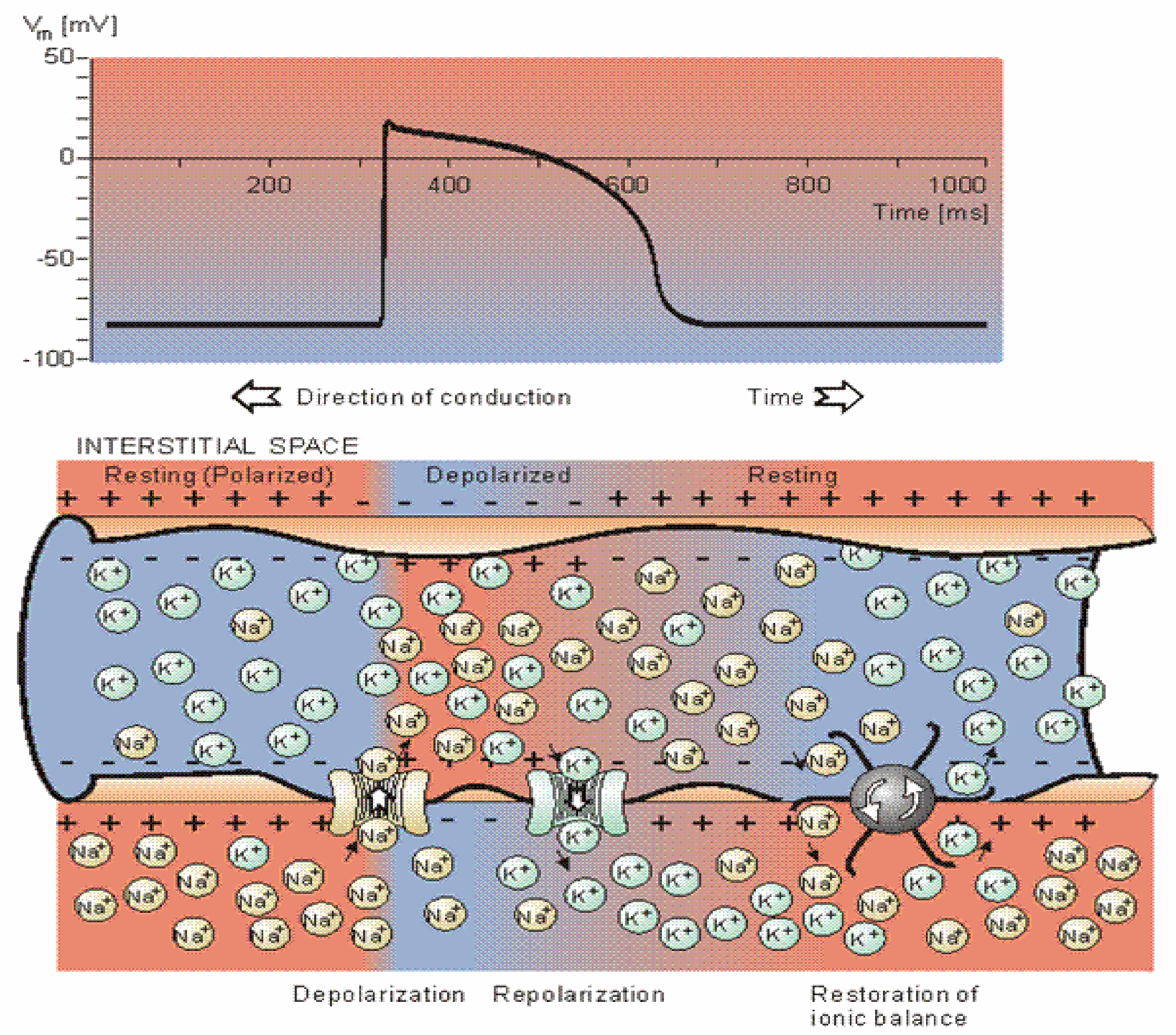
- The electrical impulse will cause activation of the myocardial cells because of changes in the ionic composition of the intracellular fluid: the physiochemical and electric properties of cell membranes will change and an electric current will be generated.

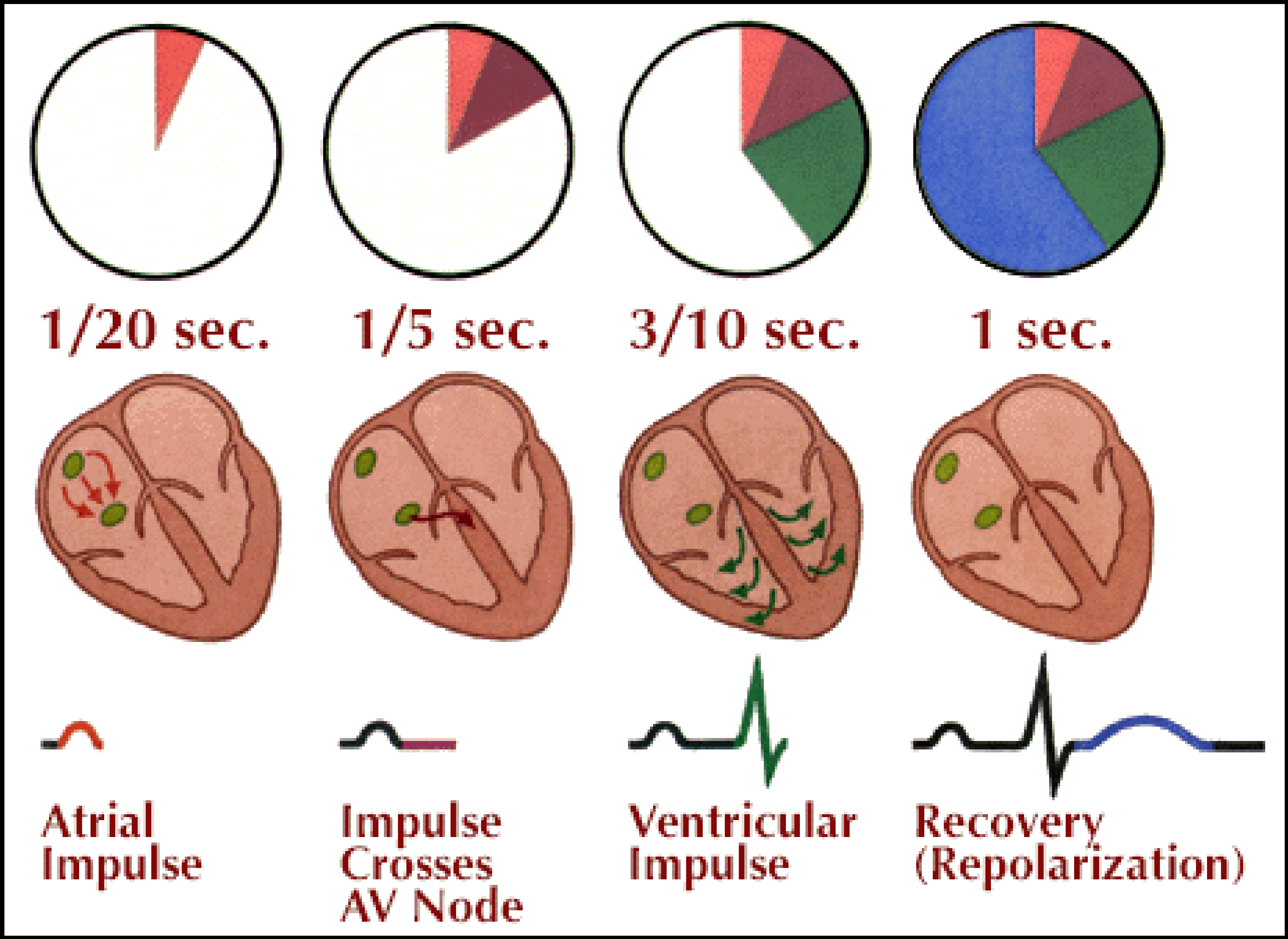
- Electric activation of *myocytes* takes place because of the inflow of Na ions across the cell membrane .

- This activation is called *depolarization* of the cells.

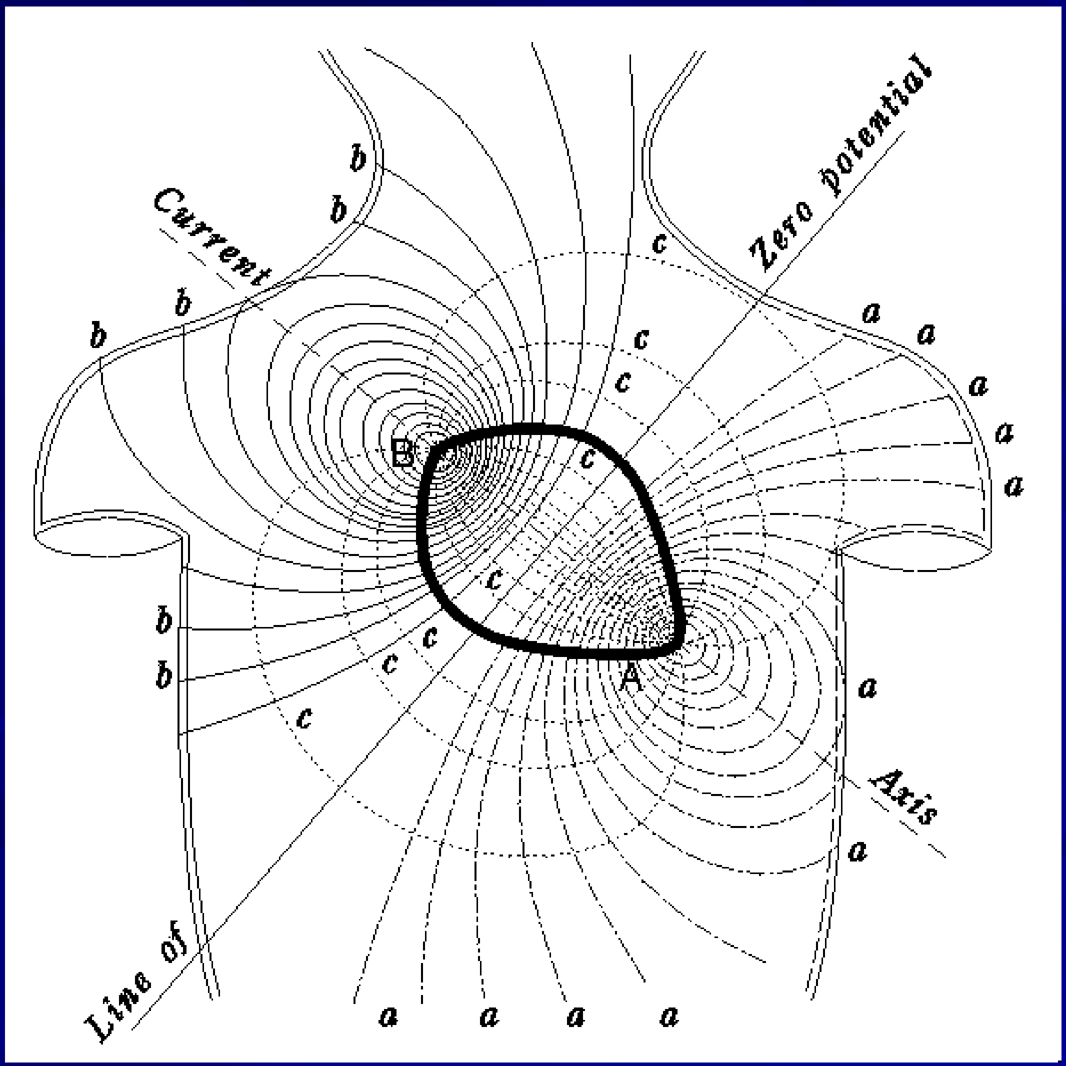
- As a consequence of ionic changes in it, the myocardial cell will contract.
- *Repolarization* (returning back of the electrical potential of the myocyte to the initial state) is a consequence of the outflow of K ions.

Electrophysiology of the cardiac muscle cell




1/20 sec.
1/5 sec.
3/10 sec.
1 sec.
Atrial Impulse
Impulse Crosses AV Node
Ventricular Impulse
Recovery (Repolarization)

So, the heart is a source of current located in a conducive body (i.e. human one) around which an electric field is generated Electric field of the heart on the surface of the thorax, recorded by Augustus Waller (1887).



The curves (a) and (b) represent the recorded positive and negative isopotential lines, respectively.

These indicate that the heart is a dipolar source having the positive and negative poles at (A) and (B), respectively.

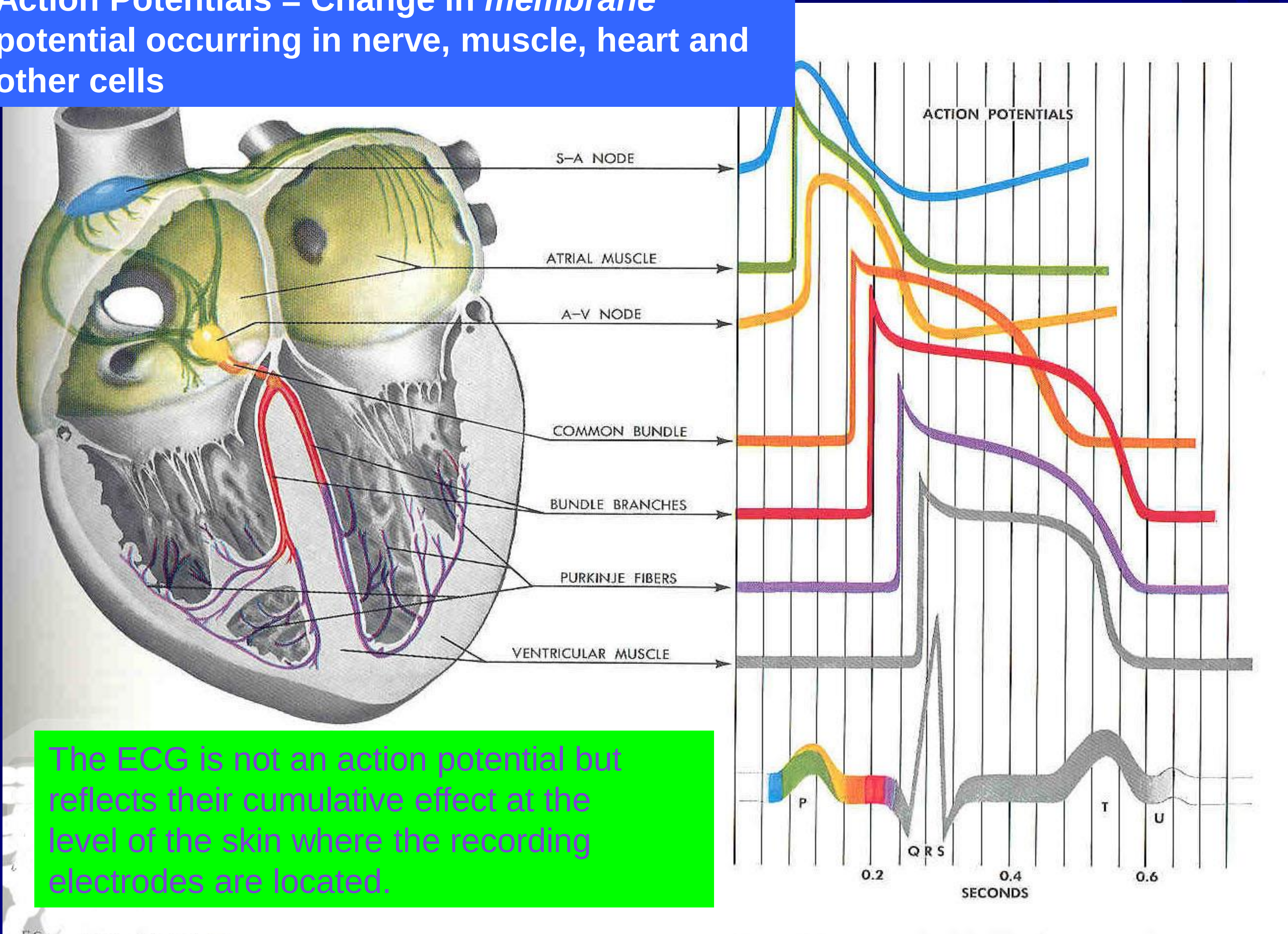
The curves (c) represent the assumed current flow lines..

What is an EKG?

is a method of graphic recording of electric currents generated by the working heart.

- Each event has a distinctive waveform
- **The direction of the electromotive force is known as the electrical axis of the heart, which is normally parallel to its anatomical mass.**

Action Potentials = Change in *membrane* potential occurring in nerve, muscle, heart and other cells

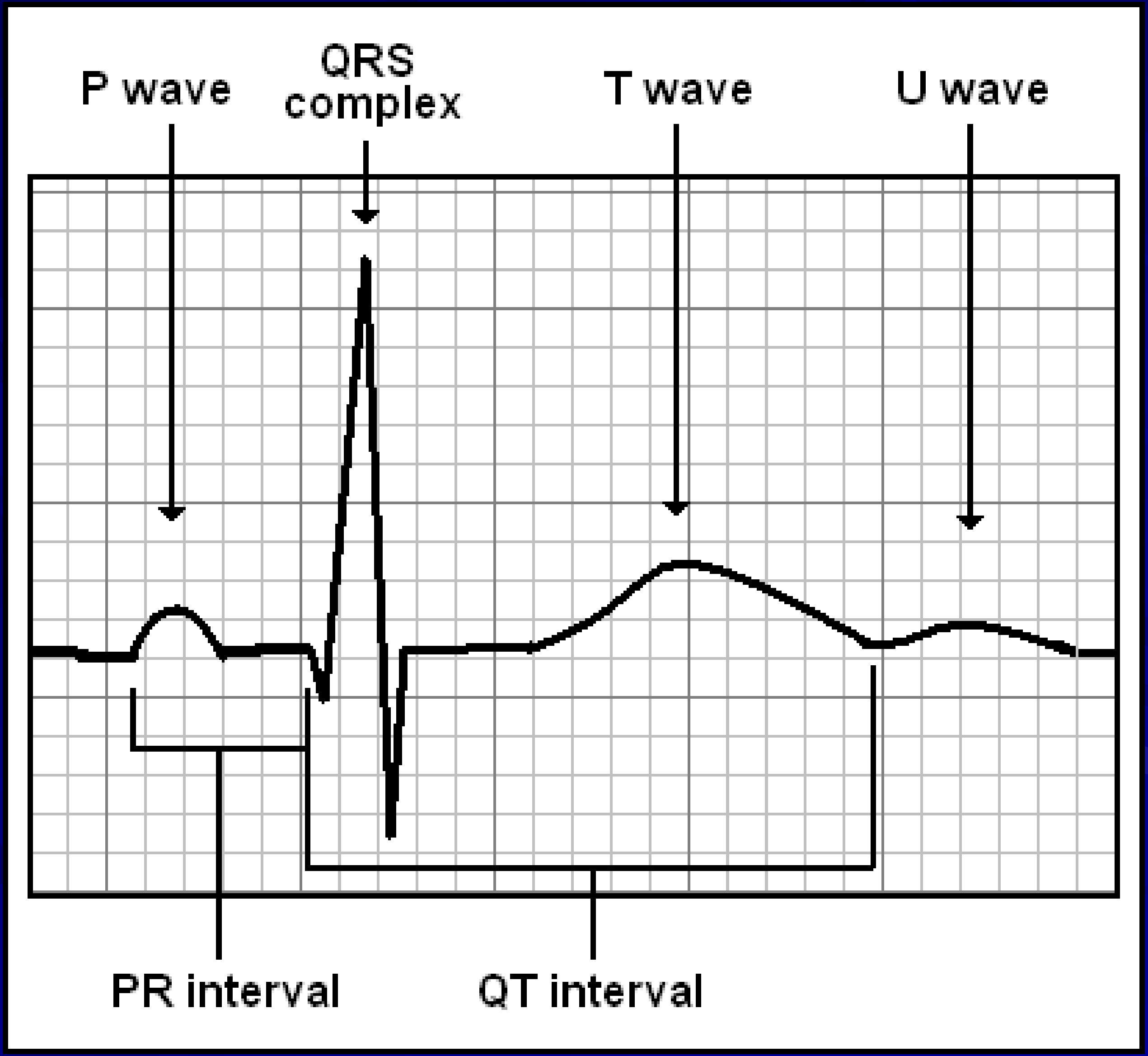


The ECG is not an action potential but reflects their cumulative effect at the level of the skin where the recording electrodes are located.

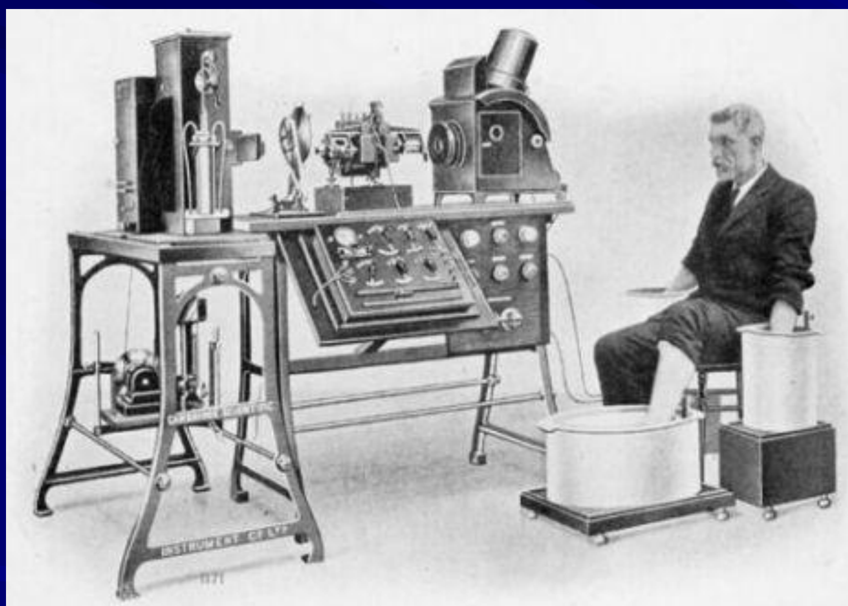
What types of pathology can we identify and study from EKGs?

- Arrhythmias
- Myocardial ischemia and infarction
- Pericarditis
- Chamber hypertrophy
- Electrolyte disturbances (i.e. hyperkalemia, hypokalemia)
- Drug toxicity (i.e. digoxin)

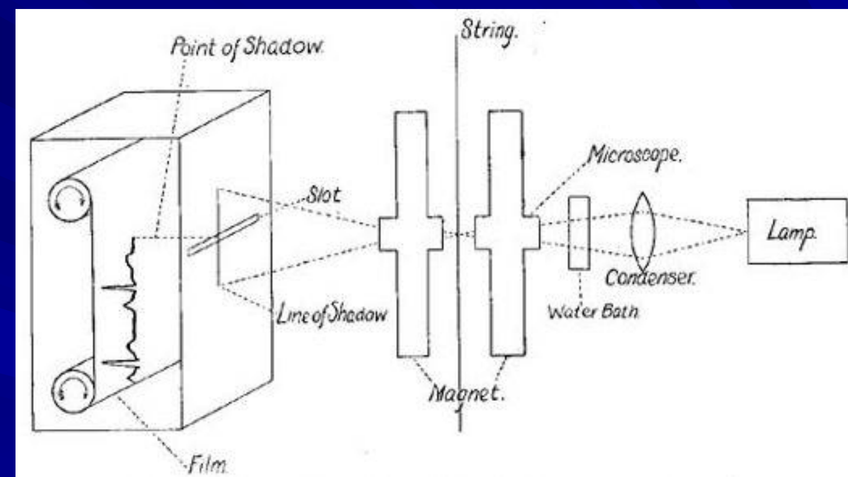
Waveforms and Intervals



Einthoven's Original EKG Recorder



String Galvanometer Based EKG Recorder. Patient with hands submerged in strong salt solution.



String Galvanometer Schematic.

EKG Leads

Leads are electrodes which measure the difference in electrical potential between either:

1. Two different points on the body (bipolar leads)

2. One point on the body and a virtual reference point with zero electrical potential, located in the center of the heart (unipolar leads)

EKG Leads

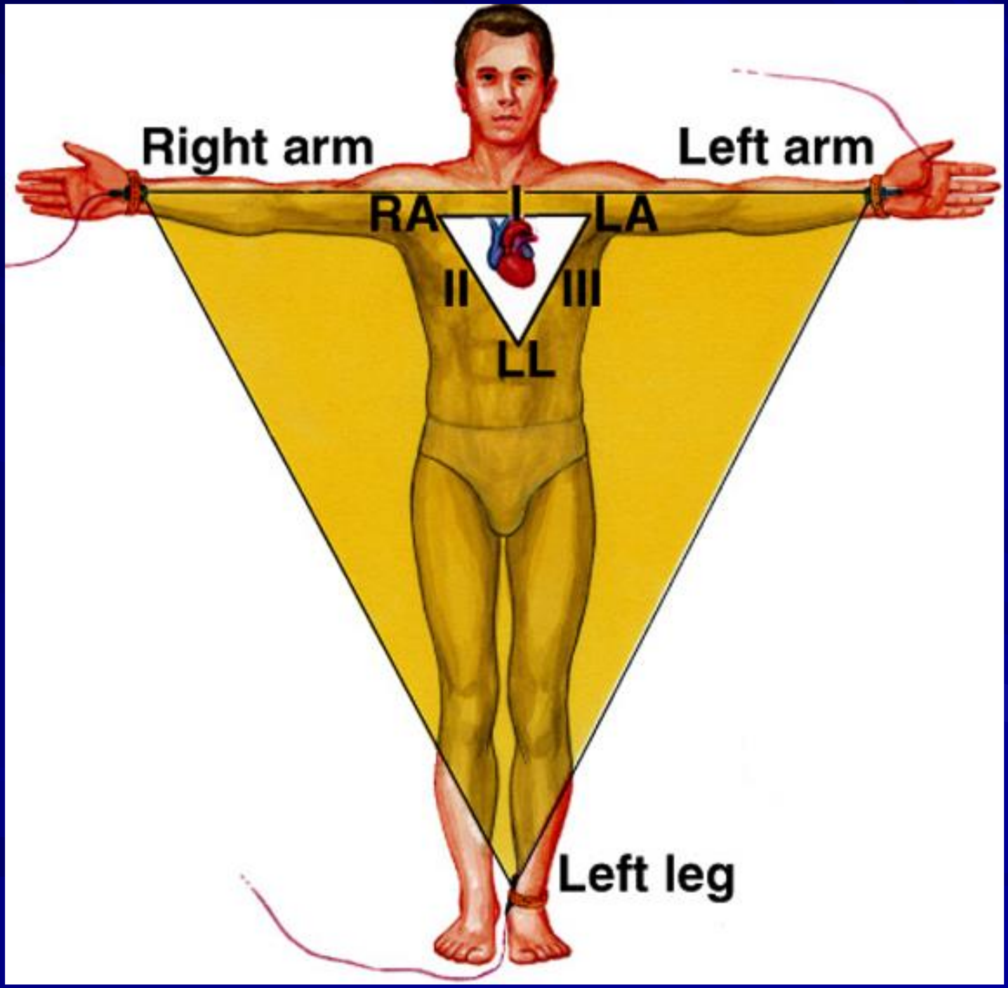
The standard EKG has 12 leads:

3 Standard Limb Leads - *I, II, III*

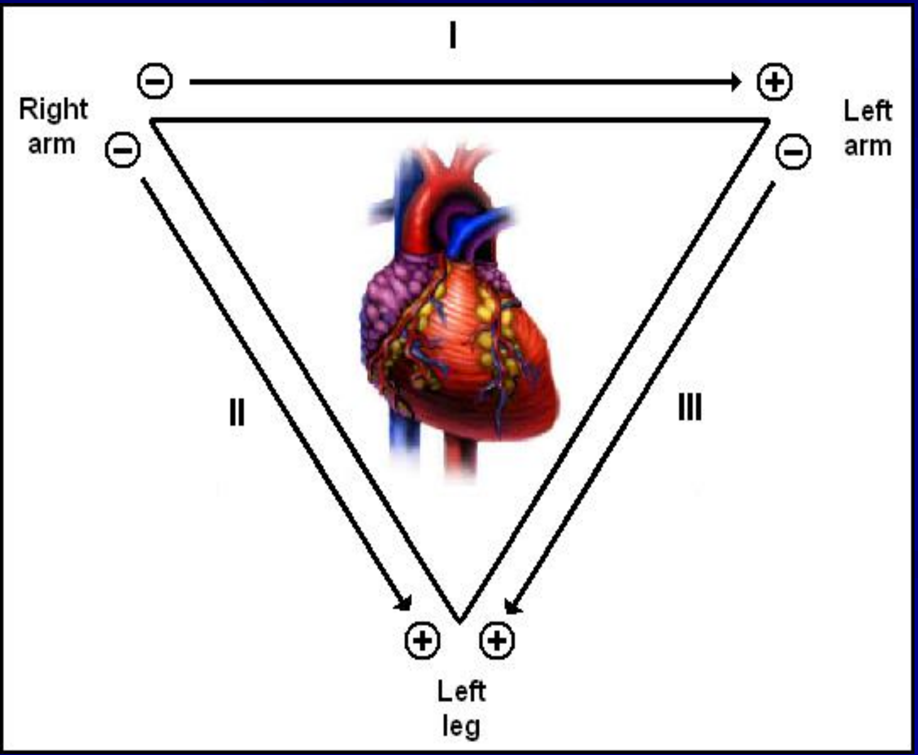
3 Augmented Limb Leads – *aVR, aVL, aVF*

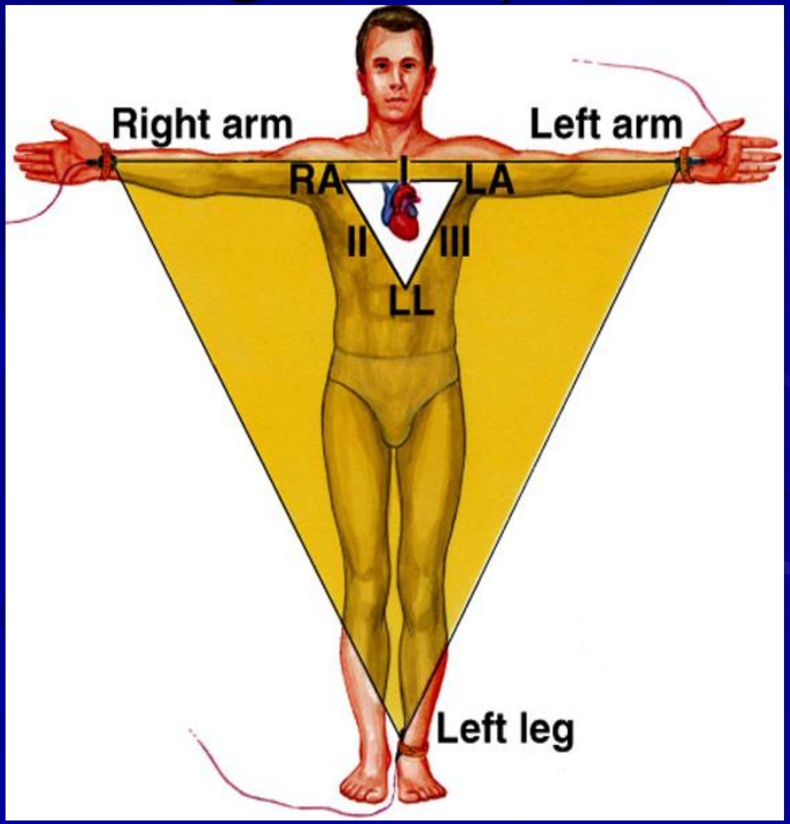
6 Precordial Leads – V_1, V_2, V_3, V_4, V_5, V_6

Standard Limb Leads

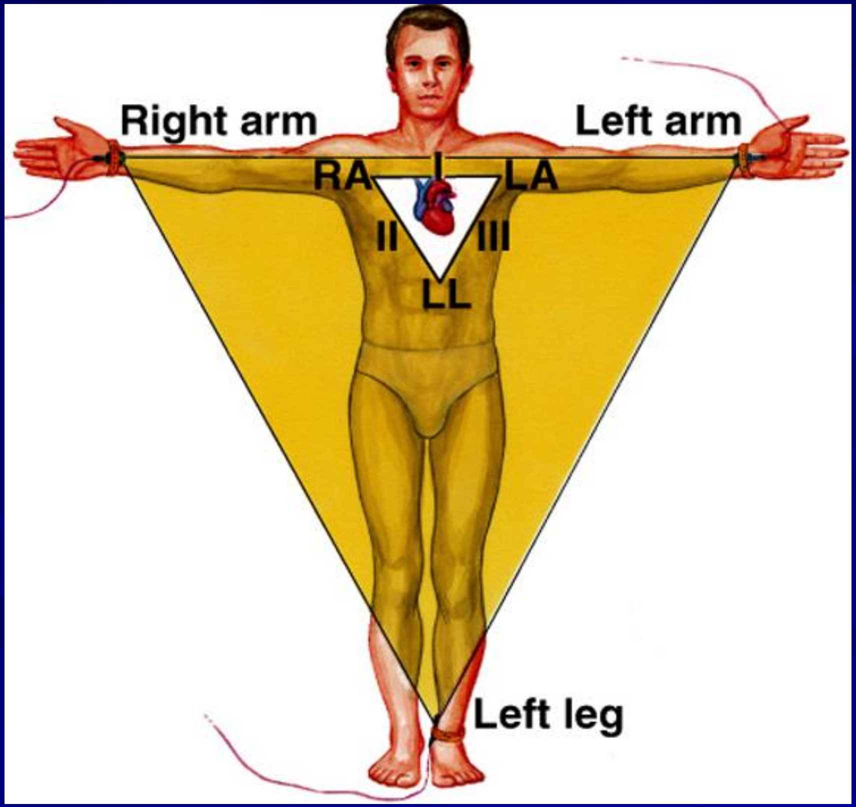


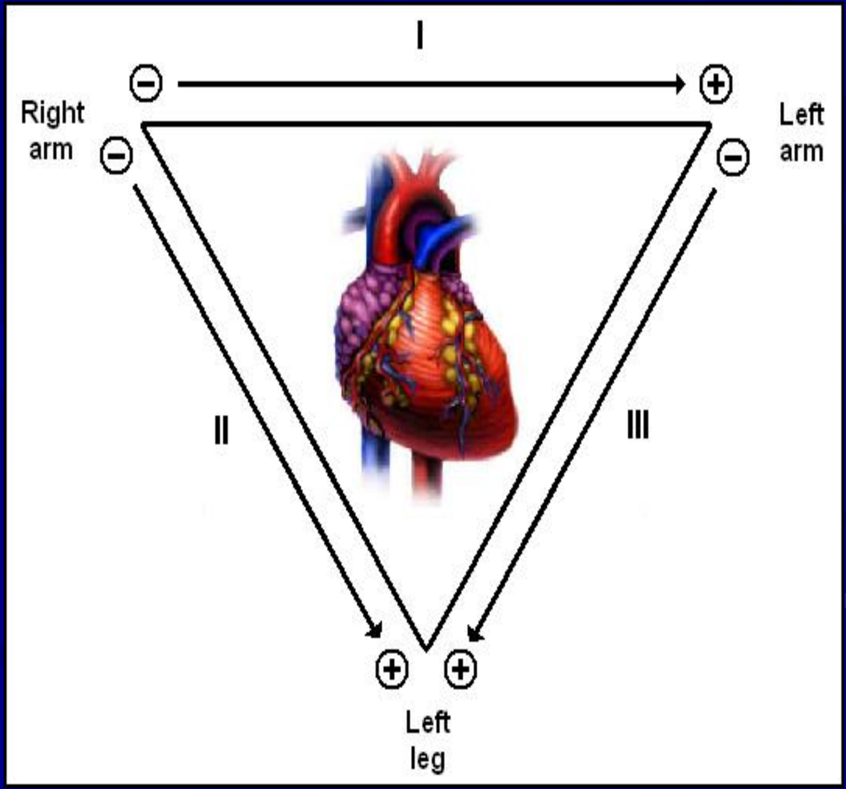
- Lead I - is recording the electrical potential differences between left arm (LA) and the right arm (RA); for it the left arm electrode is the positive pole, and the right arm electrode is the negative pole.



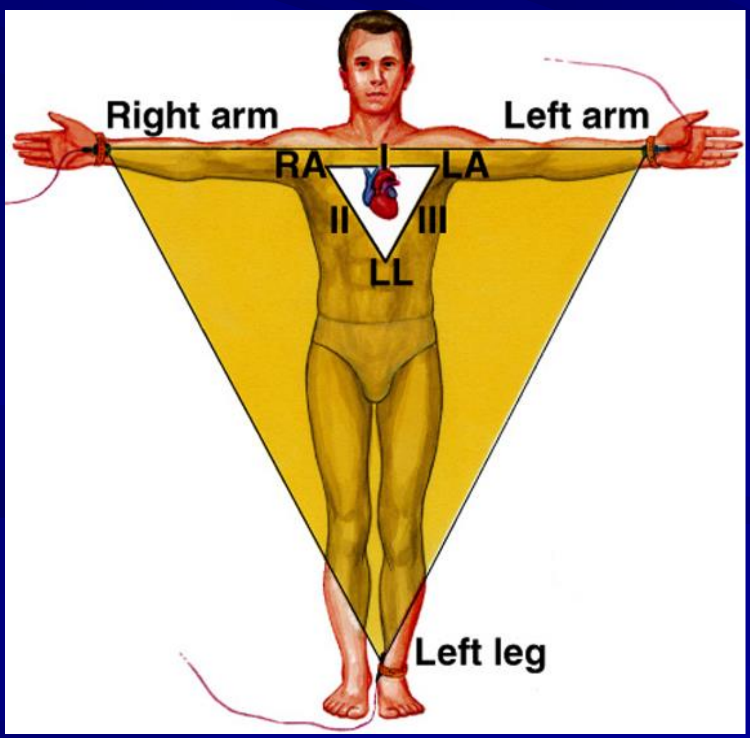


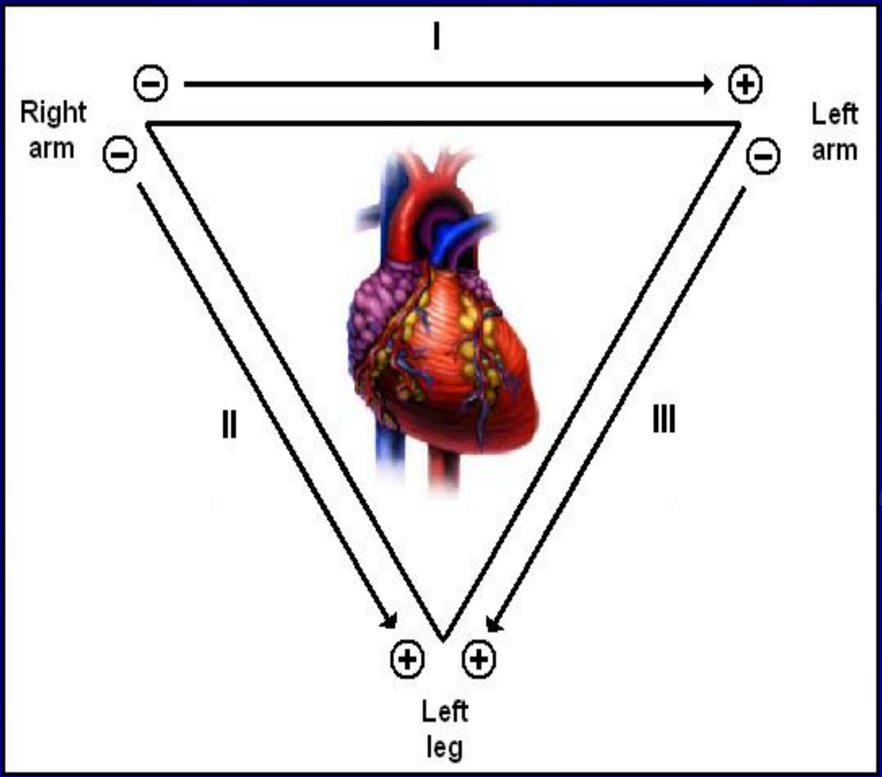
- Lead II - between right arm (RA) and the left leg (LL), with its positive pole on the left leg and its negative pole on the right arm.



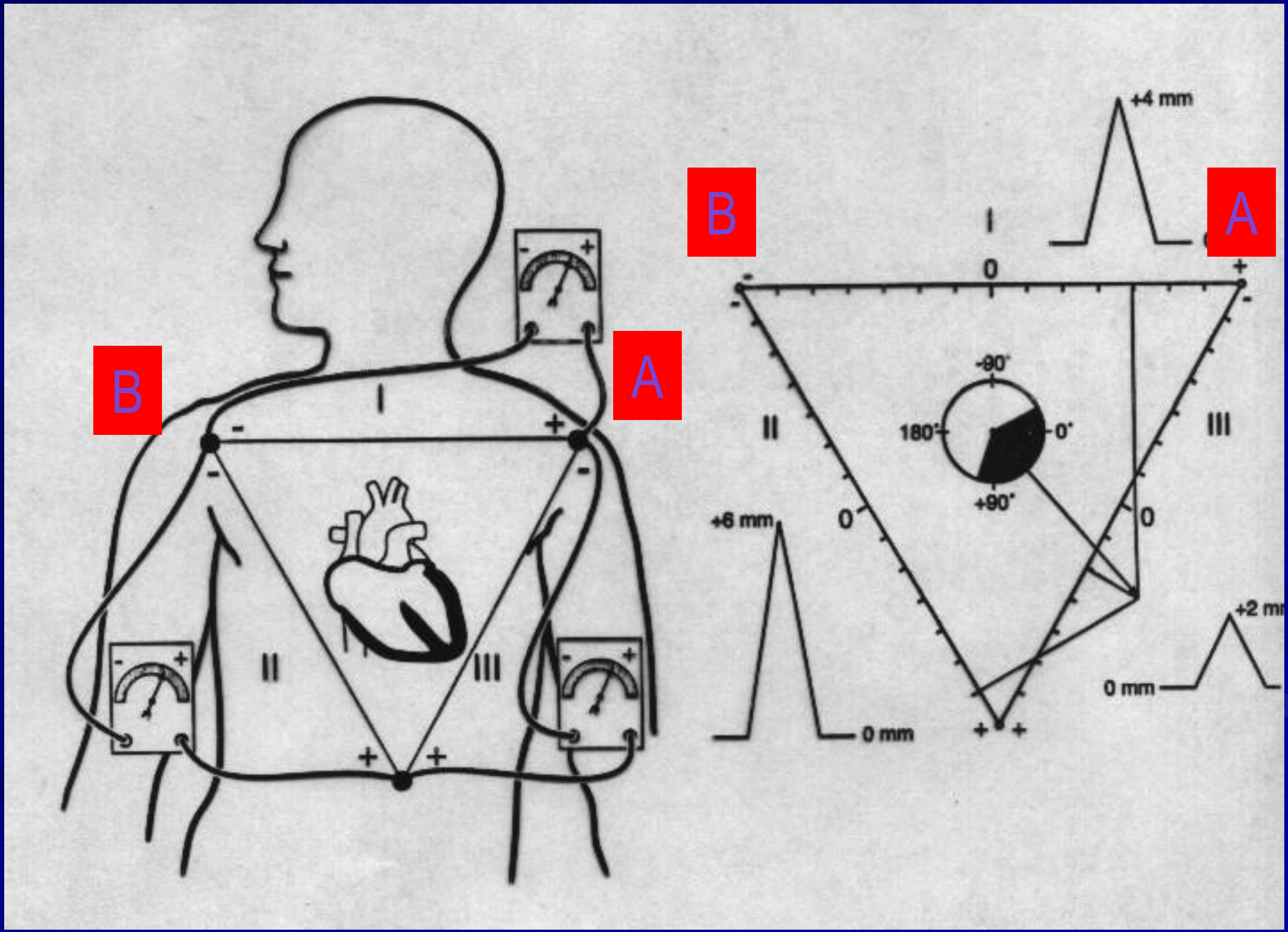


- Lead III - between left arm (LA) and the left leg (LL) has its positive pole on the left leg and its negative pole on the left arm.
- An additional electrode on the right leg is used for grounding.

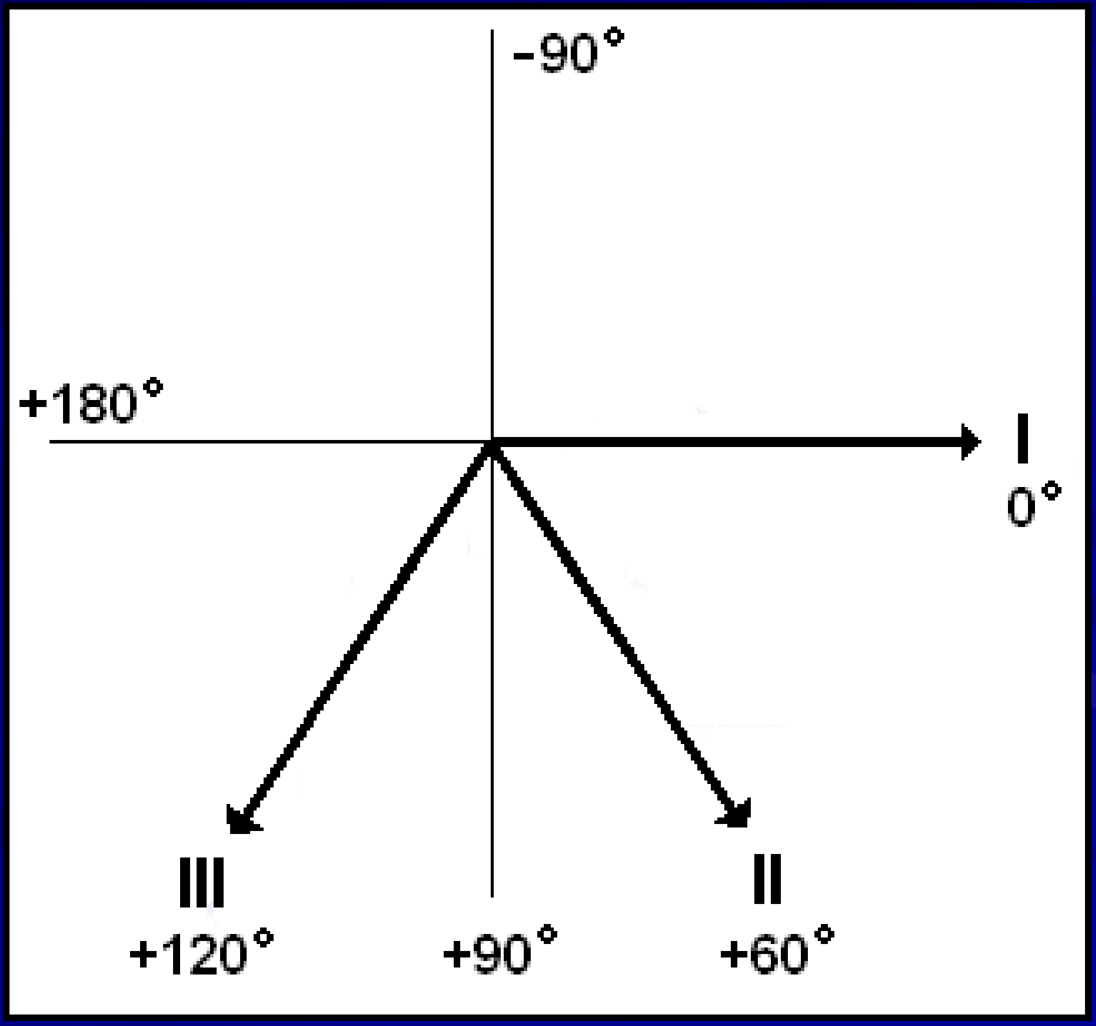




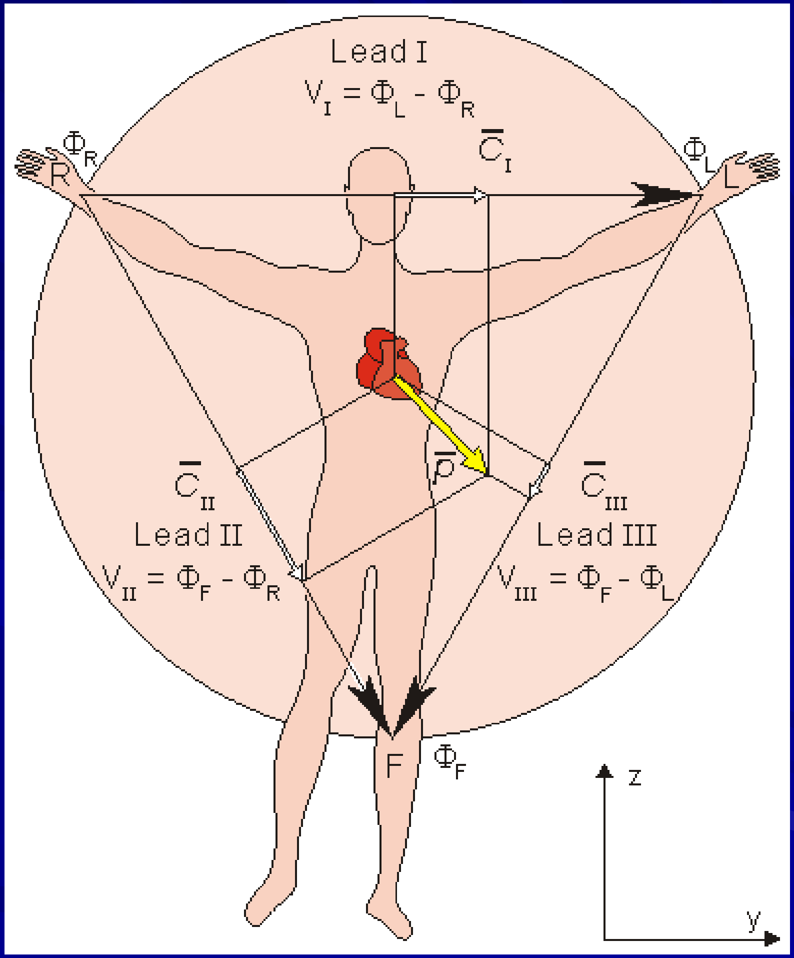
EINTHOVEN'S TRIANGLE AND LIMB LEADS



Standard Limb Leads



Standard lead vectors form an equilateral triangle



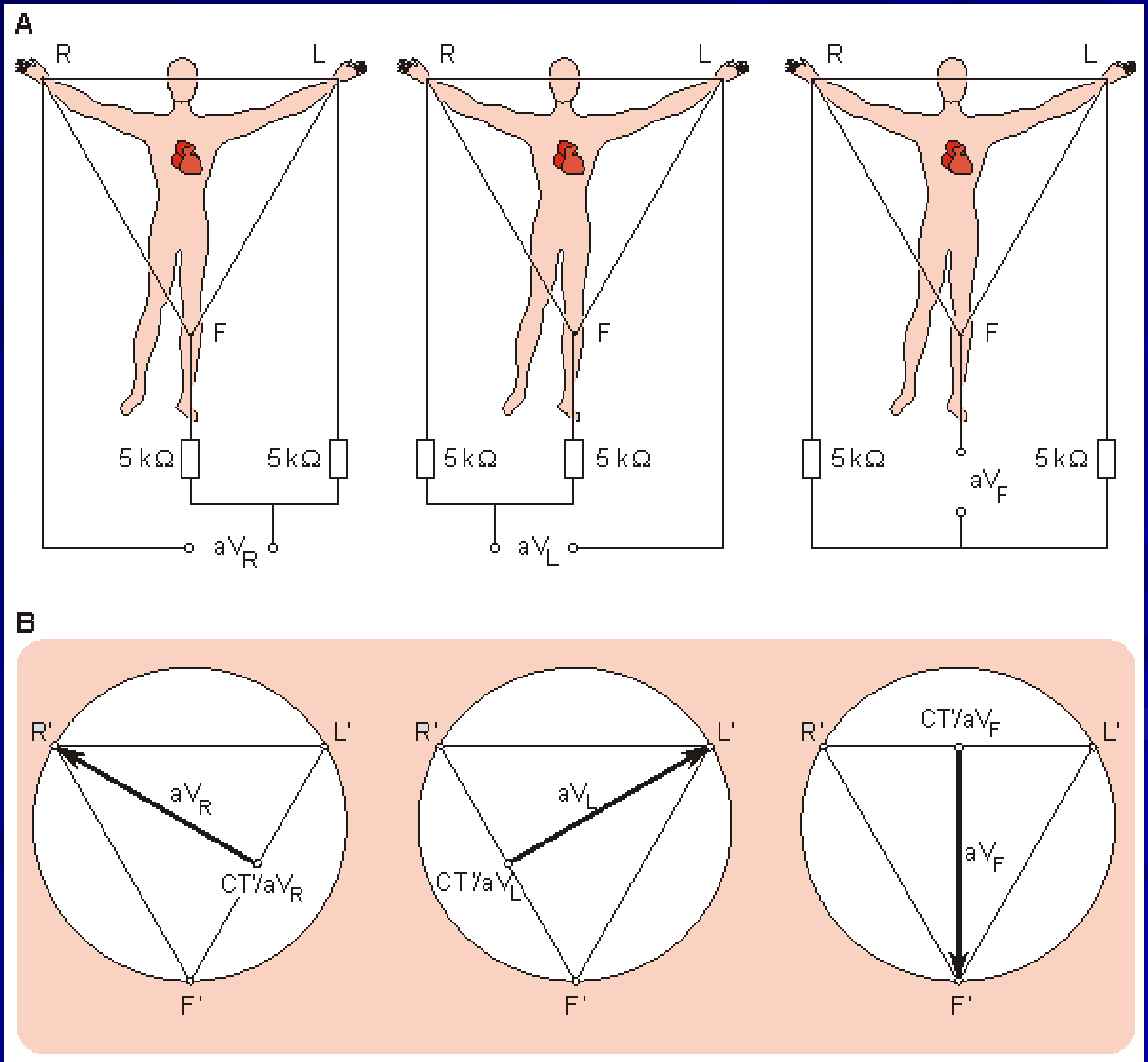
- **RA – red** color of electrode
- **LA – yellow** color of electrode
- **LL – green** color of electrode
- **RL – black** color of electrode

The augmented unipolar leads

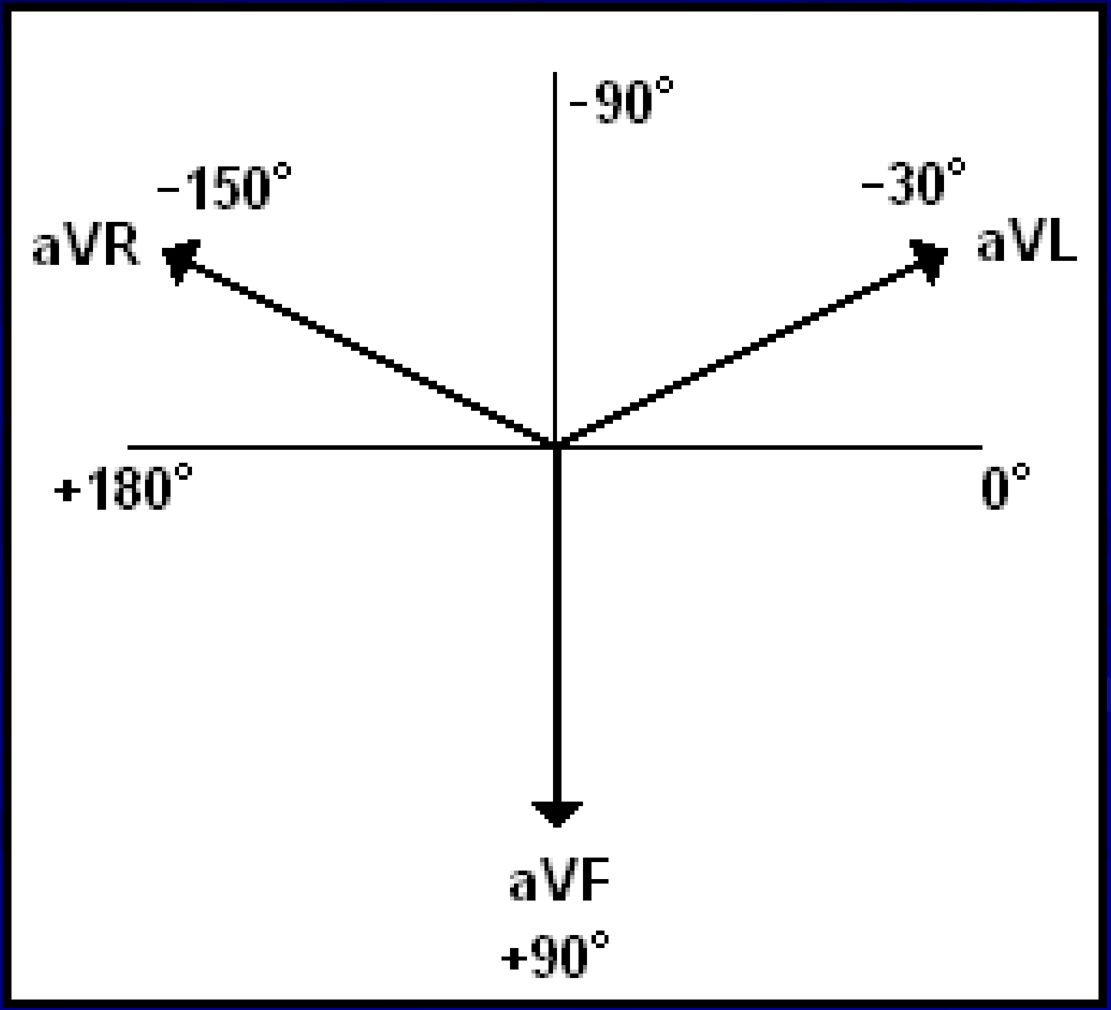
- **are recorded between one of the exploring limb electrode (RA, LA, LL) and a reference created connecting the other two limb electrodes together through a resistor.**

- **Lead aVR** - measures the potential difference between the right arm and the average of the potentials at the left arm and left leg.
- **Lead aVL** - measures the potential difference between the left arm and the average of the potentials at the right arm and left leg.
- **Lead aVF** -measures the potential difference between the left leg and the average of the potentials at the right and left arms.

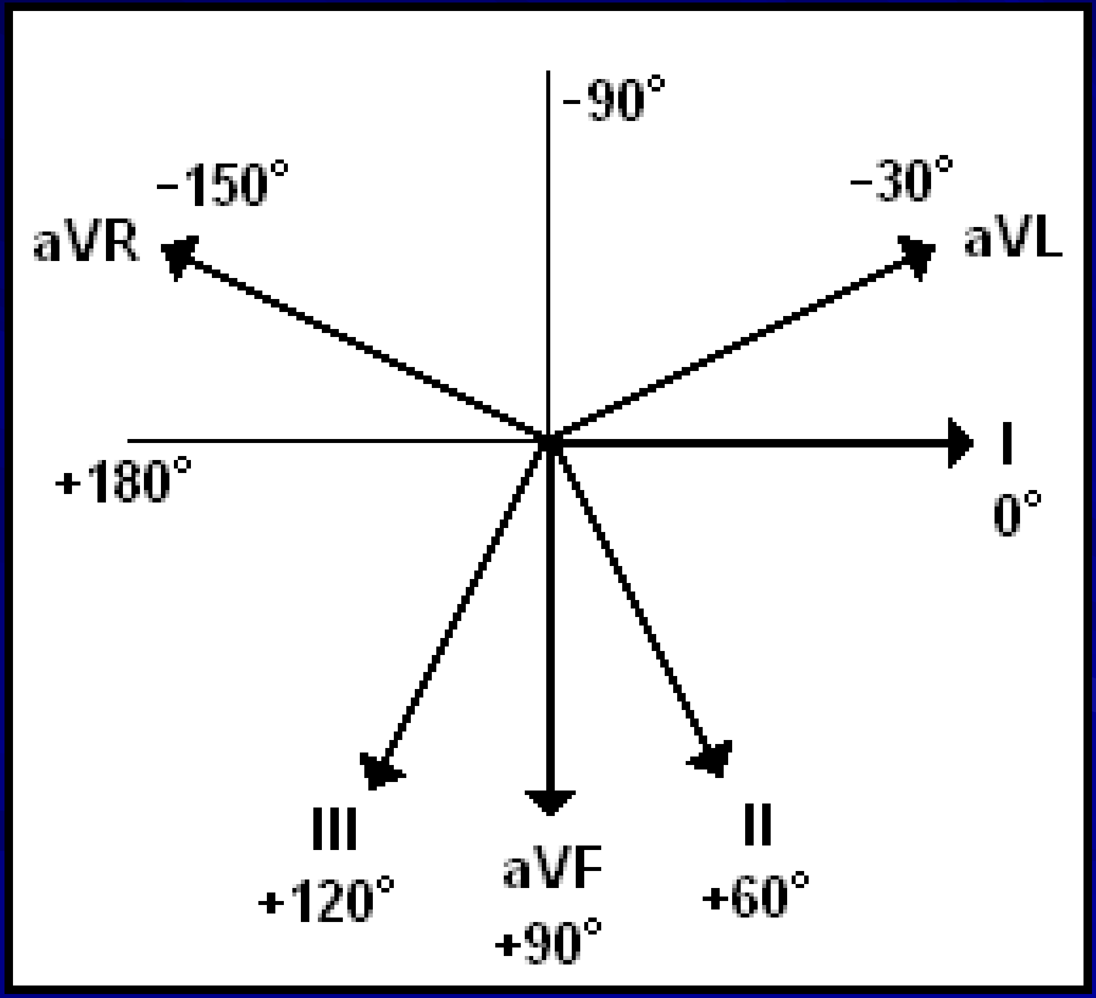
Augmented unipolar leads



Augmented Limb Leads

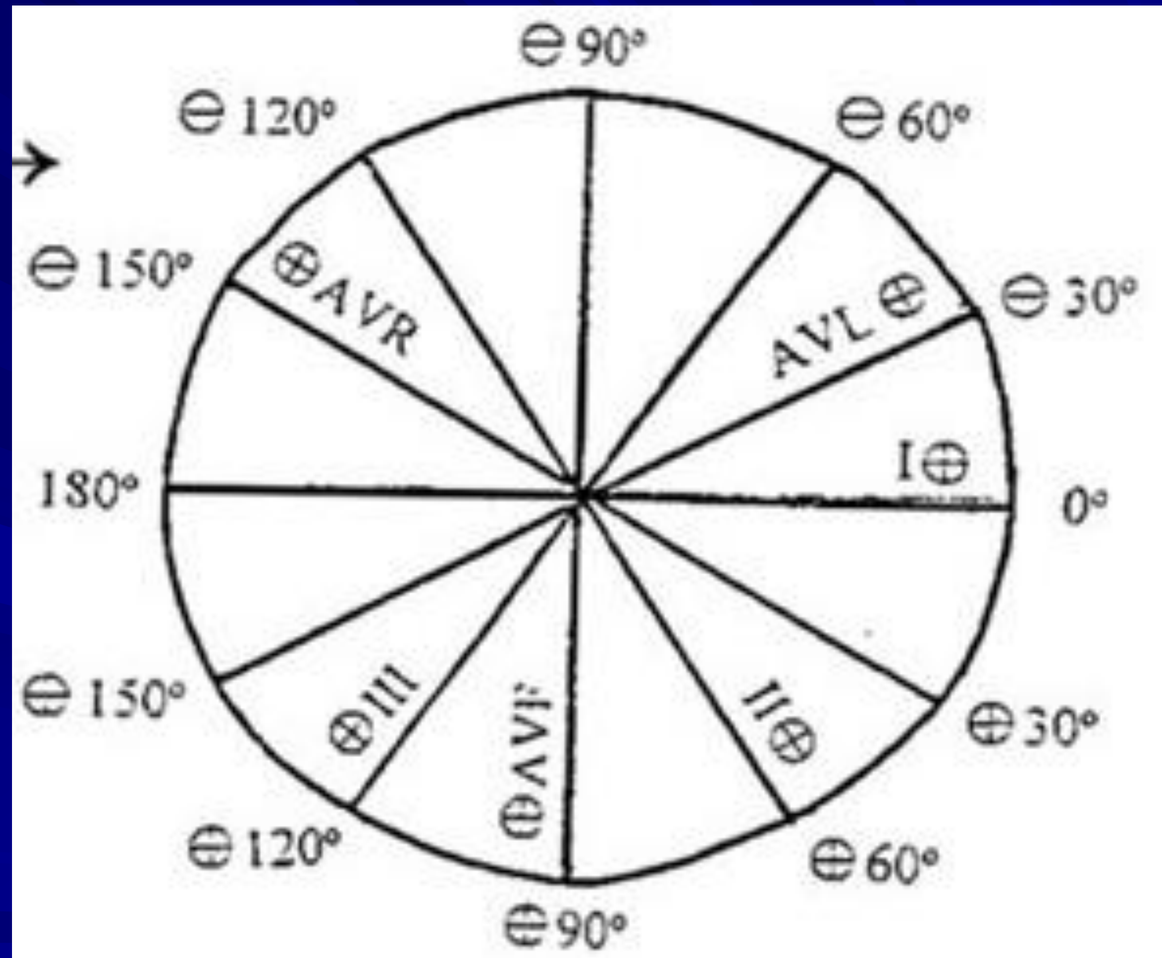


All Limb Leads



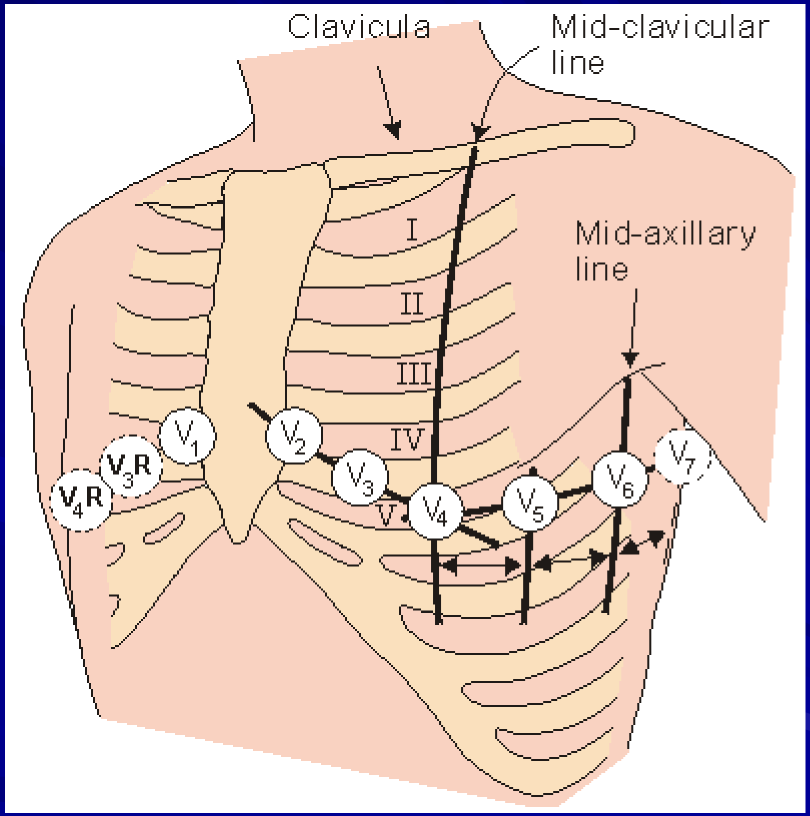
Addition of these three aV leads to the triaxial reference system in the frontal plane produces a hexaxial system,

with the six leads separated by angles of only 30°.



Precordial Leads

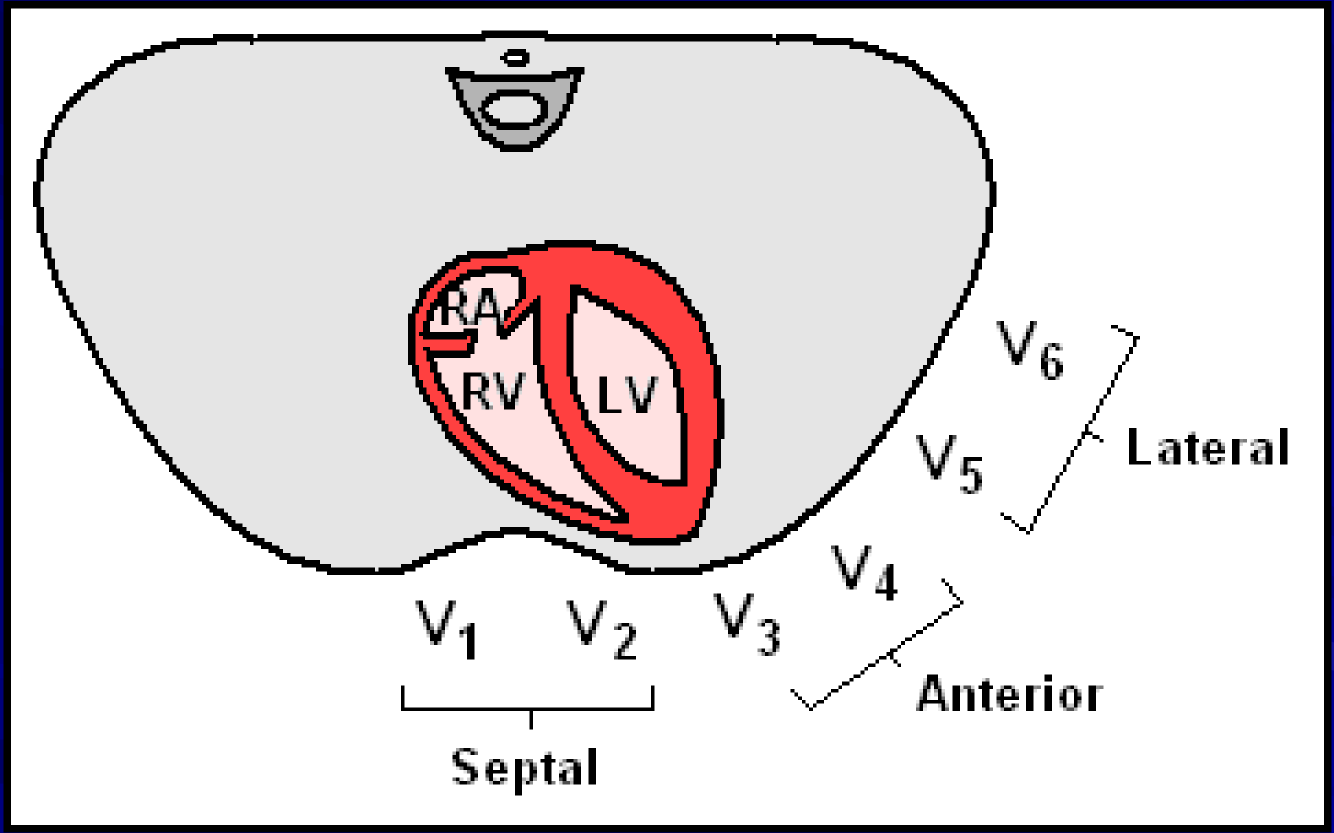
- For measuring the potentials close to the heart, Wilson introduced the precordial leads (chest leads) in 1944. These leads, V_1-V_6 are located over the left chest as described in the figure.



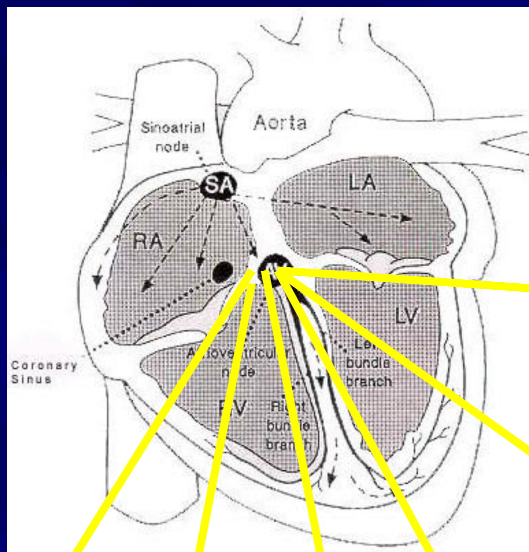
Placement of precordial leads

- **V1 Fourth intercostal space, right sternal border**
- **V2 Fourth intercostal space, left sternal border**
- **V3 Equidistant between V2 and V4**
- **V4 Fifth intercostal space, at the midclavicular line**
- **V5 Anterior axillary line, at the level of lead V4**
- **V6 Midaxillary line, at the level of lead V4**

Precordial Leads



The Chest or Precordial Leads



V6
V5

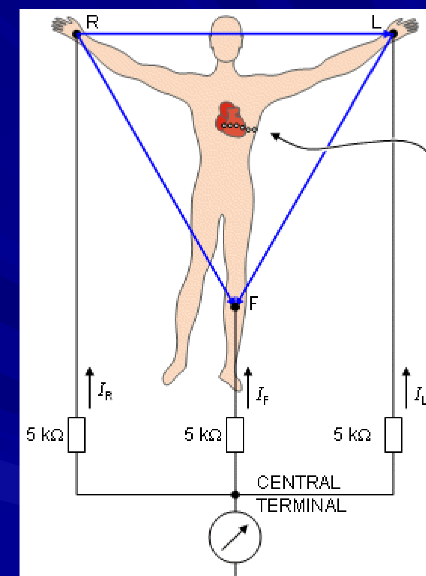
Over the Left Ventricle

V1 V2

Over right ventricle

V3 V4

Over Interventricular Septum



Special Leads

V3R Equidistant between V1 and V4R

V7 Posterior axillary line in the fifth i/c space

V8 Midscapular line

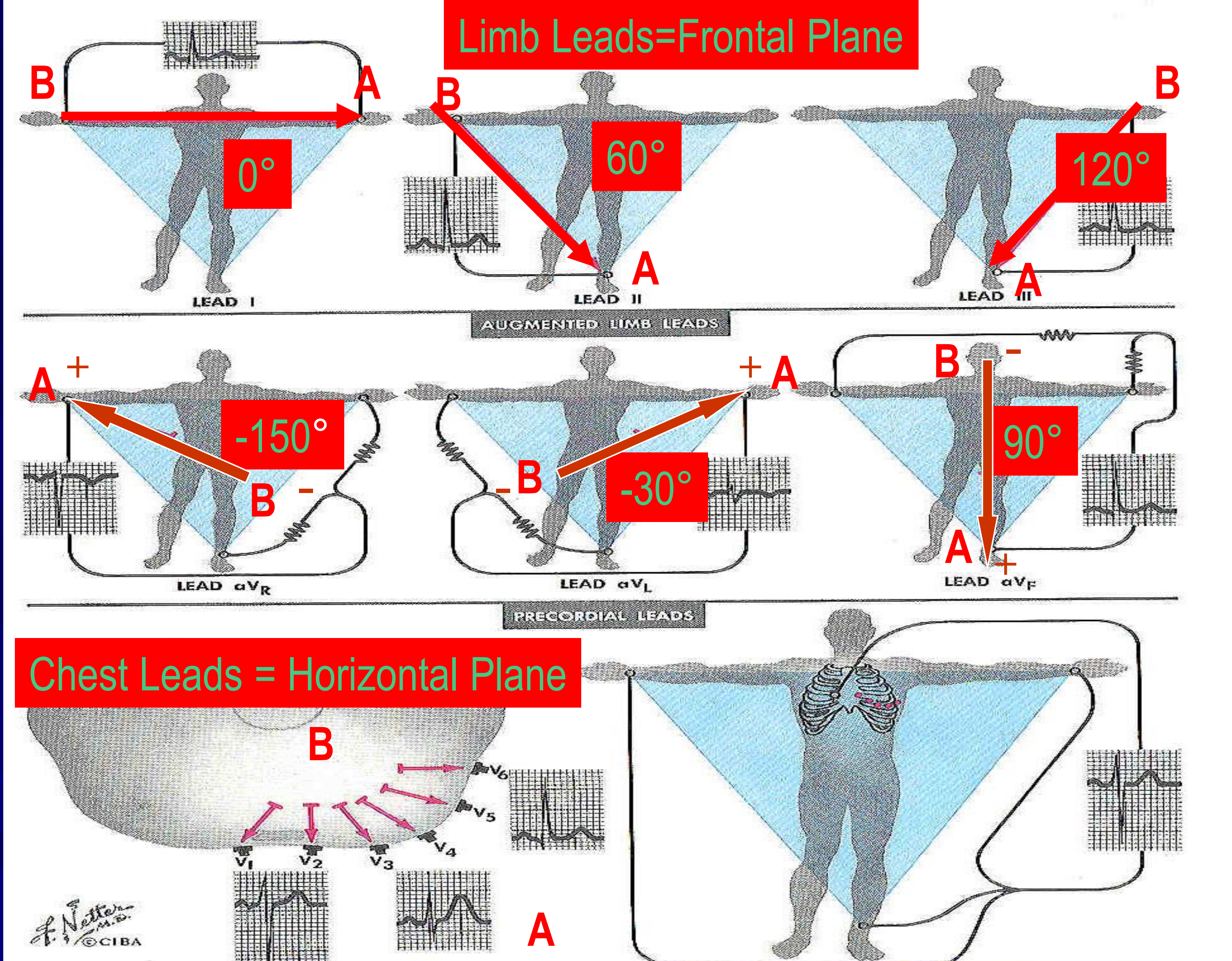
V9 Left paraspinal border

V4R Right midclavicular line, fifth i/c space

V5R Right anterior axillary line in the same horizontal plane as V4R

V6R Right midaxillary line in the same horizontal plane as V4R

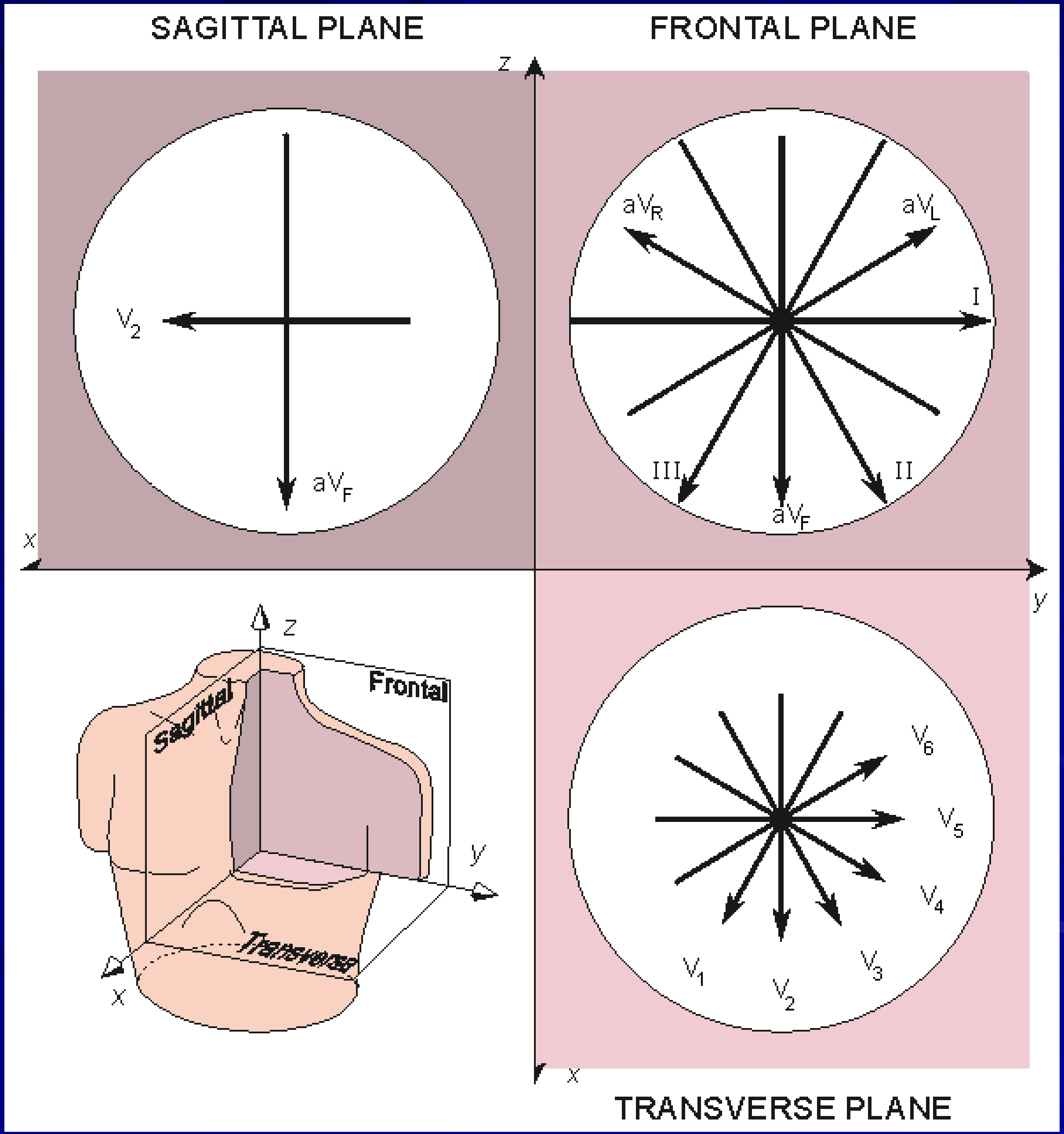
***Note: Lead V2R is the same as V1*.**



WHEN CURRENT FLOWS TOWARD RED ARROWHEADS, UPWARD DEFLECTION OCCURS IN ECG
WHEN CURRENT FLOWS AWAY FROM RED ARROWHEADS, DOWNWARD DEFLECTION OCCURS IN ECG
WHEN CURRENT FLOWS PERPENDICULAR TO RED ARROWS, NO DEFLECTION OR BIPHASIC DEFLECTION OCCURS

The projections of the lead vectors of the 12-lead ECG system in three orthogonal planes

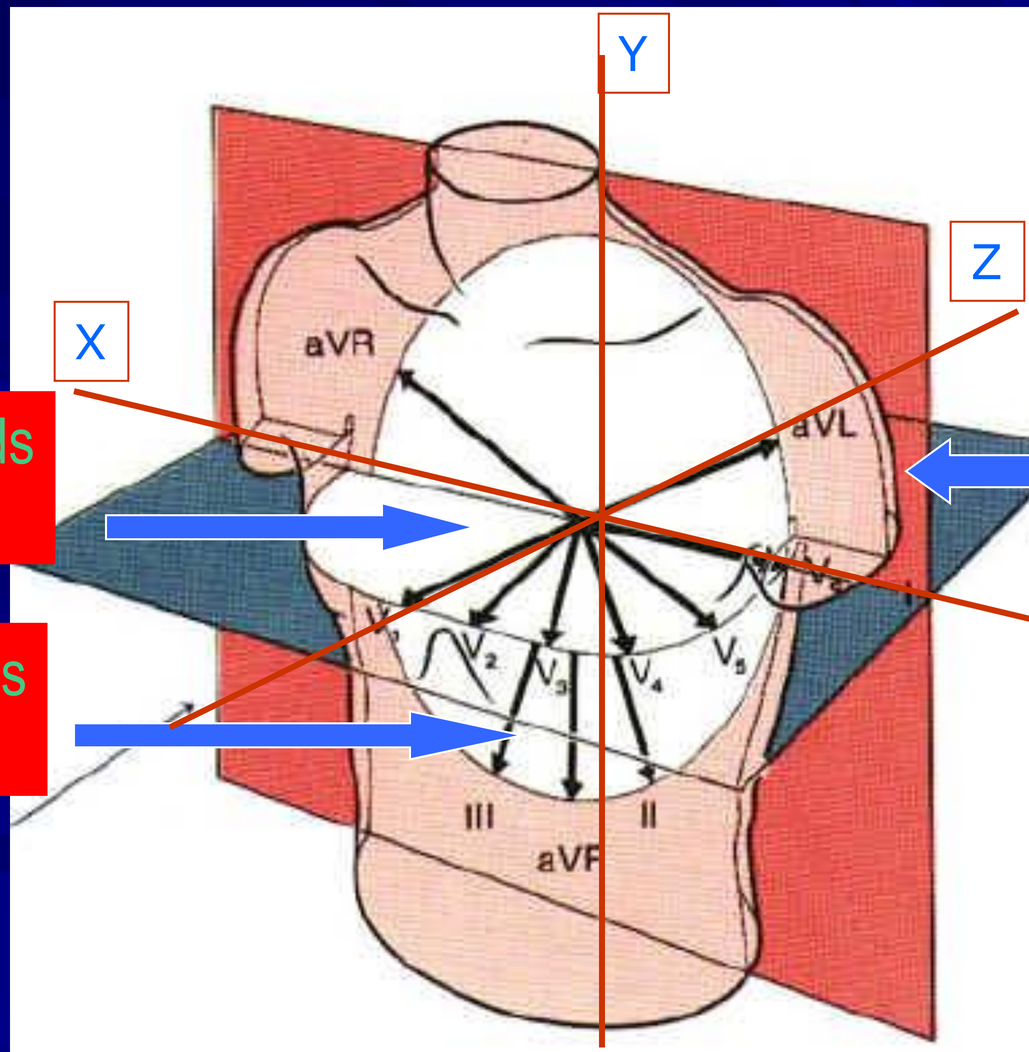
(when one assumes the volume conductor to be spherical homogeneous and the cardiac source centrally located).



Review of what each EKG Lead looks at.

Anterior Leads
V1,V2,V3,V4

Inferior Leads
II,III,AVF



Left lateral Leads
I, AVL,V5
V6

Arrangement of Leads on the EKG

I	aVR	V_1	V_4
II	aVL	V_2	V_5
III	aVF	V_3	V_6

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

Special apparatus - electrocardiograph - can record the biological currents of the heart. It is a voltago- measuring instrument. It includes:

1. The sensitive elements – electrodes – are attached to the body and pick up the potential differences;
2. The amplificatory, which amplify the voltage to the level that can be recorded;
3. A galvanometer
4. A recording apparatus including: a traction ink-writing instruments which draw curves on paper and a time marker;
5. A power unit

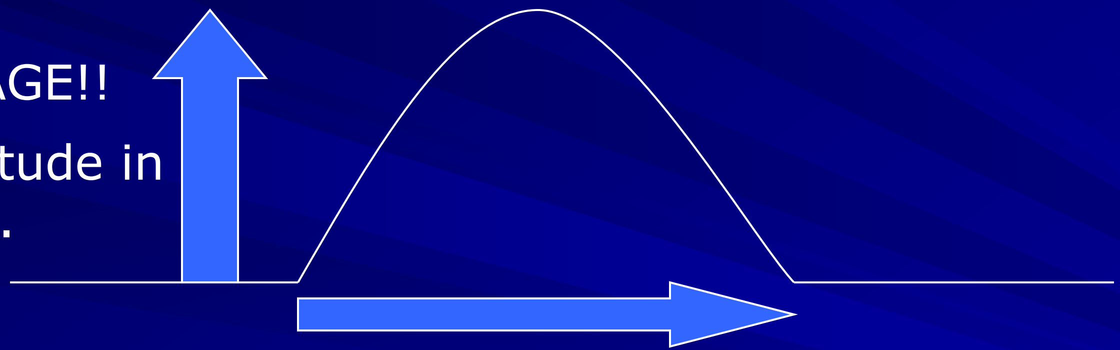
- The tape may move at various speeds: from 25 to 100 *mm/sec;* usually preferred $\geq$ 50 mm/sec.
- When the speed of the tape is known, we can calculate the duration of each element of ECG:

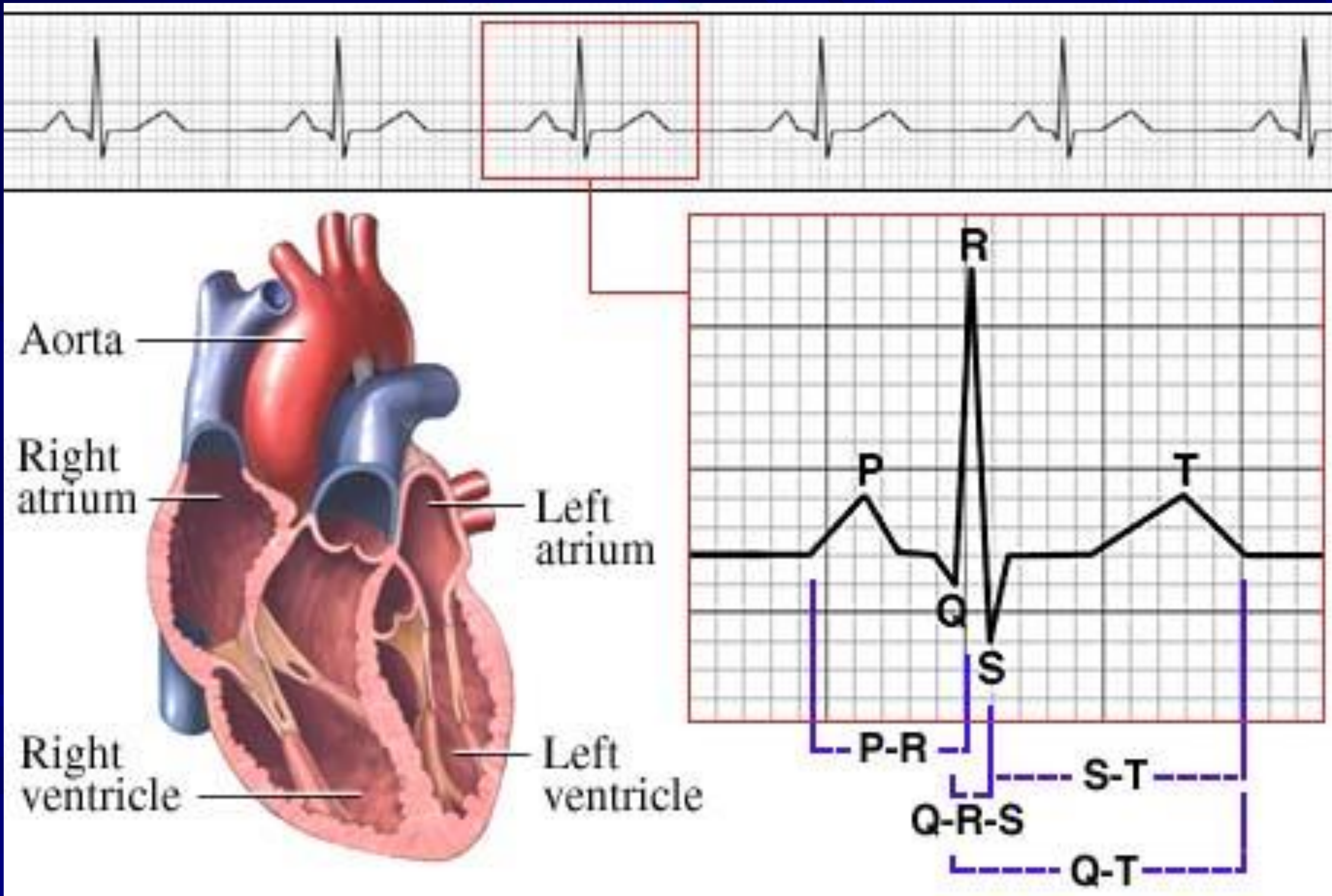
- At the speed of 50 mm/sec each millimeter of the curve corresponds to 0,02 seconds;

- At the speed of 25 mm/sec each millimeter of the curve corresponds to 0,04 seconds;

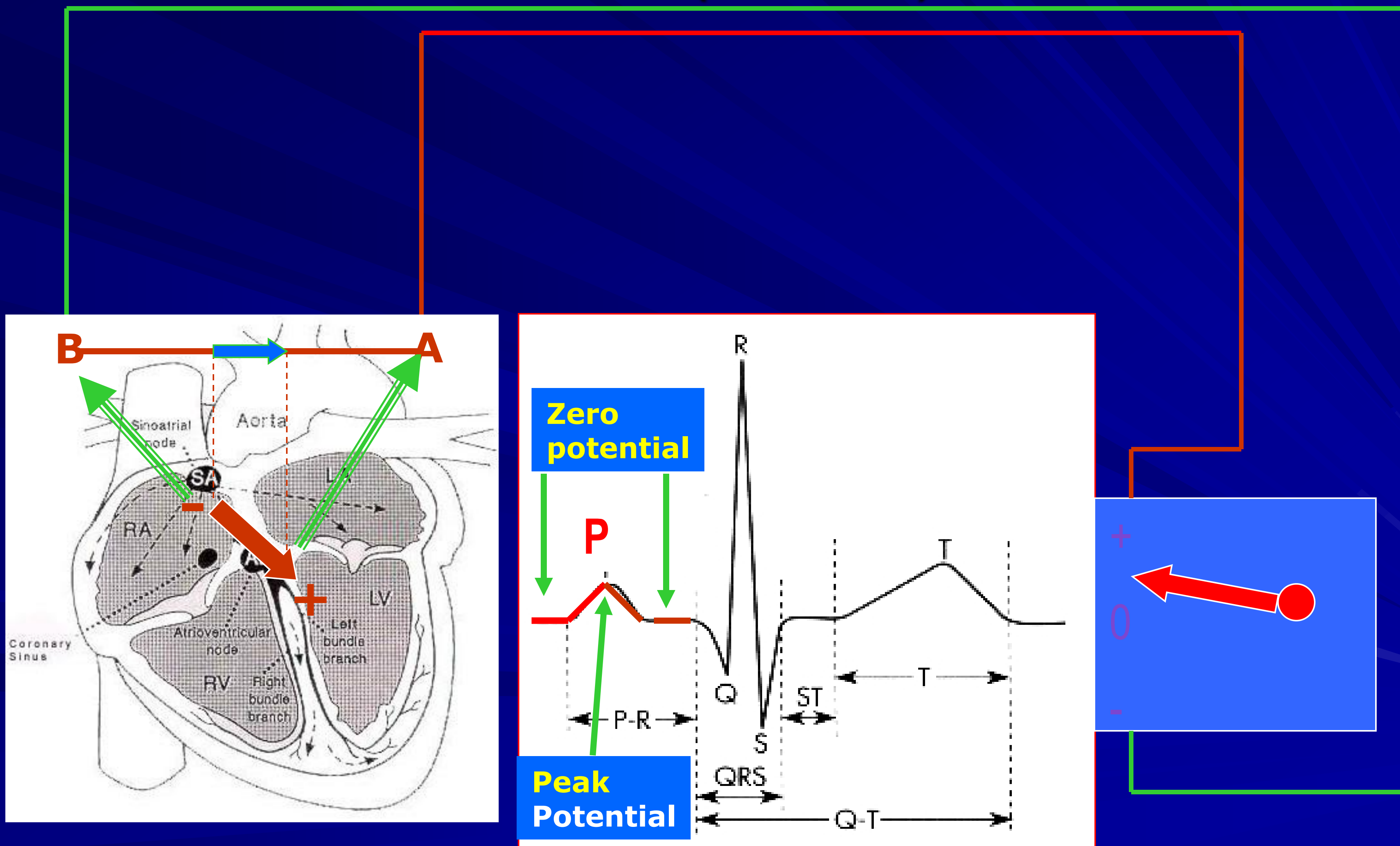
Elements of the ECG

What are we looking at in the EKG waves?



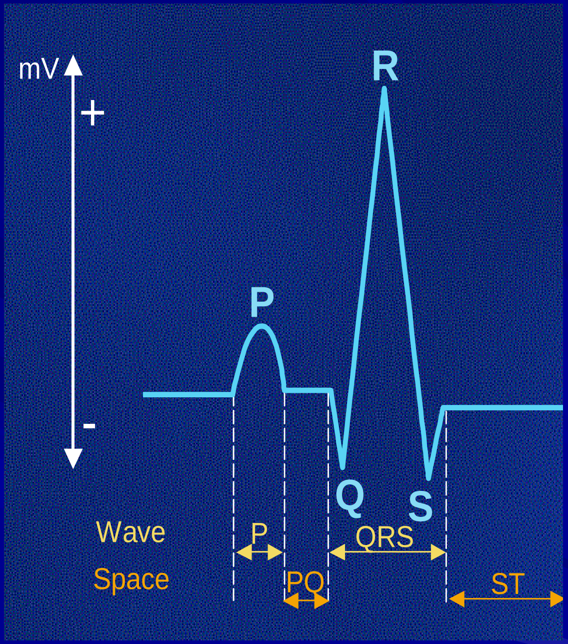

Aorta
Right atrium
Left atrium
Right ventricle
Left ventricle
R
P
T
Q
S
P-R
S-T
Q-R-S
Q-T

Atrial Depolarization
P wave (Lead I)

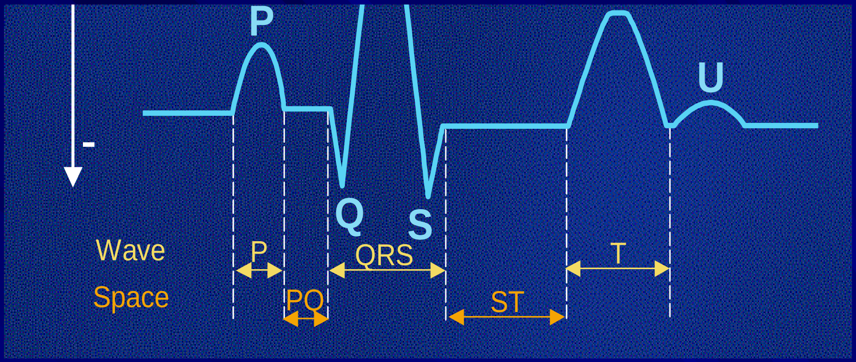


P wave

- The cardiac cycle begins with depolarization of both atria - a **positive P** wave appears on the ECG.
- The ascending portion of the P-wave is due to excitation of the right atrium; the descending part of P is due to the excitation of left atrium. This wave is small:
- its amplitude doesn't exceed 1 - 2,5 mm;
- the length (duration) = 0,08-0,1 sec.



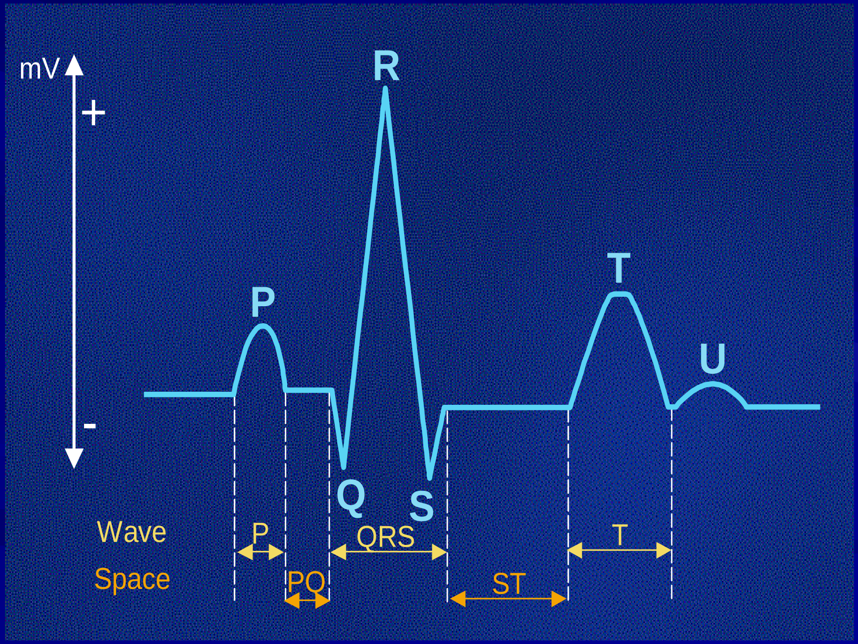
P-Q interval



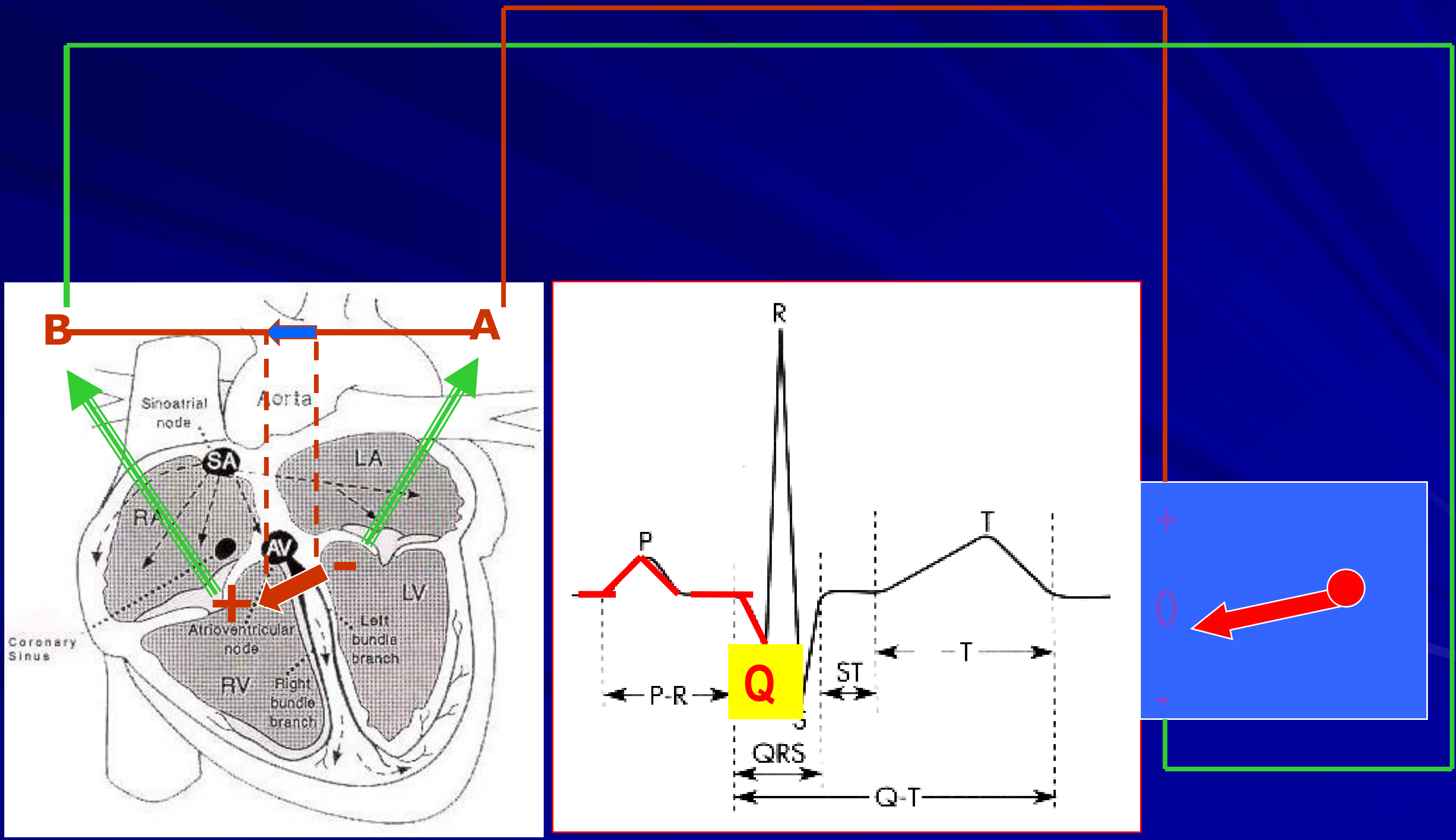
- The P wave is followed by a straight line, called P-Q interval, which connects P wave and Q-wave (or R wave in the absence of the Q wave).
- P-Q interval corresponds to the time from the beginning of atrium excitation to the beginning of ventricular excitation
- it includes the time of impulse propagation through the atrium and its physiological delay in the AV-node.
- The length of P-Q interval is 0,12 – 0,21 sec.

QRS complex – represents ventricular depolarization

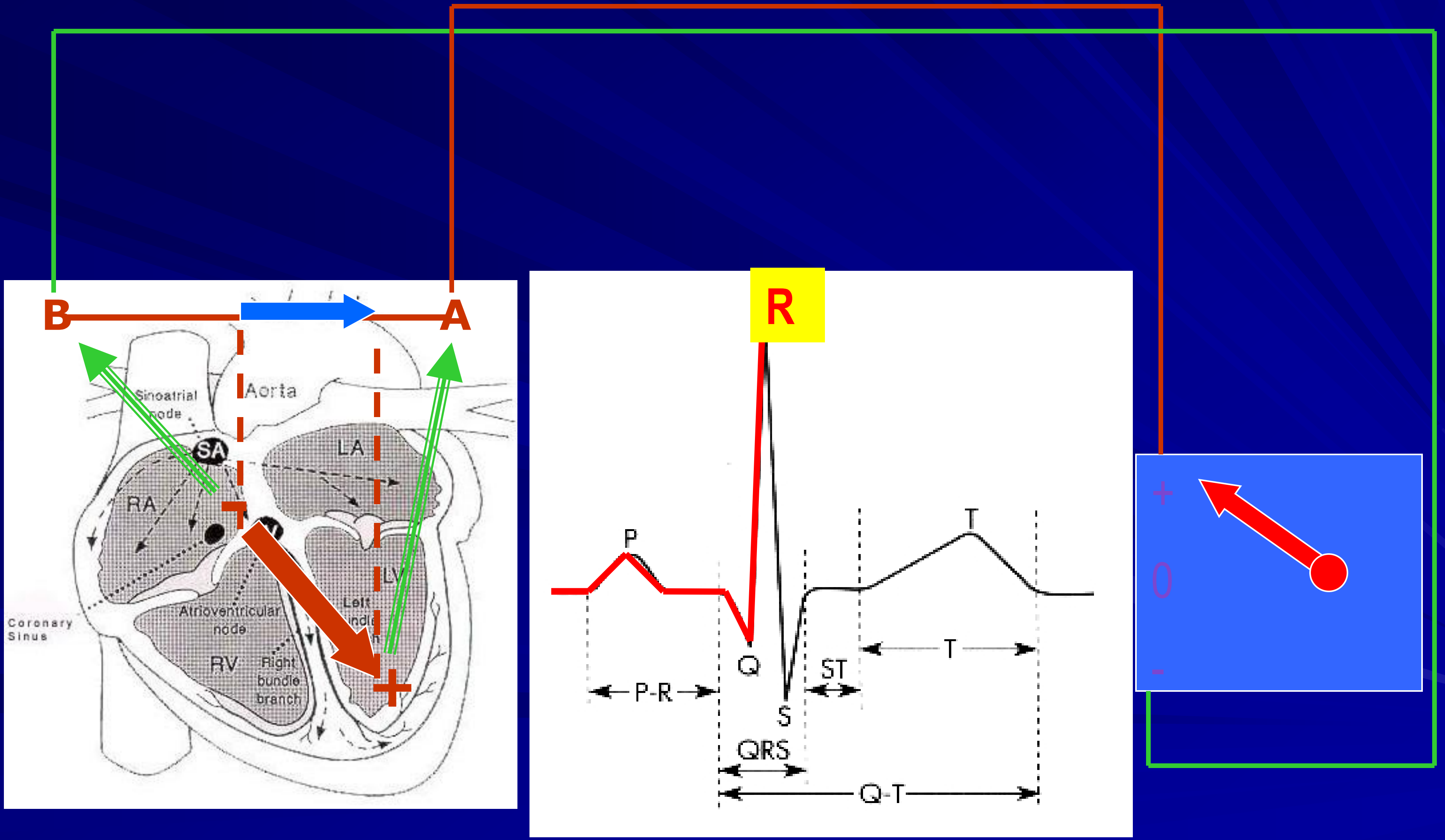
Duration of the QRS should be ≤ 0,1 sec



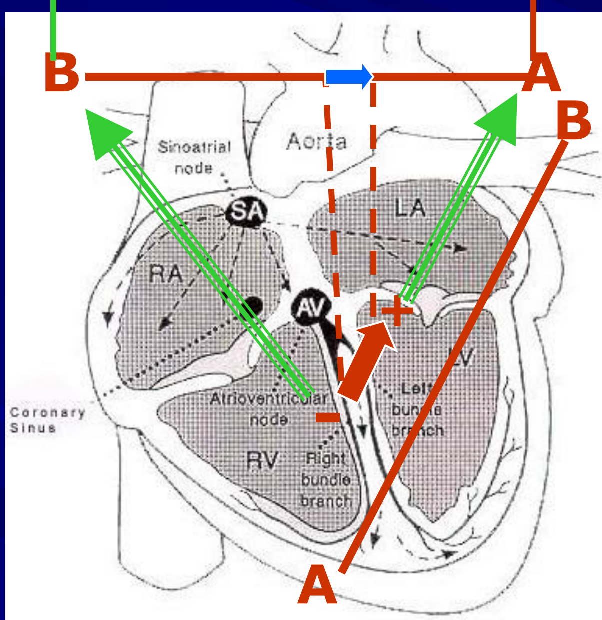
Ventricular Septal Depolarization- the Q Wave

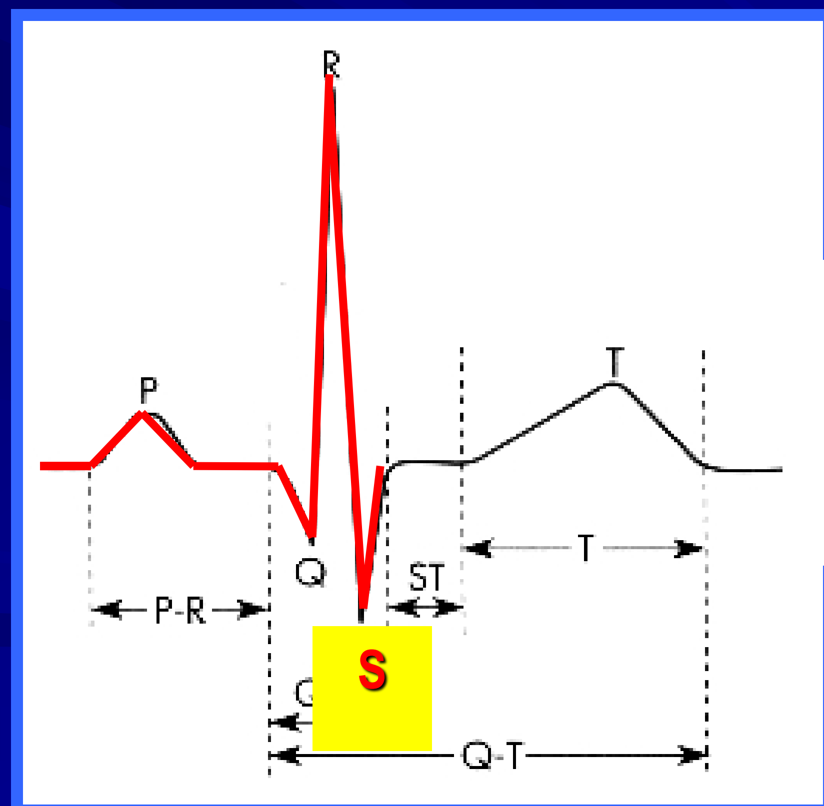


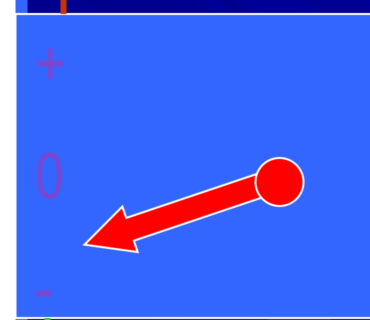
Ventricular Depolarization-the R Wave



Ventricular Depolarization-The S Wave

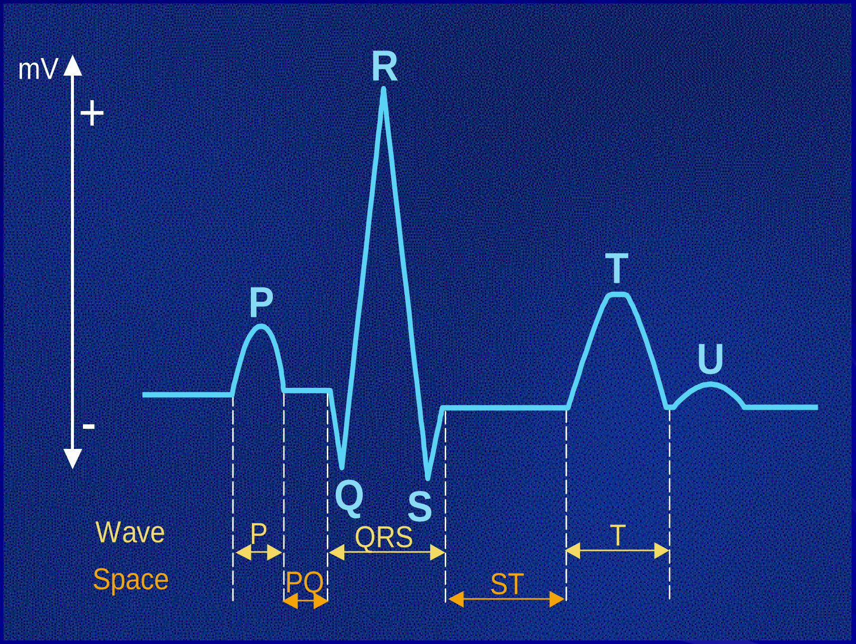






Q Waves

- A Q wave is a negative deflection at the onset of the QRS complex,
- duration less then 0,03 sec
- with a high less than 25 % from following R wave.
- The absence of small Q waves in leads V5 and V6 should be considered abnormal.



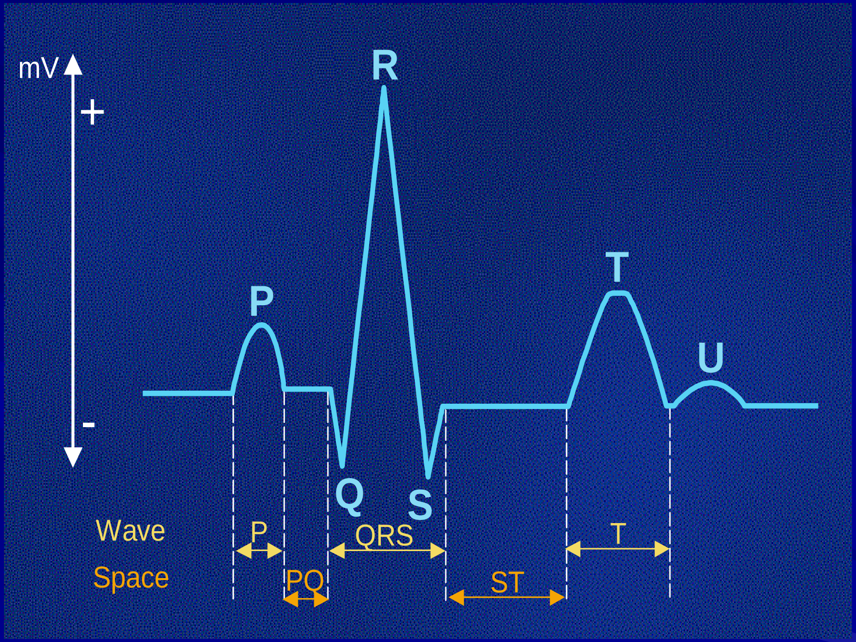
Q Waves

Conditions associated with abnormal Q waves include :

- myocardial infarction,
- ventricular hypertrophy or dilatation,
- intraventricular conduction disturbances

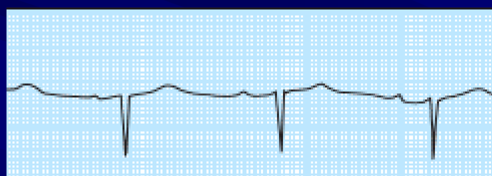
R Waves

- The positive wave of the QRS complex is called the R wave, whether or not it is preceded by a Q wave.
- When a second positive deflection occurs, it is termed R'.

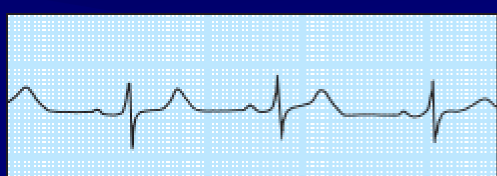


Chest leads - the R wave increases its amplitude and duration from V1 to V4 or V5.
The amplitude of the R wave in leads V5 and V6 varies directly with left ventricular dimension.

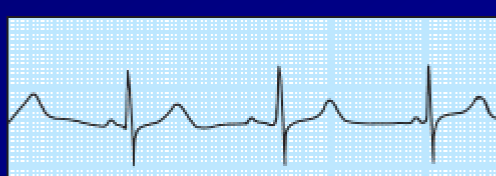
- Lead V_1



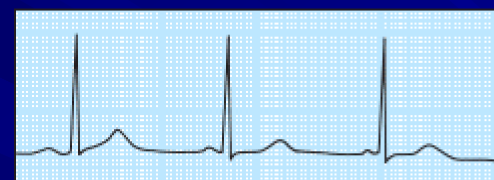
- Lead V_2



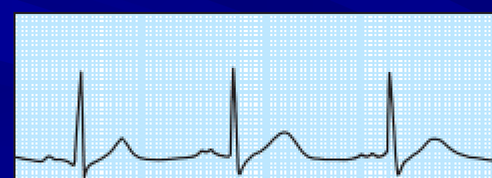
- Lead V_3



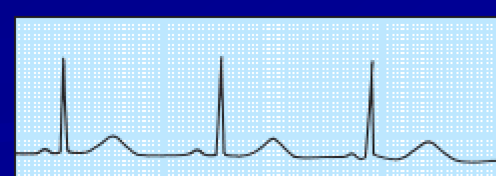
Lead V4



Lead V5

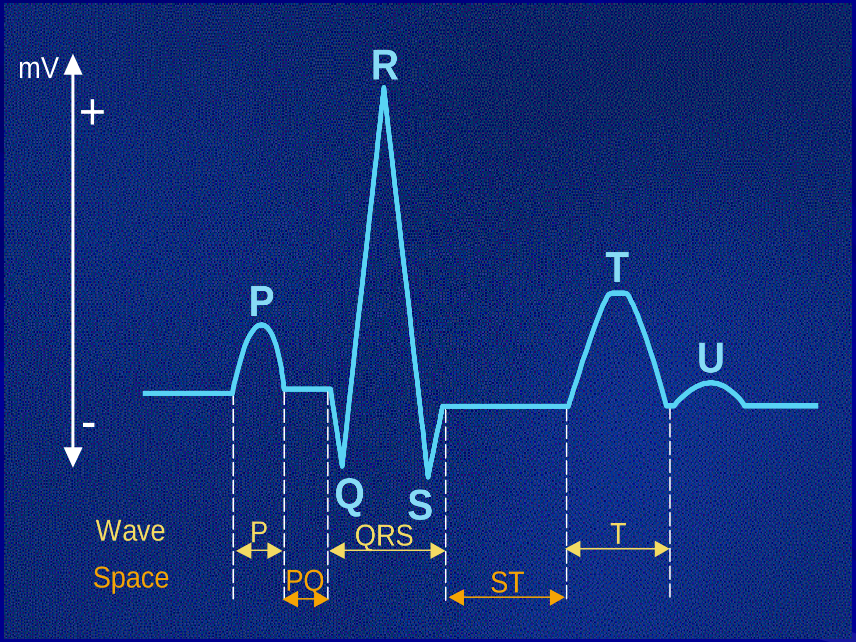


Lead V6



S Waves

- A negative deflection following an R wave is called an S wave.



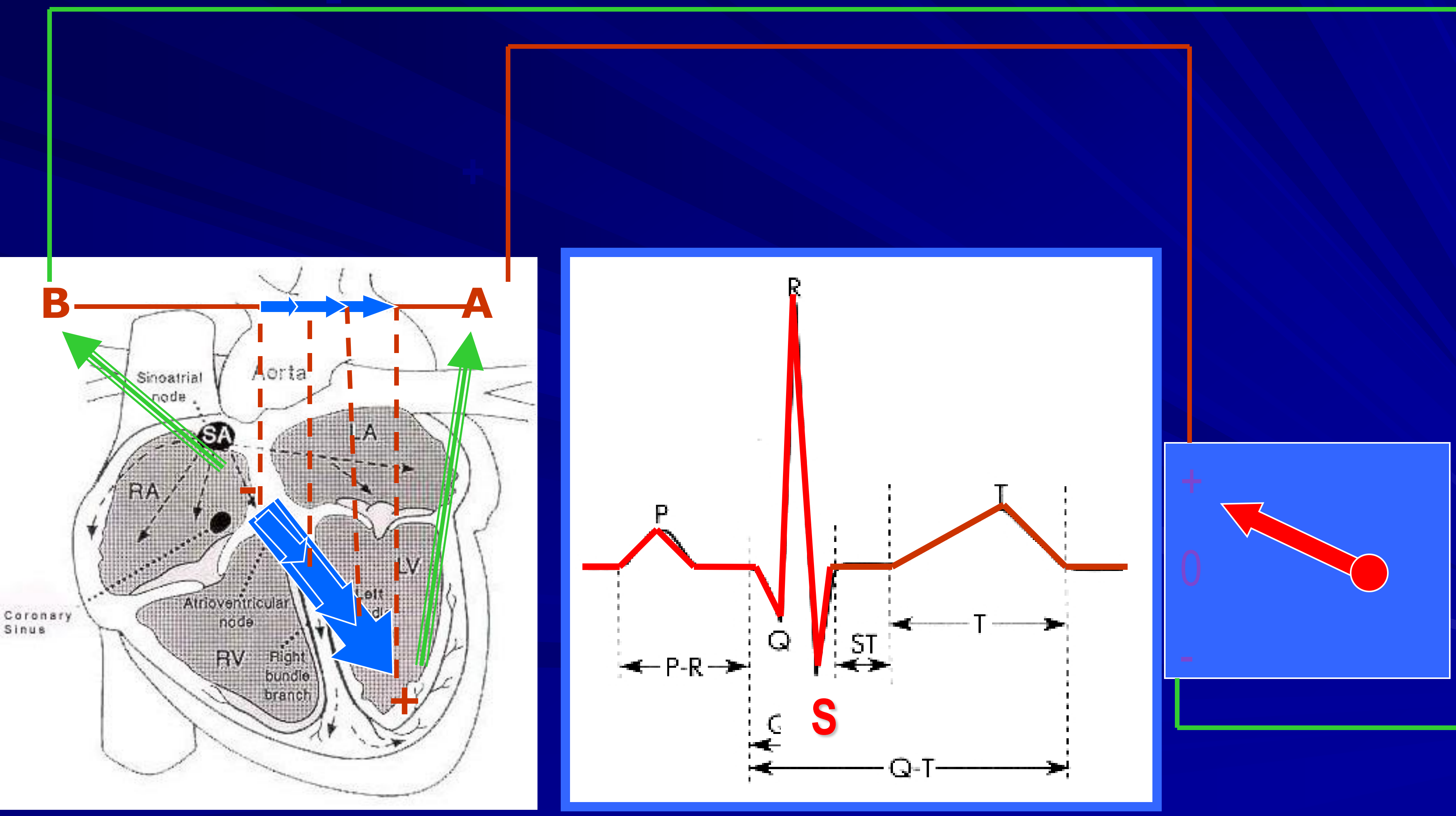
ST Segment

- **The ST segment represents the time period in which the ventricular myocardium remains depolarized.**
- **At its junction with the QRS (i.e., J point), the ST segment forms a nearly 90° angle and then proceeds horizontally until it curves gently into the T wave.**
- **The ST segment is normally on the isoelectric line, on the same level with the PR and TP segments.**

ST Segment

- **Alterations of the ST segment include elevation and depression. The most important cause of ST-segment elevation is infarction or ischemia.**
- Slight elevation (particularly in leads V1 to V3), depression of the ST segment ≤ 1 mm may occur as a normal variant.

Ventricular Repolarization- the T Wave



T Wave

- The T wave represents only the ventricular repolarization.
- The shape of the T wave is positive, rounded but asymmetrical, because the initial deflection is longer than the terminal deflection.
- Slight “peaking” of the T wave may occur as a normal variant.

T Wave

Abnormalities of the T wave are seen in a number of conditions.

- **usually consist of inverted T waves – negative T wave.**
- **is observed during myocardial ischemia, myocarditis, pericarditis, mitral valve prolapse,**
- **may be induced by drugs**
- **May be associated with bundle-branch block, ventricular hypertrophy, cardiomyopathies and WPW syndrome.**
- **Positive, peaked T waves are seen during hyperkalemia and in the “hyperacute” phase of acute myocardial ischemia. .**

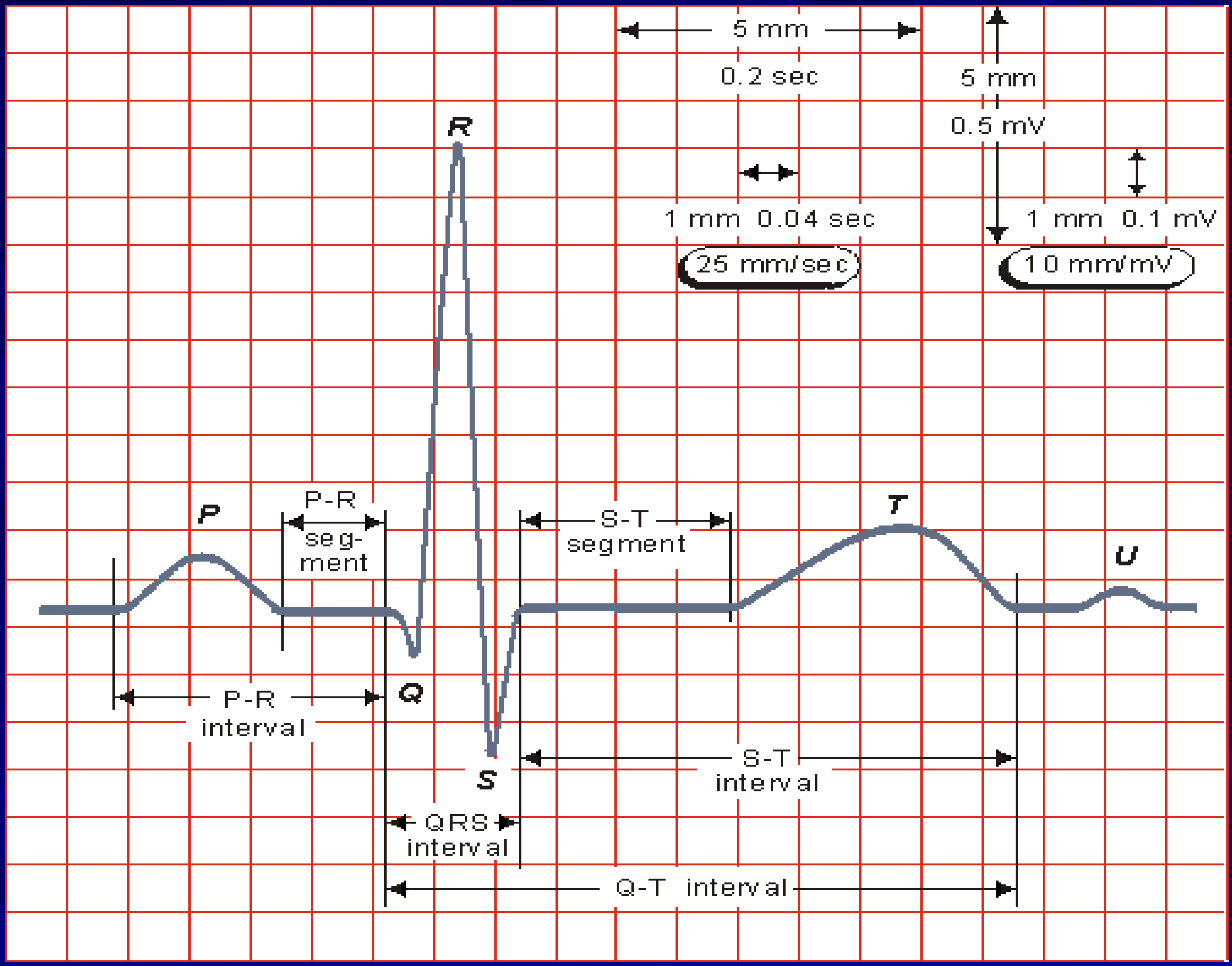
QT Interval

- Measured from beginning of QRS to the end of the T wave
- Normal QT is usually about 0.40 sec
- QT interval varies based on heart rate

QT Interval

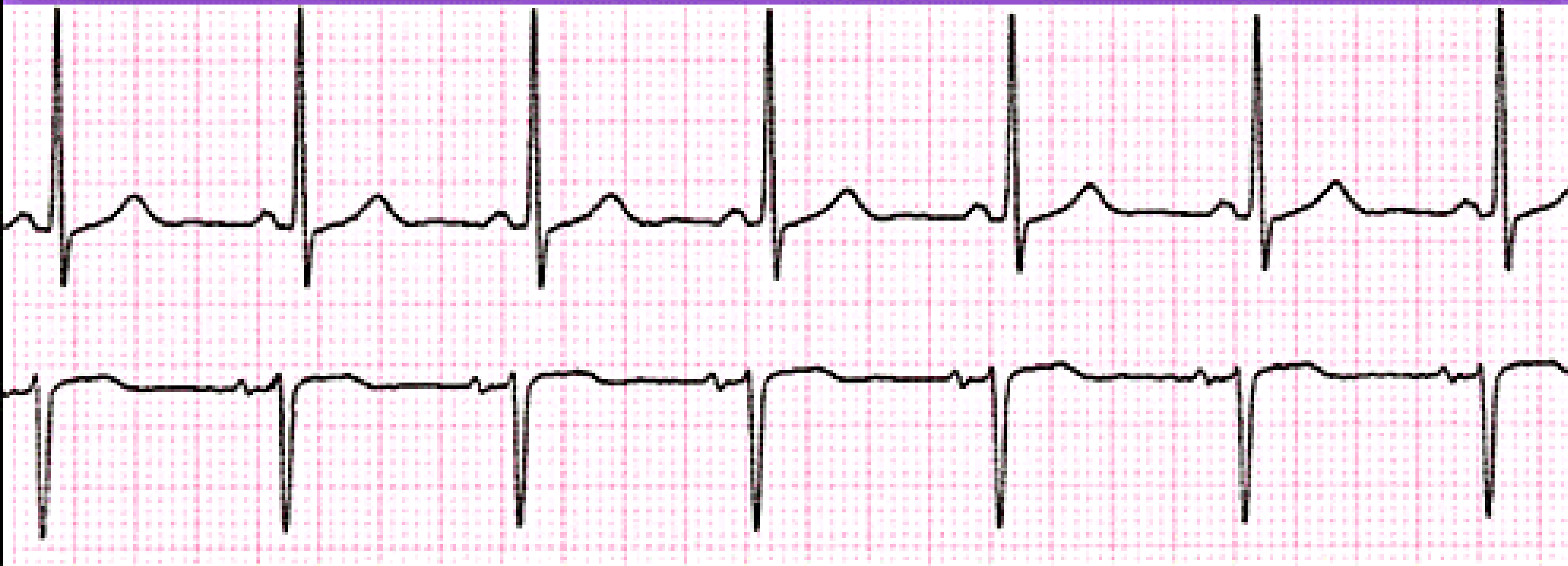
- Causes of abnormal prolongation of the QT interval include myocardial ischemia, cardiomyopathies, hypokalemia, hypocalcemia, autonomic influences, drug effects, hypothermia, and congenital long QT syndrome

The normal electrocardiogram



"Practice Strip"

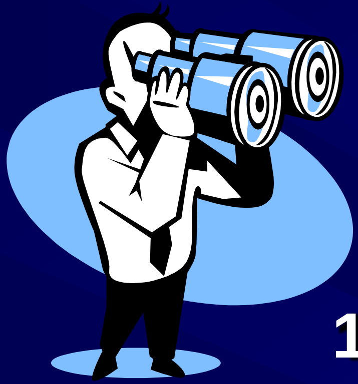
Normal Sinus Rhythm



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

EKG Tracing , 50 mm/sec …….

- Grid Paper
- Each small box = 0.02 seconds
- Each large box = 0.1 seconds (5 small boxes across)
- One second is 10 large boxes
- Three seconds is 30 large boxes
- Six seconds is 60 large boxes
- Each minute has 600 large boxes



What Do We Look For?

Interpretation of the ECG:

1. **Is the rhythm sinusal?**
2. **Is it Regular?**
3. Appreciate the **Heart rate**
4. Appreciate the electrical axis of the heart.
5. *Describe all the waves and intervals:*

- ► **P wave**
- ► **QRS Complex**
- ► **T wave**
- ► **Measure the intervals** – PQ (PR) Interval, QRS, QT

1. What is the Sinus Rhythm ?

When the electrical impulse originates in the SA Node

The rhythm is sinusal when in front of each QRS complex appears a P-wave (we look in the II lead, where is better seen). So, should be:

2. Is it Regular?

- Regularity of the cardiac rhythm is appreciated by counting the R-R intervals
- R-R intervals should be equal or not different than 0,1 sec.

3. Determining the Heart rate The formula is:

- At the speed 50 mm/sec: 600 / N
  N - number of big squares (with 5 small ones in it)

- At the speed 25 mm/sec: 300/ N
  N - number of big squares.

Why?

- Heart rate = We have to appreciate the number of heart cycles in a minute.
- A minute has 60 seconds. If we divide 60 seconds to the duration of R-R interval (period between 2 contractions) - we have heart rate.
- R-R interval = 0,1 sec x Number of big squares (if the speed 50 mm/sec).
- So 60/ R-R = 60 / 0,1 x N = 600 / N.

If the speed = 25 mm/sec:

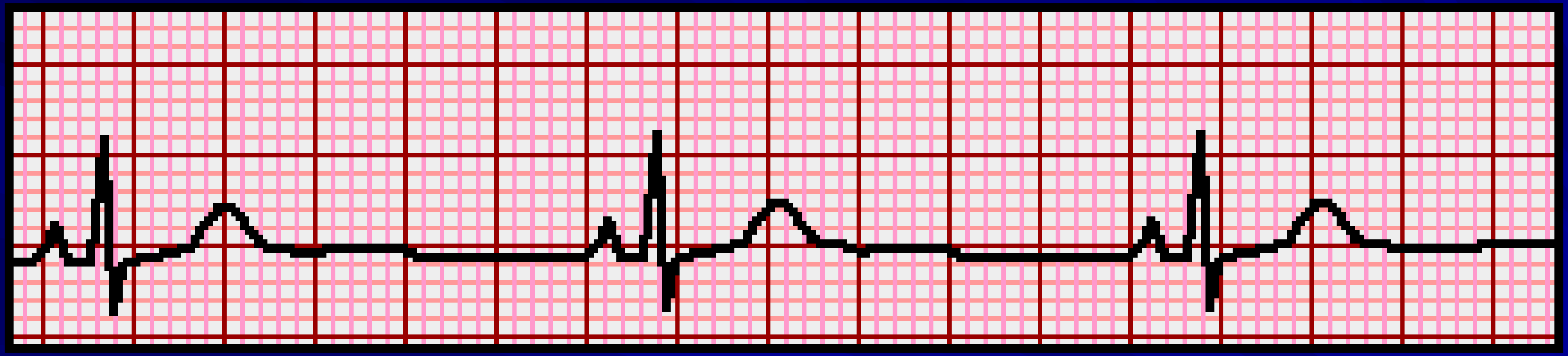
- 60/ R-R = 60 / 0,2 x N = 300 / N.

So, rule of 300 (speed 25 mm/sec)

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.

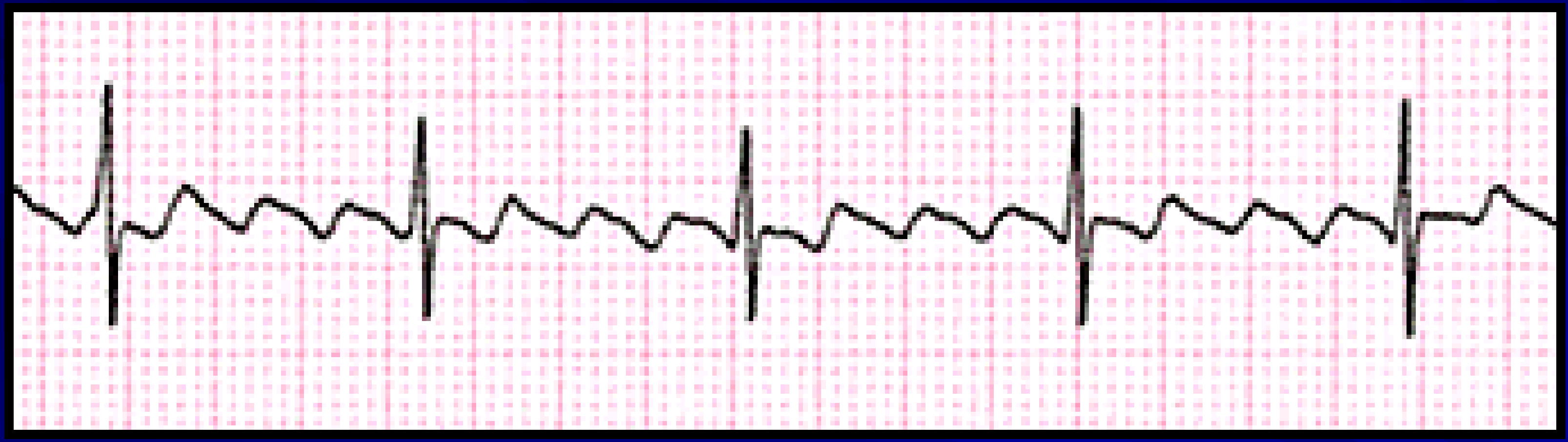
What is the heart rate?



www.uptodate.com

(300 / 6) = 50 bpm

What is the heart rate?



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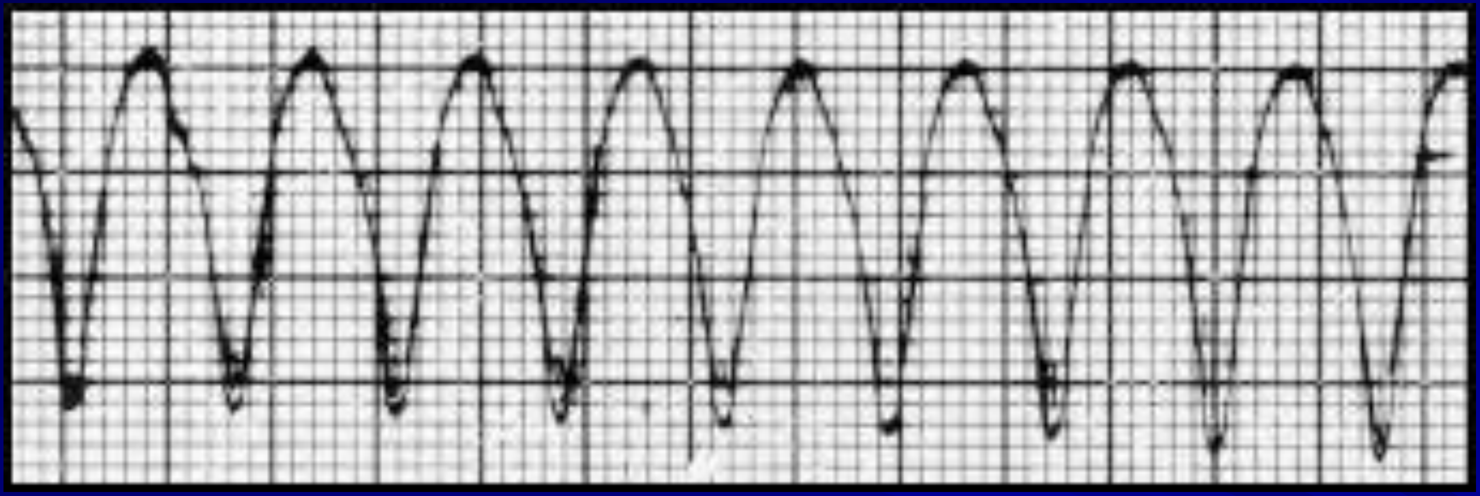
(300 / ~ 4) = ~ 75 bpm

What is the heart rate?



(300 / 1.5) = 200 bpm

4. Determining of the electrical axis of the heart (EAH)

The QRS axis represents the net overall direction of the heart’s electrical activity.

Abnormalities of axis can hint at:

- Ventricular enlargement
- Conduction blocks (i.e. hemiblocks)

EAH

We must look at the height of the R wave in standard leads (R1, R2, R3). If the height of the R wave is the following:

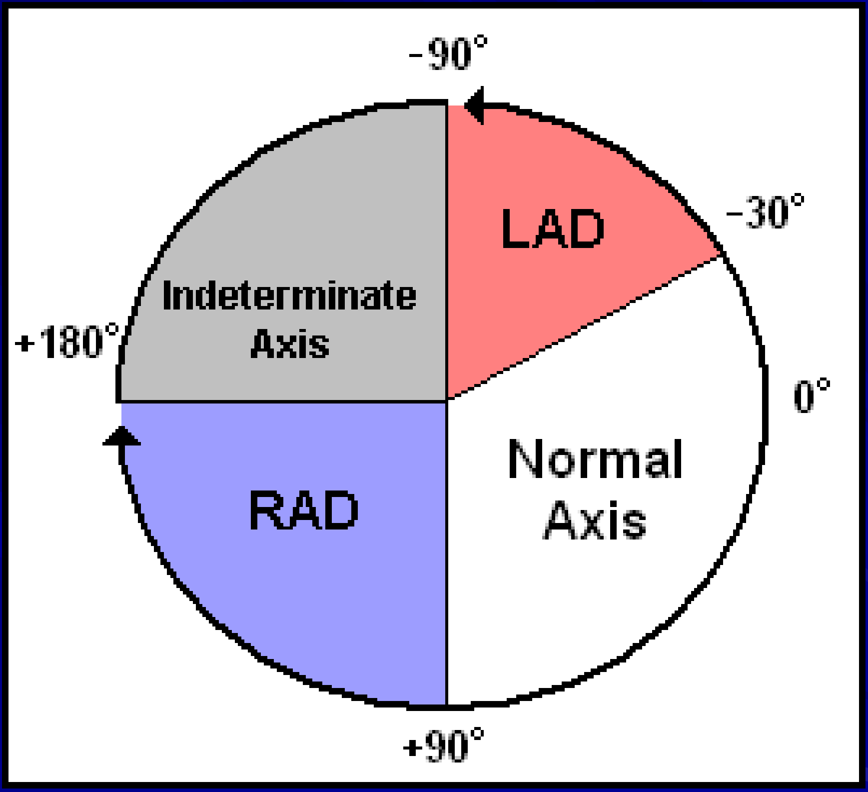
- R2 > R1> R3 – the electrical axis is normal;
- if we have : R1>R2>R3 - the axis is horizontal or turned to left;
- R2>R3>R1 - the axis is vertical;
- R3>R2>R1 - the axis is turned to right

EAH

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)

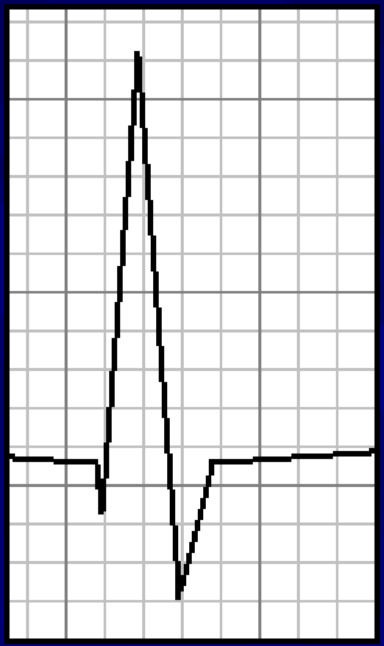
+90° to +180° is referred to as a right axis deviation (RAD)



Determining the Axis

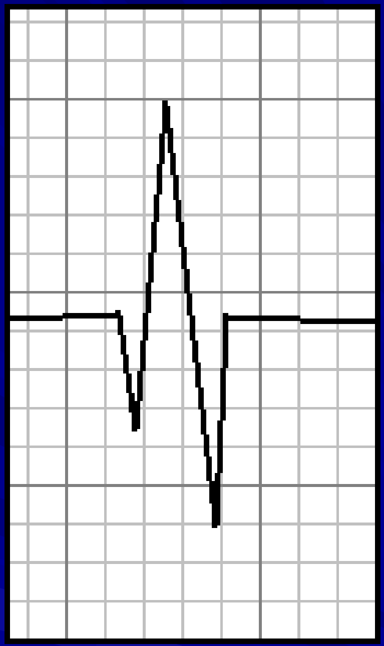
- The Quadrant Approach
- The Equiphasic Approach

Determining the Axis



Predominantly
Positive

Predominantly
Negative



Equiphasic

The Quadrant Approach

1. Examine the QRS complex in leads I and aVF to determine if they are predominantly positive or predominantly negative.
2. 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

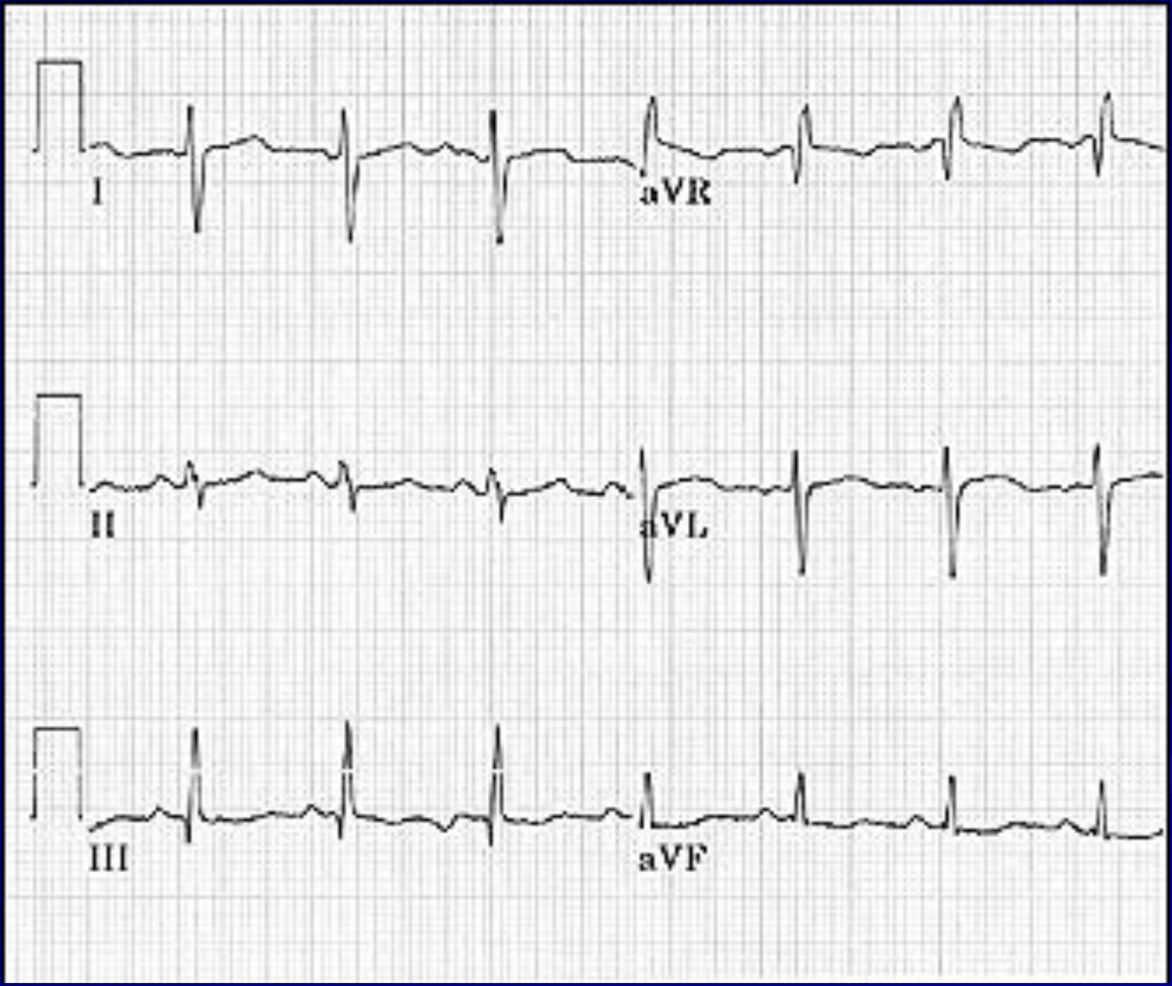
The Quadrant Approach

2. In the case that LAD is present, examine lead II to determine if this deviation is pathologic.

If the QRS in II lead is predominantly positive, the LAD is non-pathologic (in other words, the axis is horizontal). If it is predominantly negative, it is pathologic LAD.

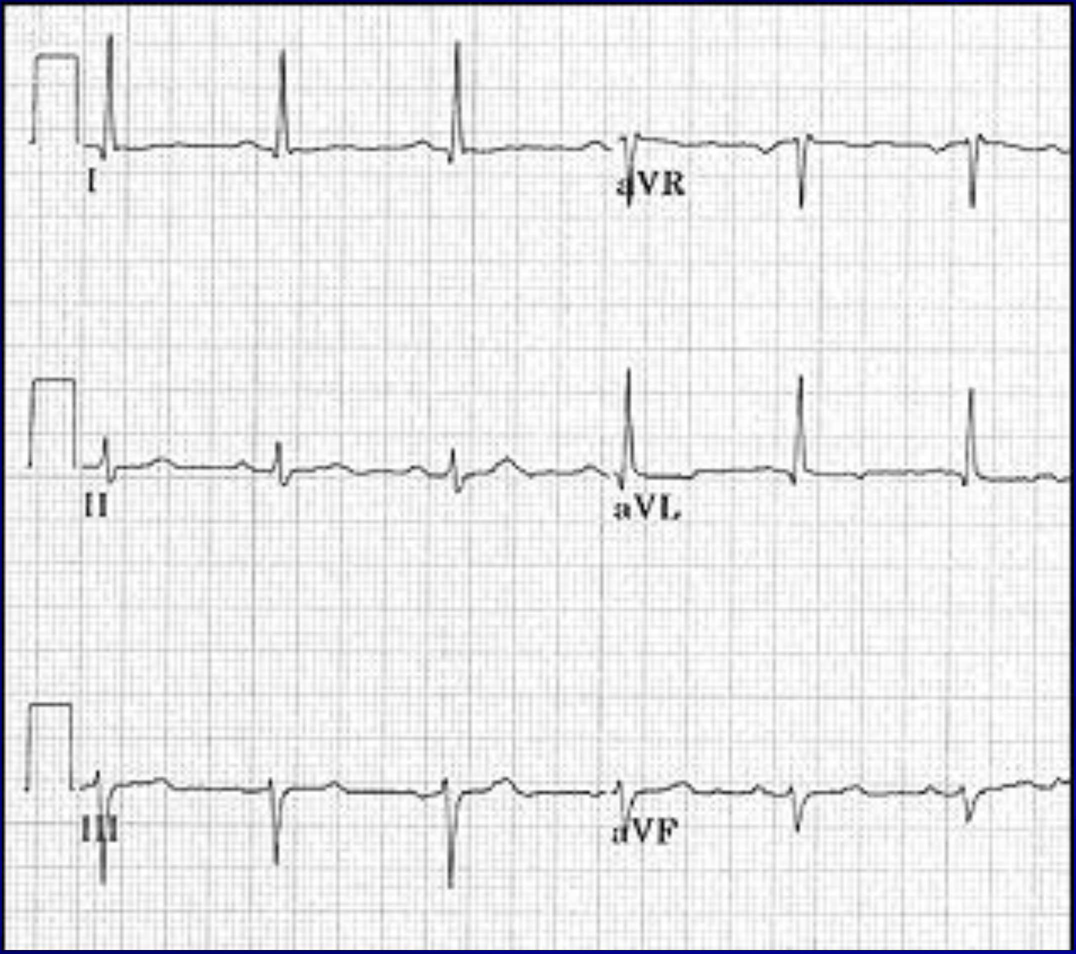
		Lead aVF	
		Positive	Negative
Lead I	Positive	Normal Axis	LAD
	Negative	RAD	Indeterminate Axis

Quadrant Approach: Example 1



Negative in I, positive in aVF → RAD

Quadrant Approach: Example 2



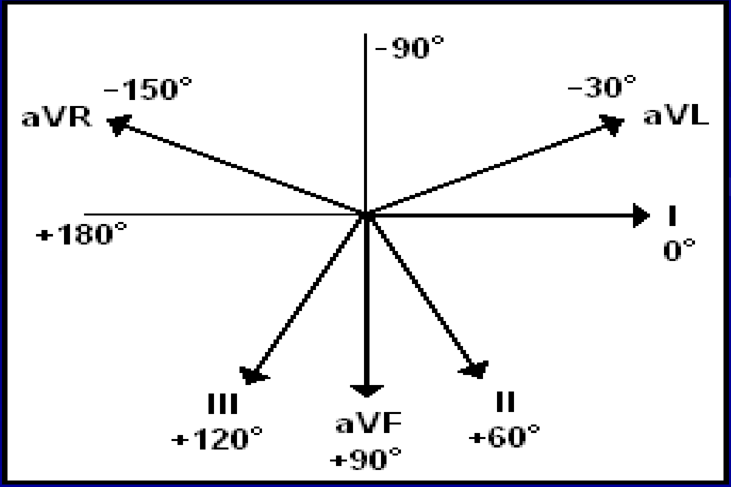
Positive in I, negative in aVF → Predominantly positive in II →

Normal Axis (non-pathologic LAD)

The Equiphasic Approach

Step 1. Determine which lead contains the most equiphasic QRS complex.

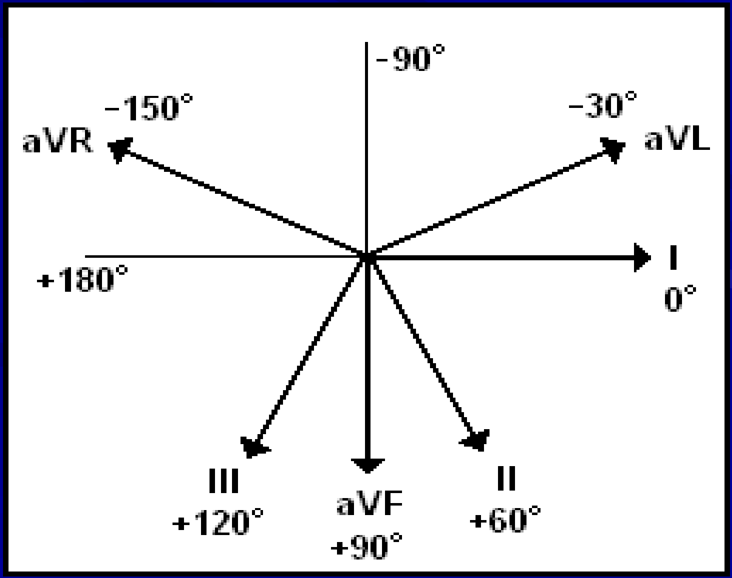
- The fact that the QRS complex in this lead is equally positive and negative indicates that the net electrical vector (i.e. overall QRS axis) is perpendicular to the axis of this particular lead.



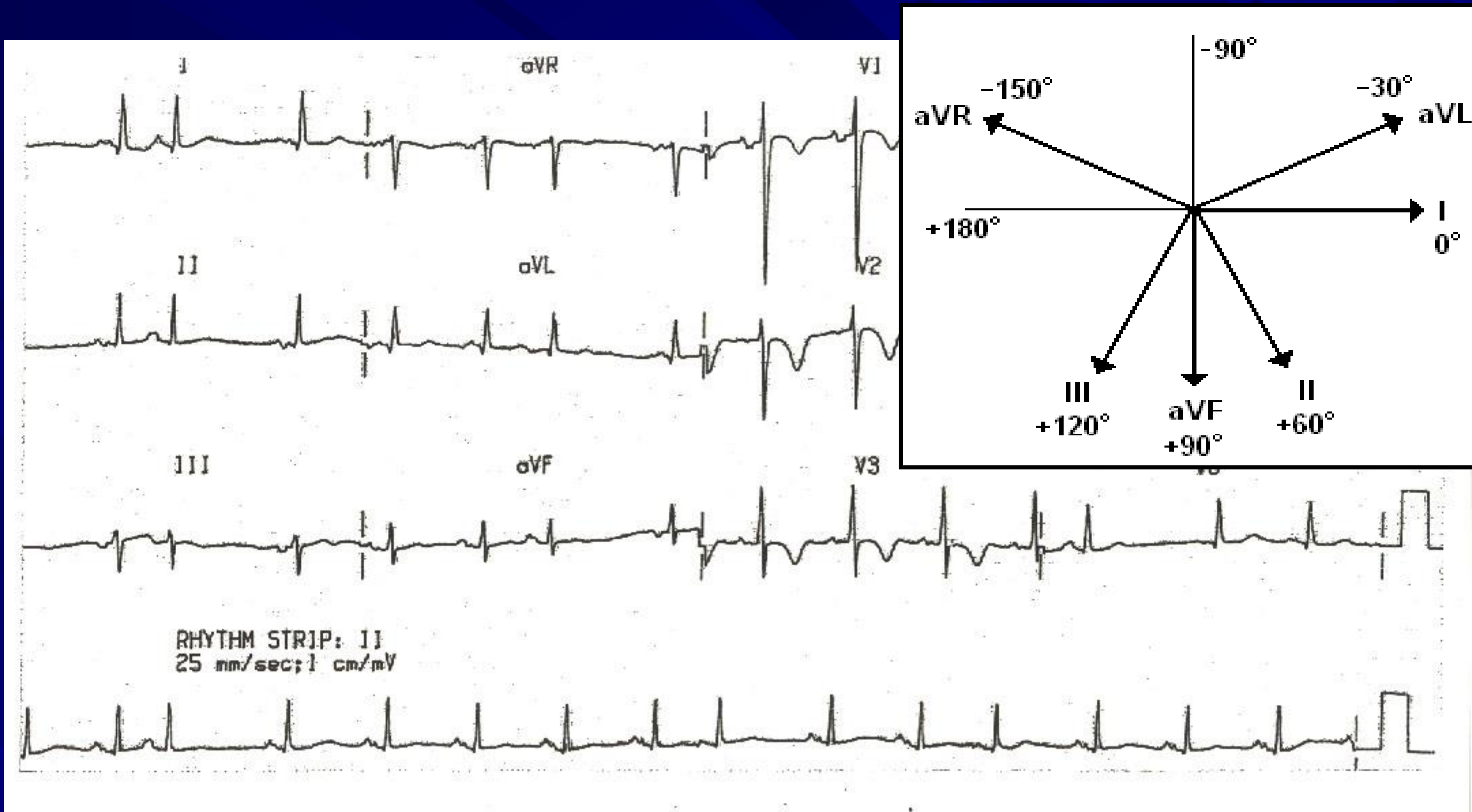
Step 2. Examine the QRS complex in whichever lead lies 90° away from the lead identified in step 1.

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.



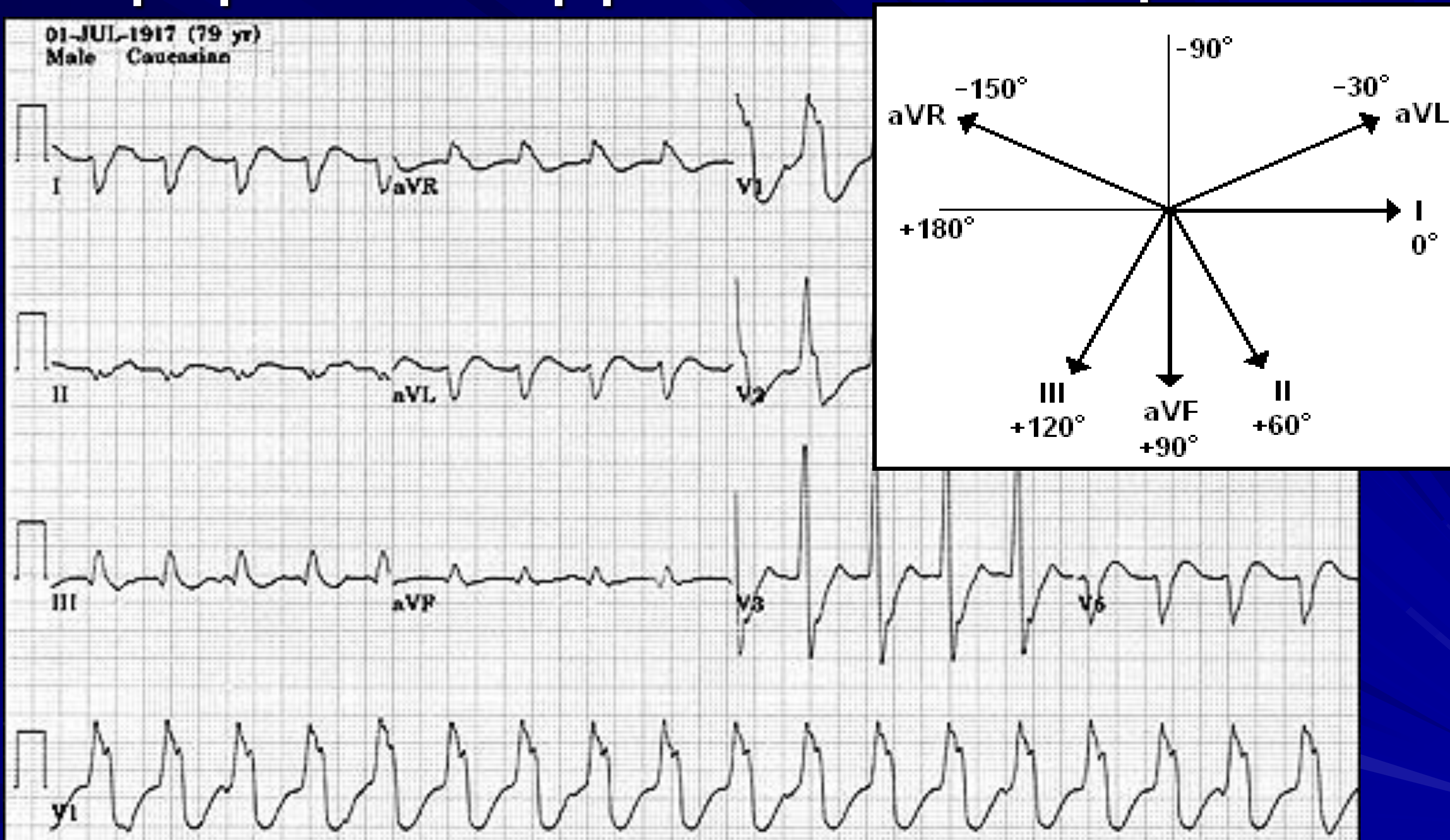
Equiphasic Approach: Example 1



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

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°

5. Describe all the waves and intervals:

- We must determine the length and size of ECG elements - P-wave, P-Q interval, QRS complex, ST interval , T-wave.

Characterize the ECG elements:

- **P wave,**
- **PQ interval**
- **QRS complex,**
- **St segment**
- **T waves .**

Normal ECG :

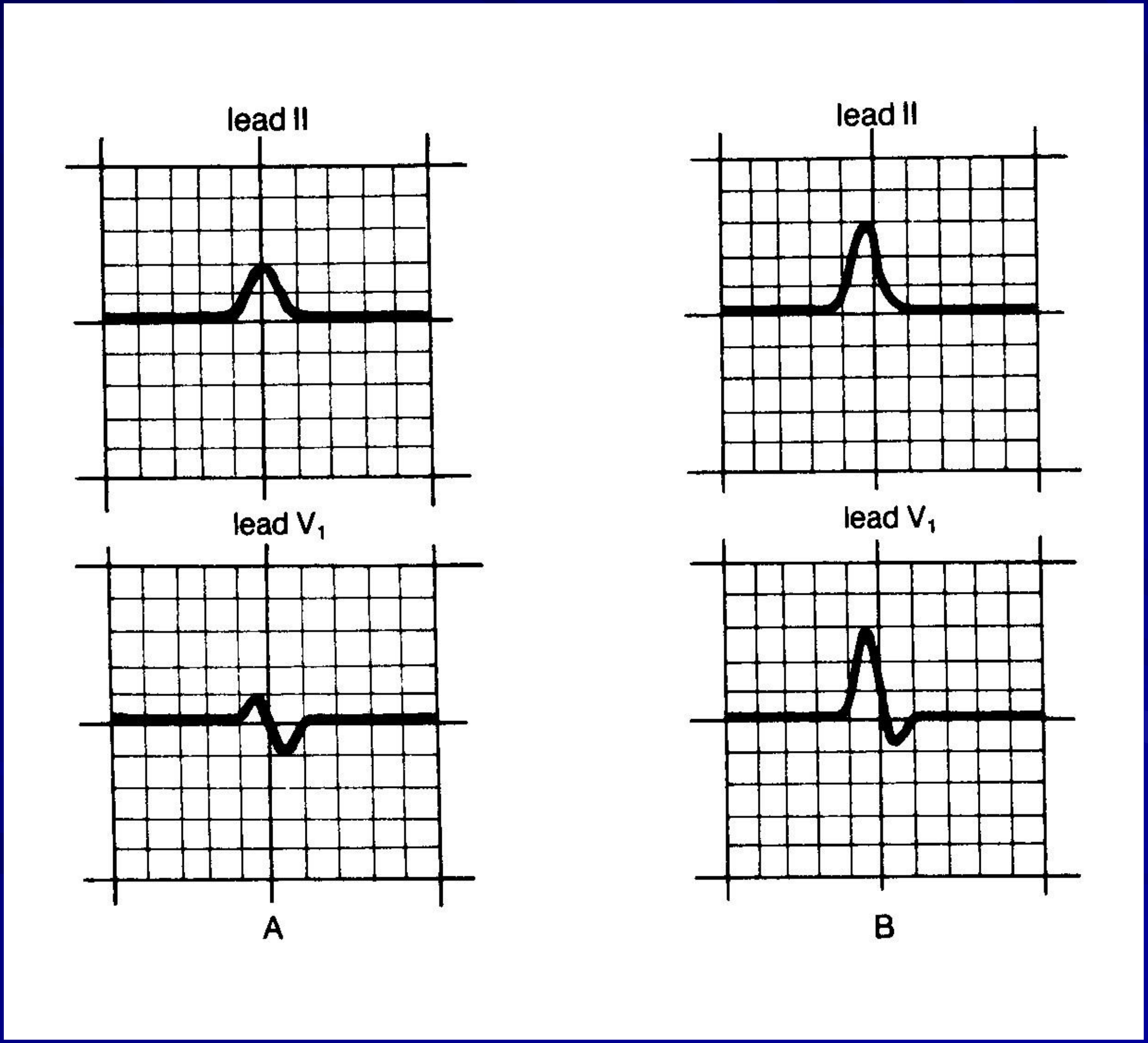
- A normal heartbeat originates in the upper chambers of the heart (atria) – sinusal rrhythm.
- The heart rate (usually between 60 and 100 beats per minute) and rhythm appear regular.
- P waves, QRS complexes, T waves appear normal.
- ST segments are not elevated above or depressed below the baseline of the EKG tracing.

Abnormalities in ECG components

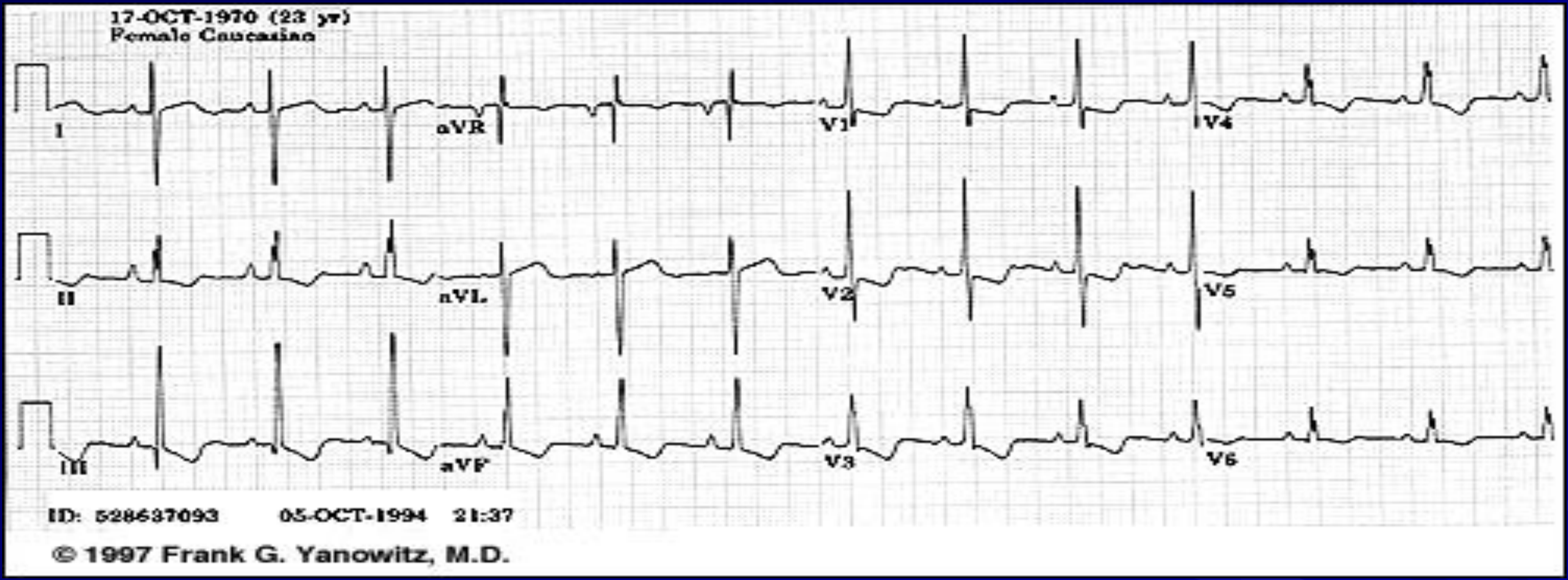
Right Atrial Hypertrophy

- P waves peaked > 2,5 mm in leads II, III, and aVF.
- It is called “P pulmonale”, because it is often met in cor pulmonare.

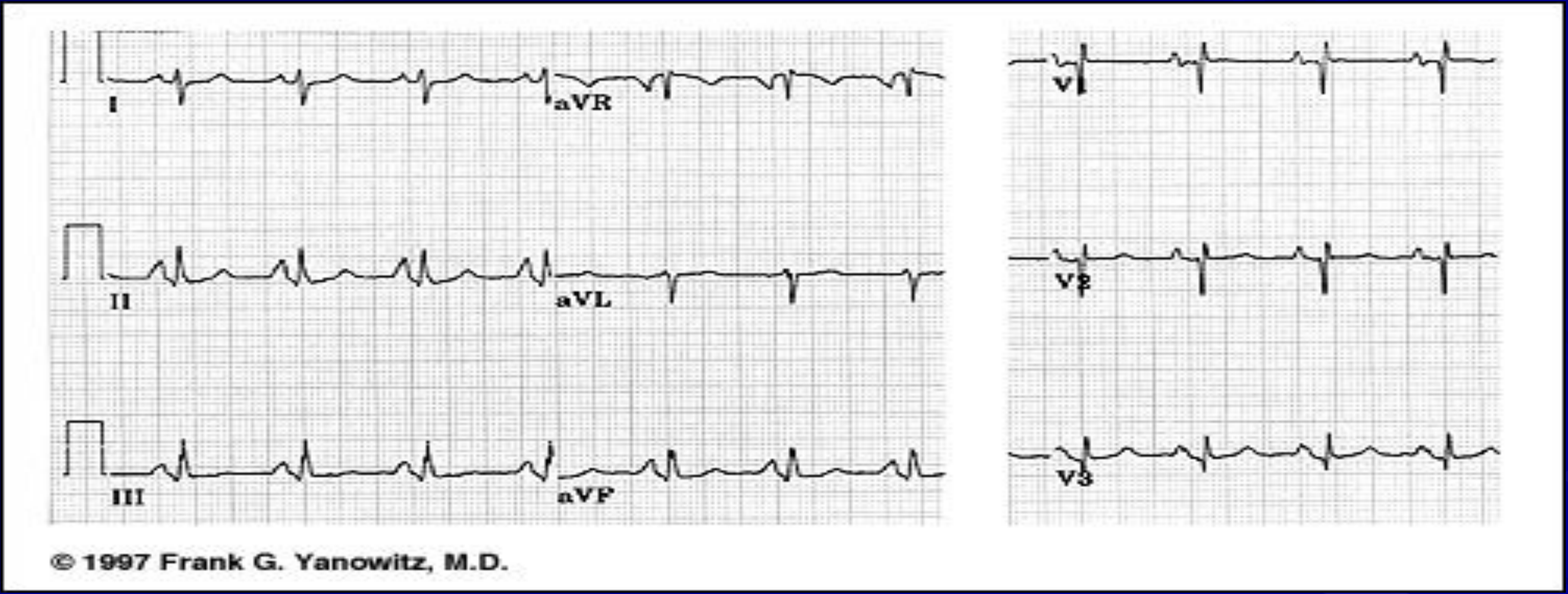
Right Atrial Enlargement



Right Atrial Hypertrophy



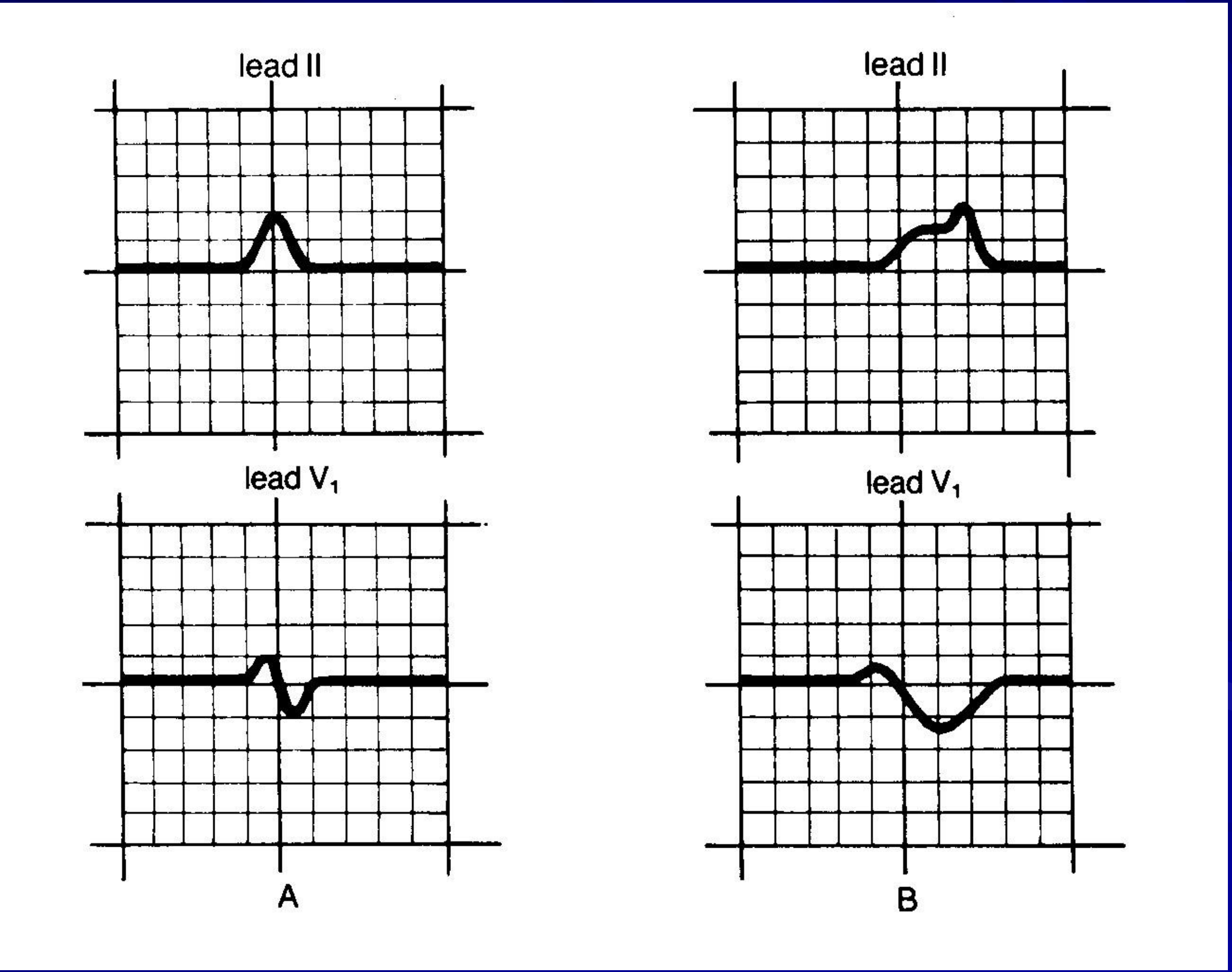
Right Atrial Hypertrophy



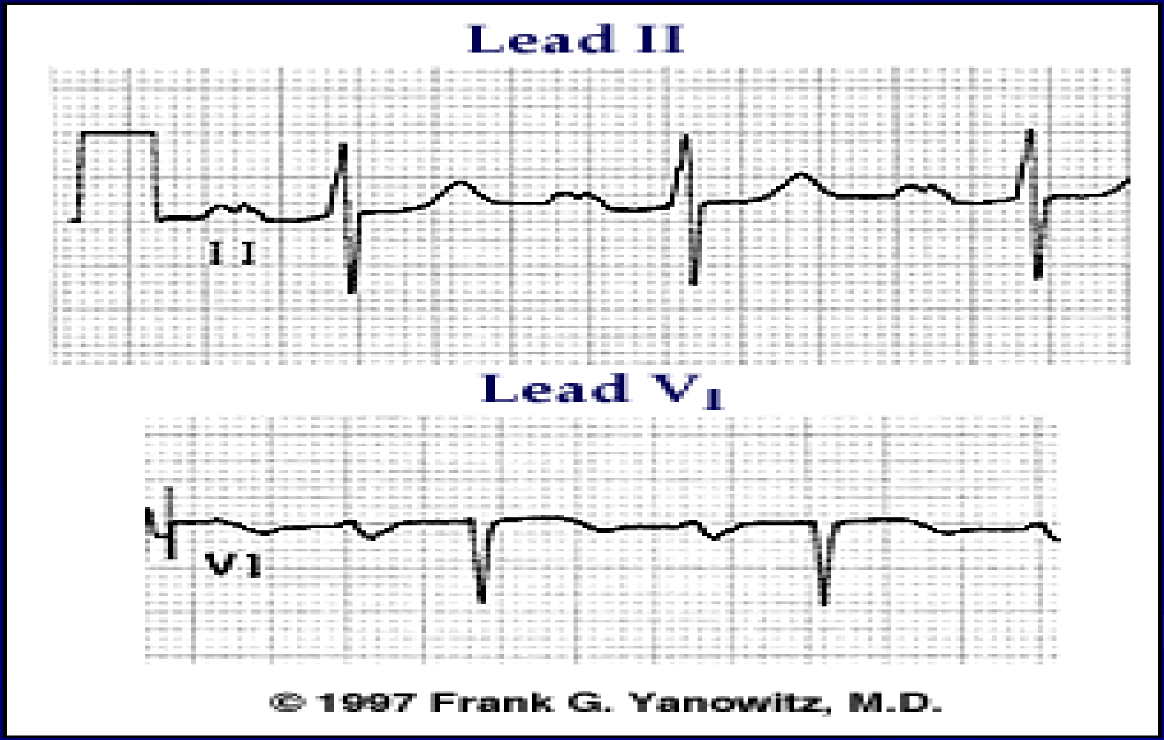
Left Atrial Hypertrophy

- a notched P wave with a duration > 0,1 seconds (usually 0.12 second).
- It is called P mitrale; it may be two-humpbached (it has two humps) ;
- is best observed in leads II and V1.

Left Atrial Enlargement



Left Atrial Enlargement



Right Ventricular Hypertrophy (RVH)

- Tall R wave in V1 (R wave taller than S wave)
- R wave in V1-V2 > 7 mm
- Right Axis Deviation and deep S wave in left precordial leads.
- Signs of RBBB

Occurs with pulmonary valve disease, primary or secondary pulmonary hypertension or various congenital lesions resulting in either volume or pressure overload of the right ventricle.

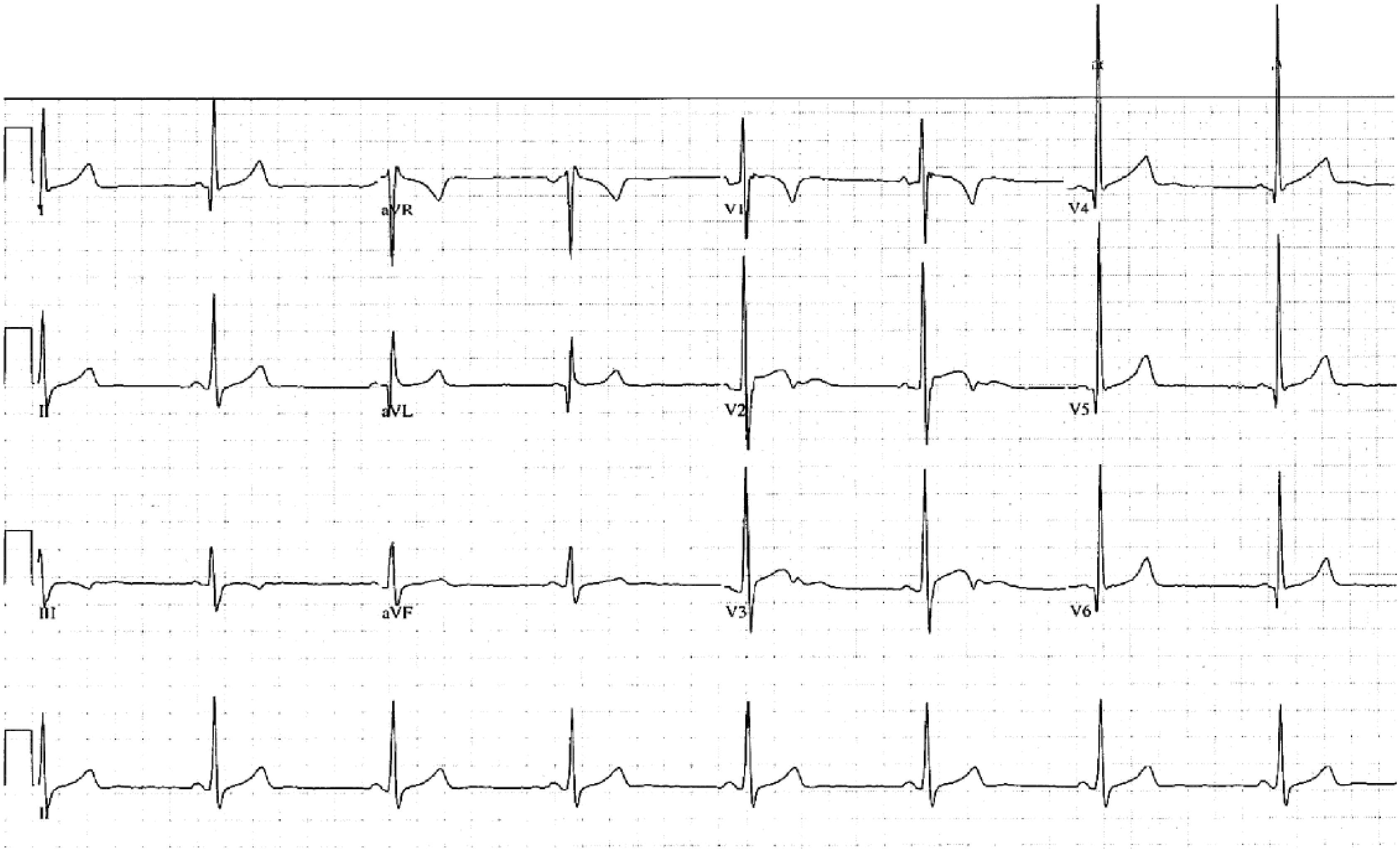
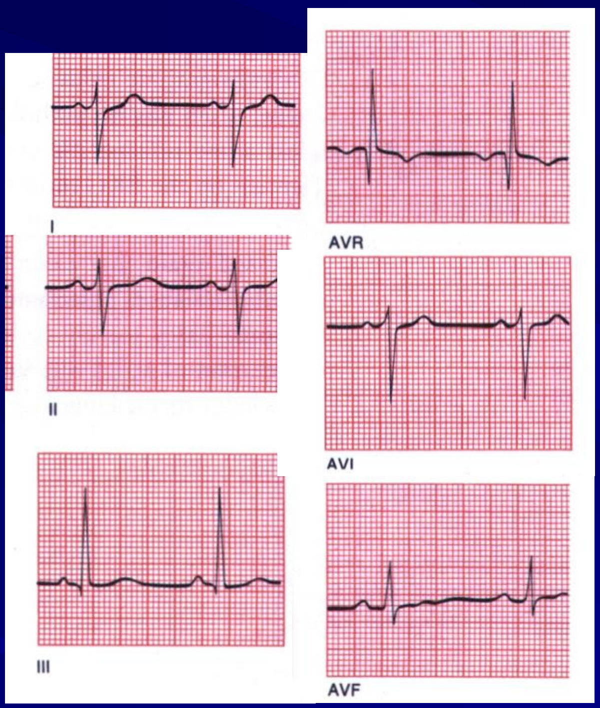


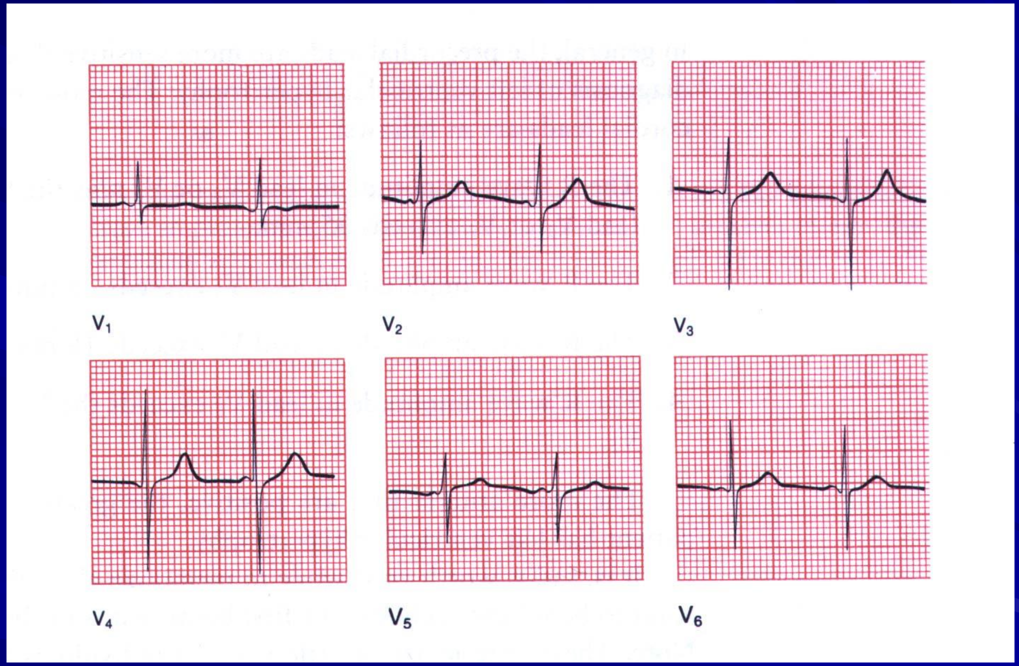
Fig. 6 Hypertrophic cardiomyopathy. Note the prominent RS wave in leads V_1 and V_2 as well as the lateral Q waves. This ECG was

RV Ventricular Hypertrophy

Limb Leads



Precordial Leads

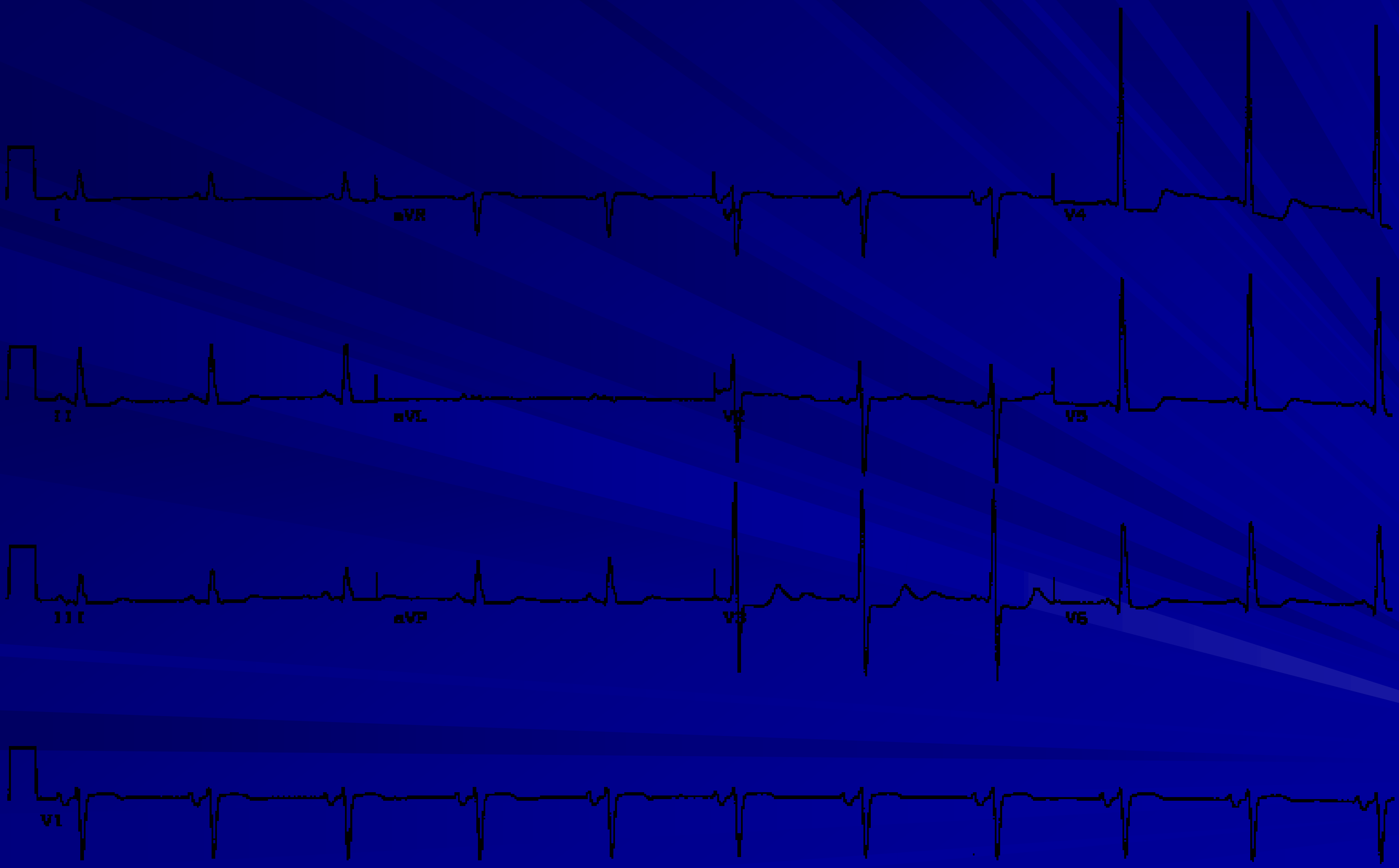


Left Ventricular Hypertrophy

- R wave in I and S wave in III > 15 mm, or
- R wave in V_5 or V_6 + S wave in V_1 or V_2 > 35 mm ($RV_{5-6} + SV_{1-2} > 35$ mm)
- R wave in V_5 or V_6 > 25 mm
- R wave in AVL > 11 mm
- Left Axis Deviation and deep S wave in left precordial leads.
- Also see ST and T wave shift opposite to the R wave (in absence of digitalis effect) and LAE and LAD.

Occurs with systemic hypertension, aortic valve disease , conditions resulting in pressure or volume overload of the left ventricle.

Left Ventricular Hypertrophy



Ventricular Hypertrophy 2

Precordials

S wave

R exceeding 18mm

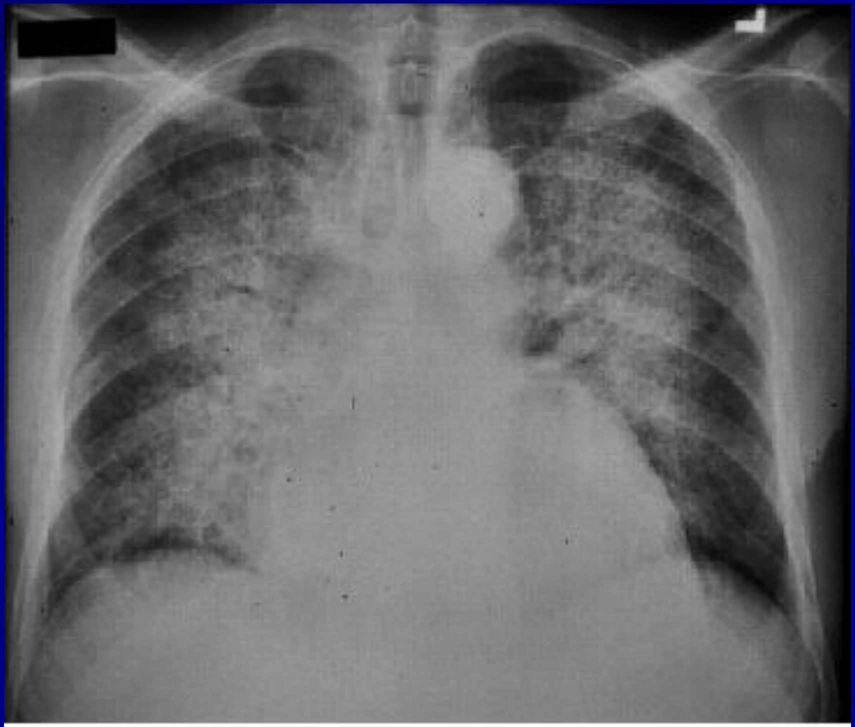
R exceeding 26mm

Like in Music, with the EKG

only Practice Makes Perfect

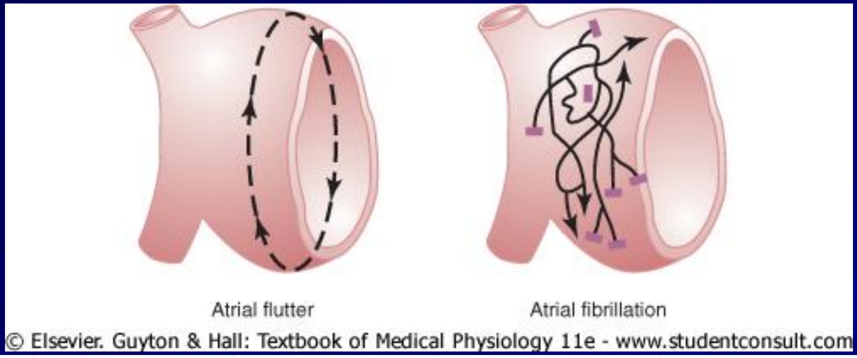
Chest X-ray

- Pulmonary Edema
- Venous congestion
- Enlarged Cardiac Silhouette
- R/O PE



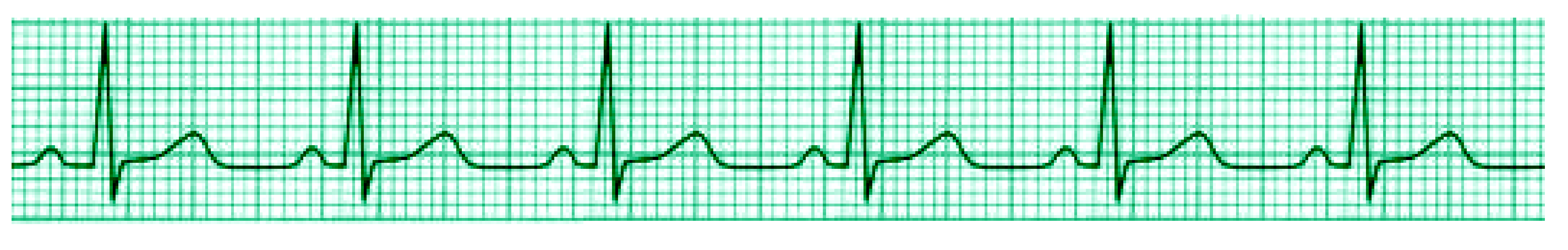
Cardiogenic pulmonary edema Pulmonary edema in a " butterfly distribution" due to left ventricular failure. Chest radiograph shows large perihilar opacities in patient with enlarged cardiac silhouette. Courtesy of Paul Stark, MD.

Atrial Flutter

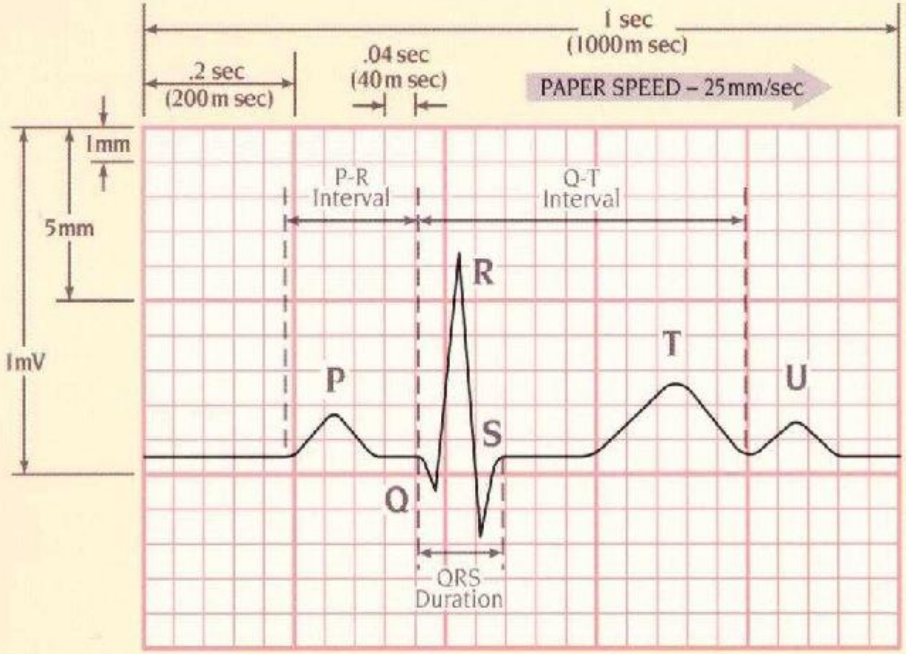


F wave

Normal EKG



EKG Standards and Intervals

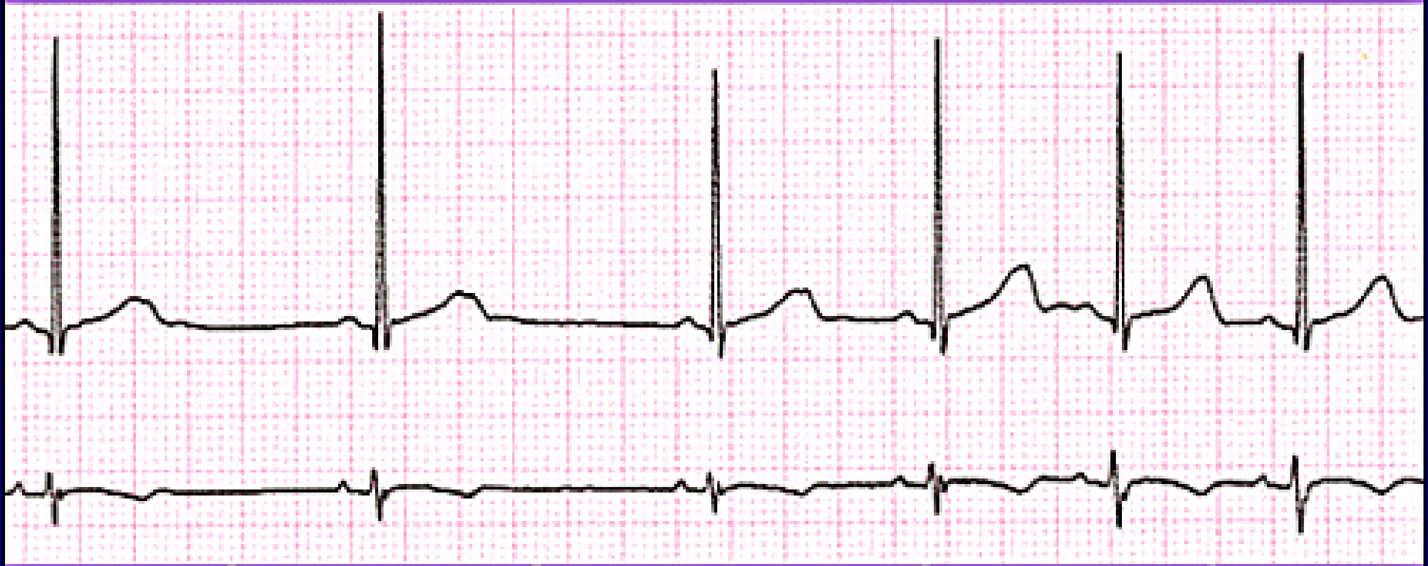


VERTICAL AXIS	
	1 Small Square = 1mm (0.1mV)
	1 Large Square = 5mm (0.5mV)
	2 Large Squares = 1mV

HORIZONTAL AXIS	
	1 Small Square = .04 sec (40 m sec)
	1 Large Square = .2 sec (200 m sec)
	5 Large Squares = 1 sec (1000 m sec)

Sinus Arrhythmia

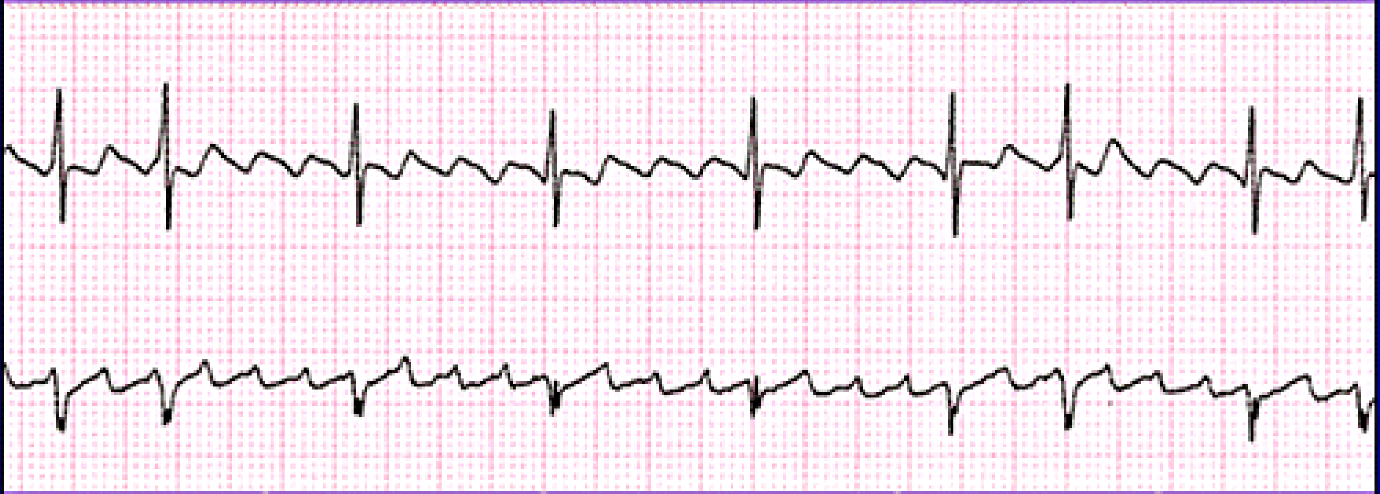
Sinus Arrhythmia



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

Atrial Flutter

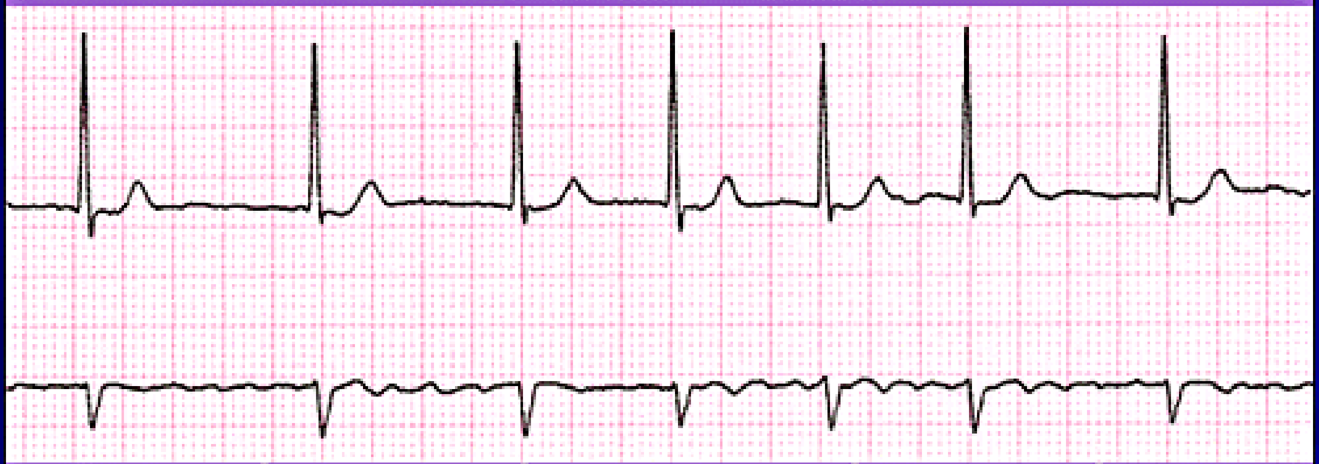
Atrial Flutter



Heart Rate	Rhythm	P Wave	PR interval (in seconds)	QRS (in seconds)
A: 220-430 bpm V: <300 bpm	Regular or variable	Sawtoothed appearance	N/A	<.12

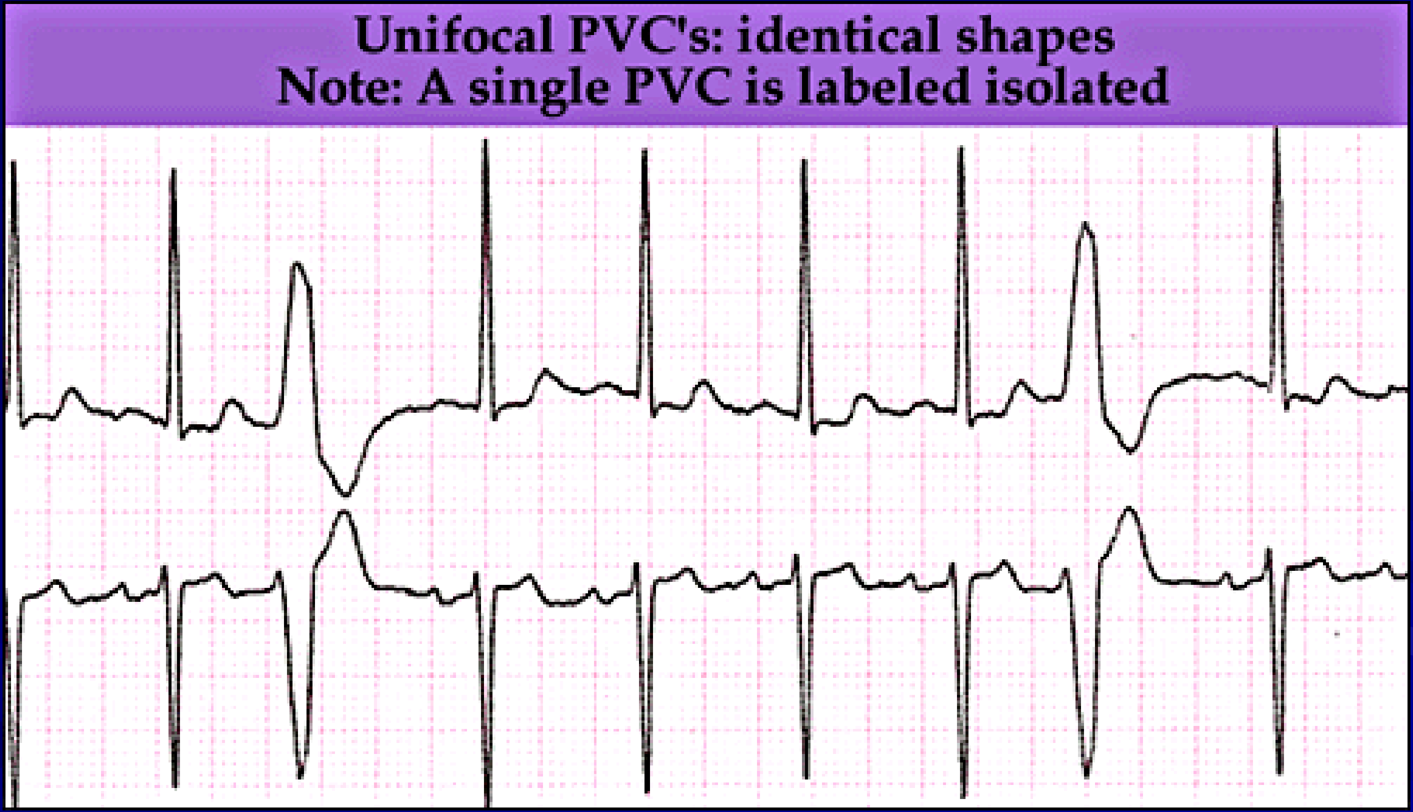
Atrial Fibrillation

Atrial Fibrillation



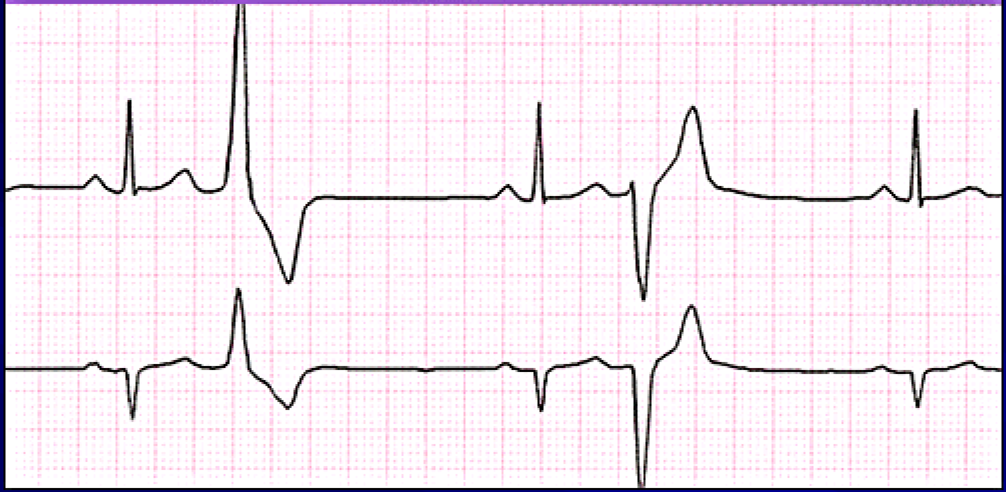
Heart Rate	Rhythm	P Wave	PR interval (in seconds)	QRS (in seconds)
A: 350-650 bpm V: Slow to rapid	Irregular	Fibrillatory (fine to course)	N/A	<.12

Premature Ventricular Contraction



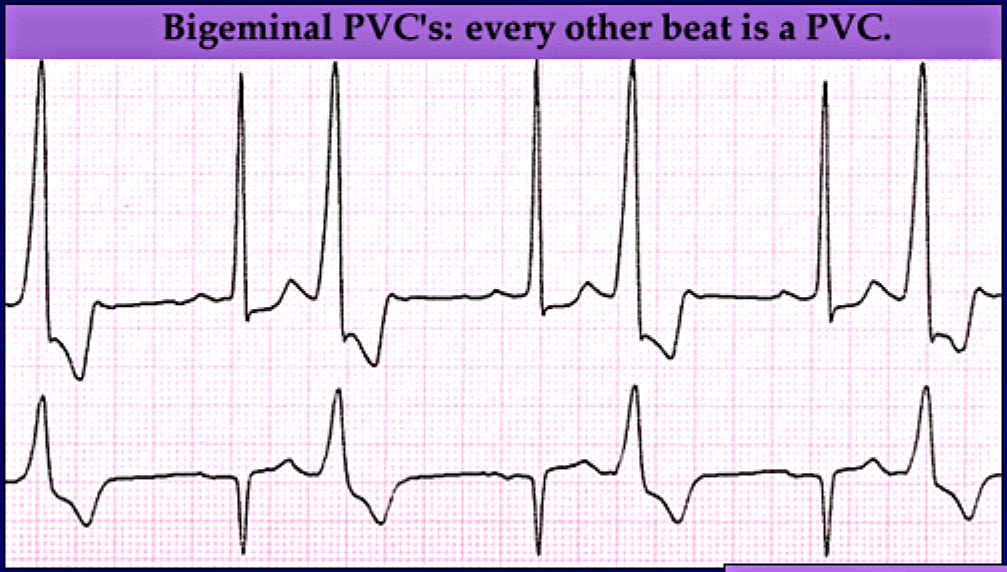
Premature Ventricular Contraction

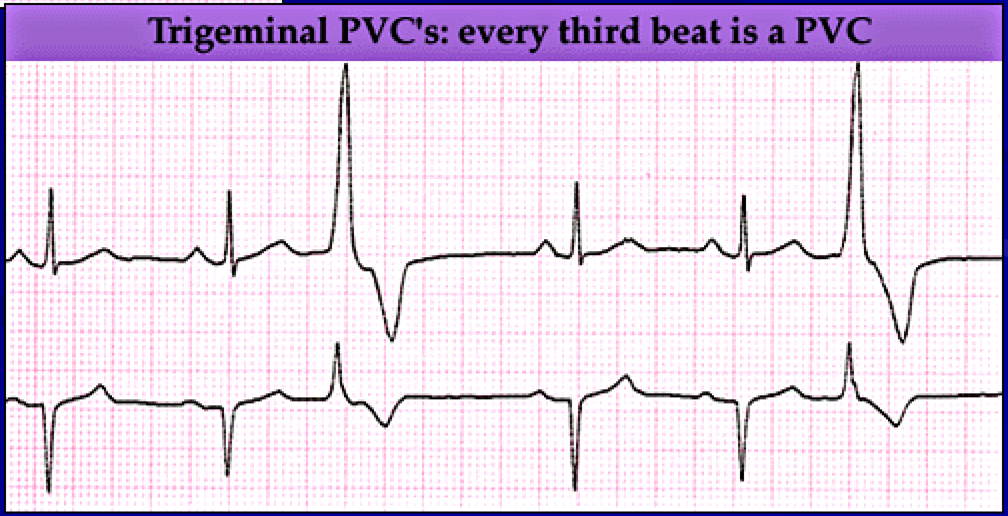
Multifocal PVC's: more than one shape



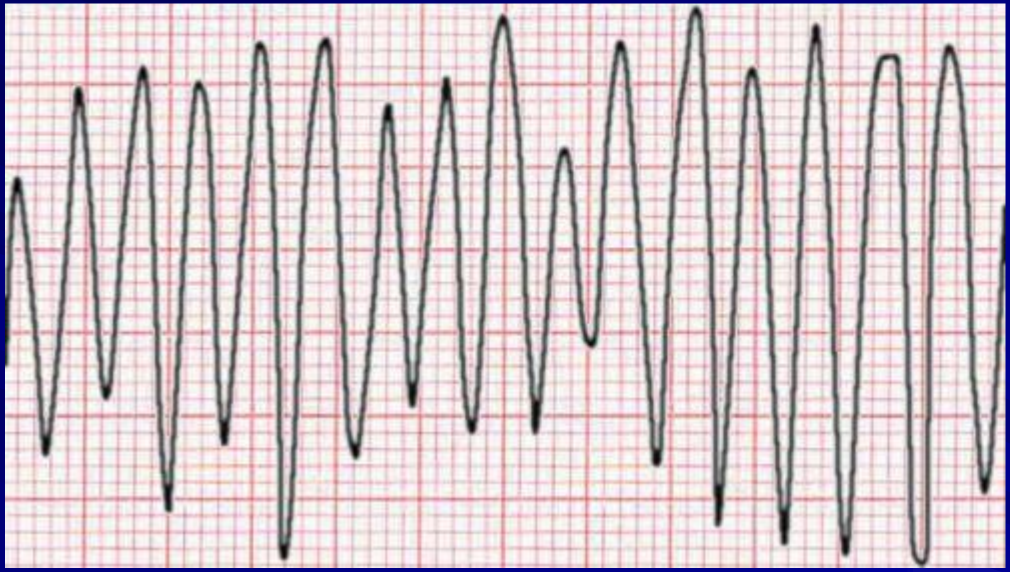
Triplet PVC's: occur in groups of three

_____geminy


Bigeminal PVC's: every other beat is a PVC.

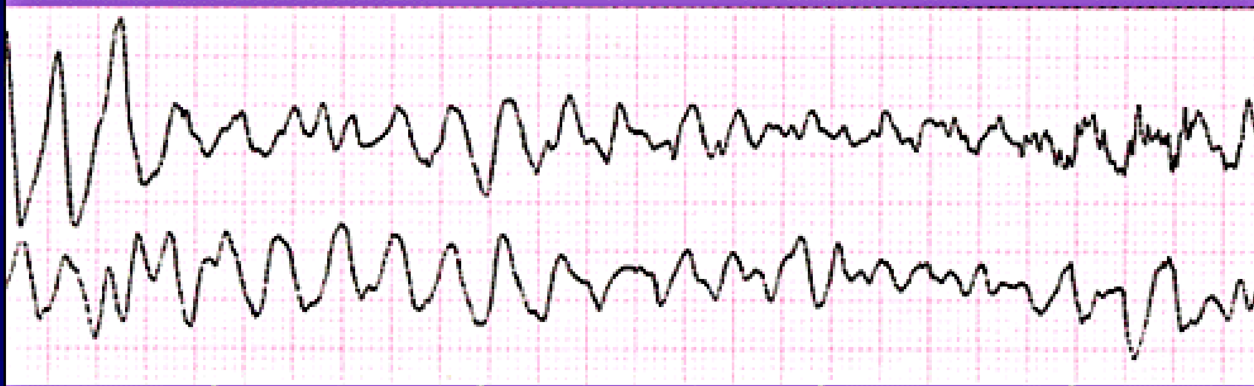

Trigeminal PVC's: every third beat is a PVC

Ventricular Flutter



Ventricular Fibrillation

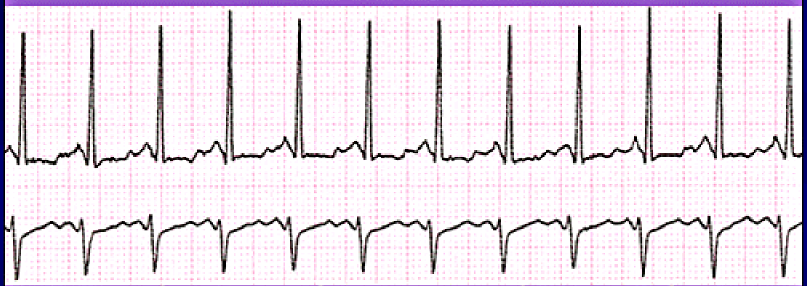
Ventricular Fibrillation



Heart Rate	Rhythm	P Wave	PR interval (in seconds)	QRS (in seconds)
300-600	Extremely irregular	Absent	N/A	Fibrillatory baseline

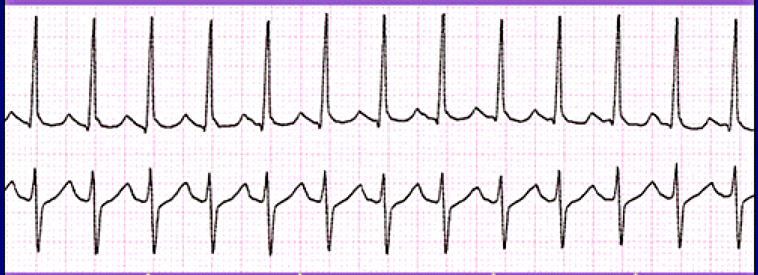
Tachycardia (supraventricular)

Sinus Tachycardia



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

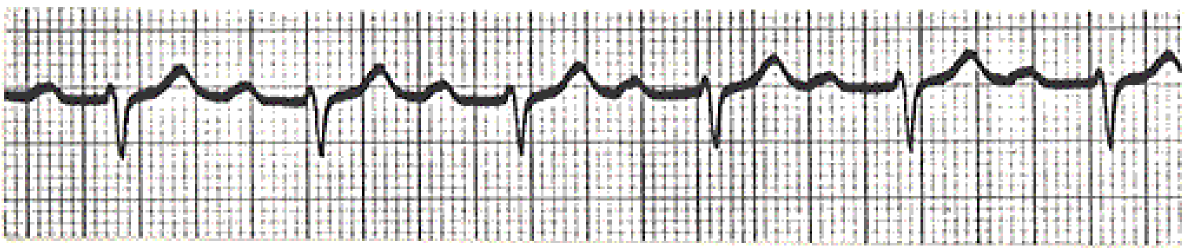
Atrial Tachycardia



Heart Rate	Rhythm	P Wave	PR interval (in seconds)	QRS (in seconds)
140-250 bpm	Regular	Abnormal P before each QRS (difficult to see)	<.20	<.12

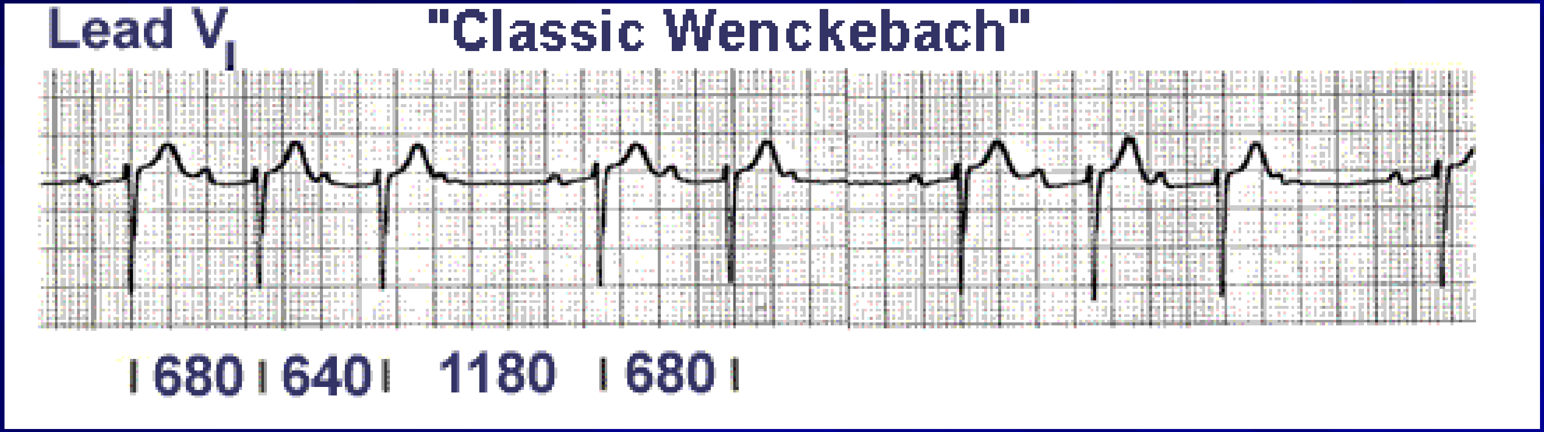
Junctional Tachycardia

First Degree AV Block

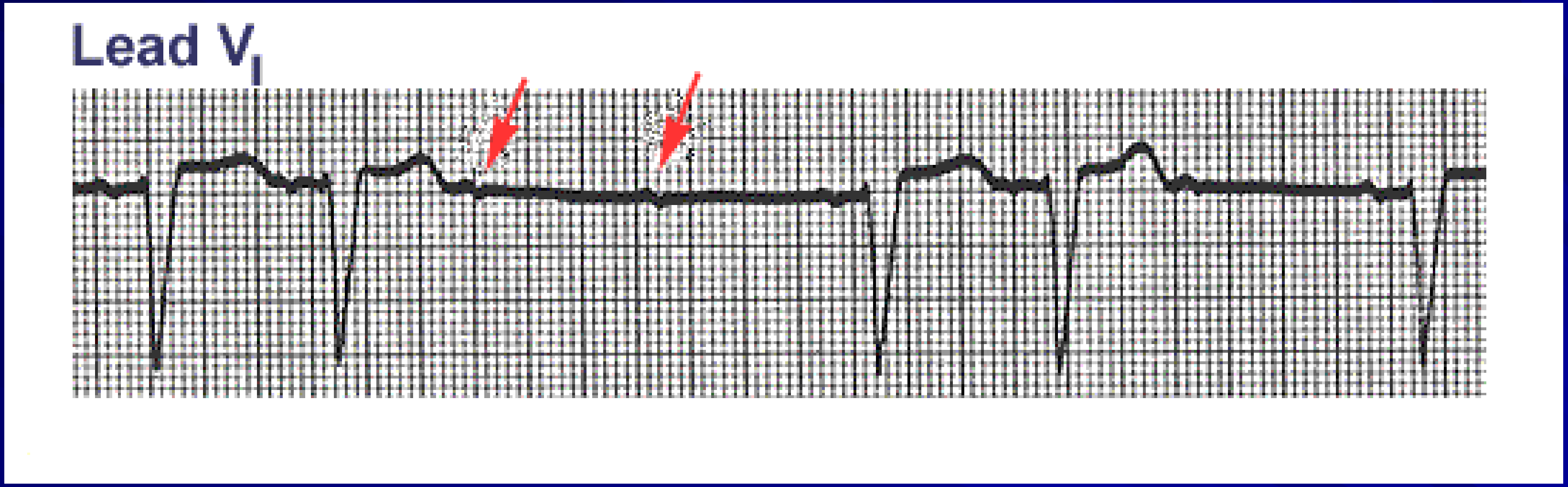


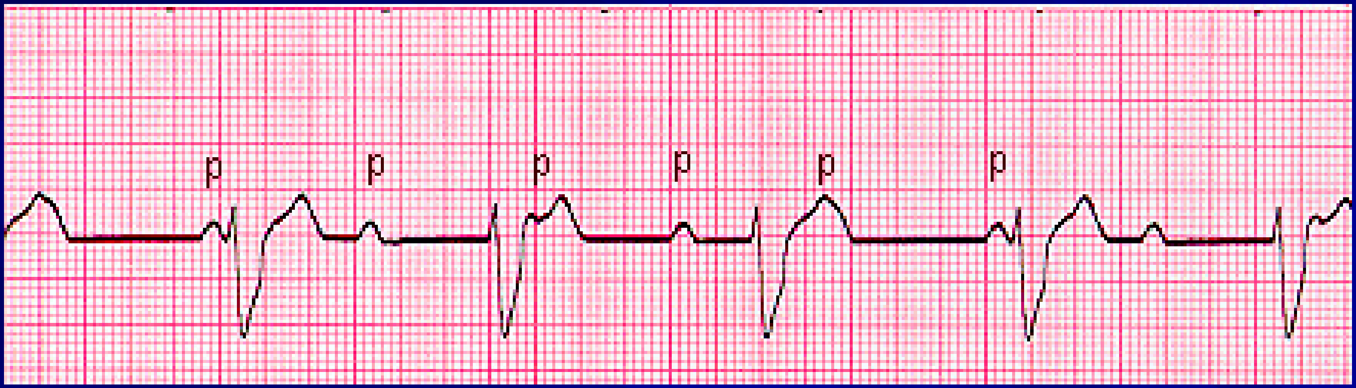
1st degree AV block (PR = 280 ms)

Second Degree AV Block Mobitz I (Wenckebach)



Second Degree AV Block Mobitz II

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