EKG LAB

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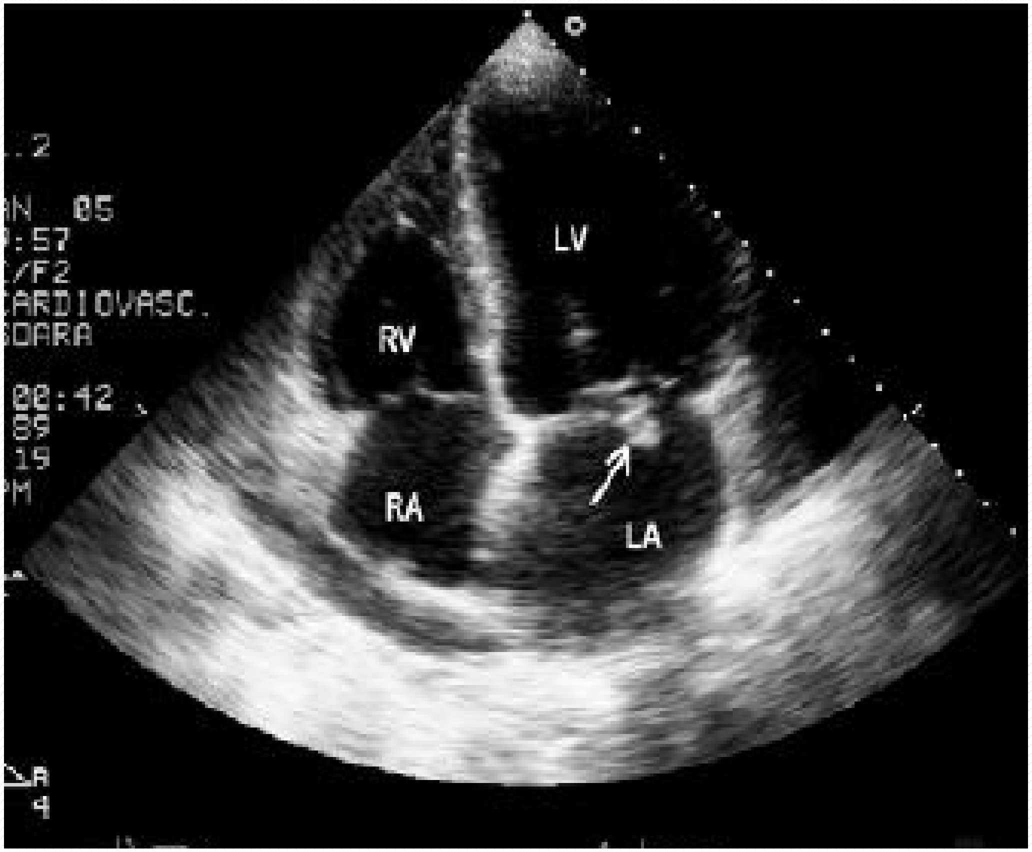
Echocardiography (ECHO)

- Noninvasive ultrasound test
- Used to examine size, shape and motion of heart structures

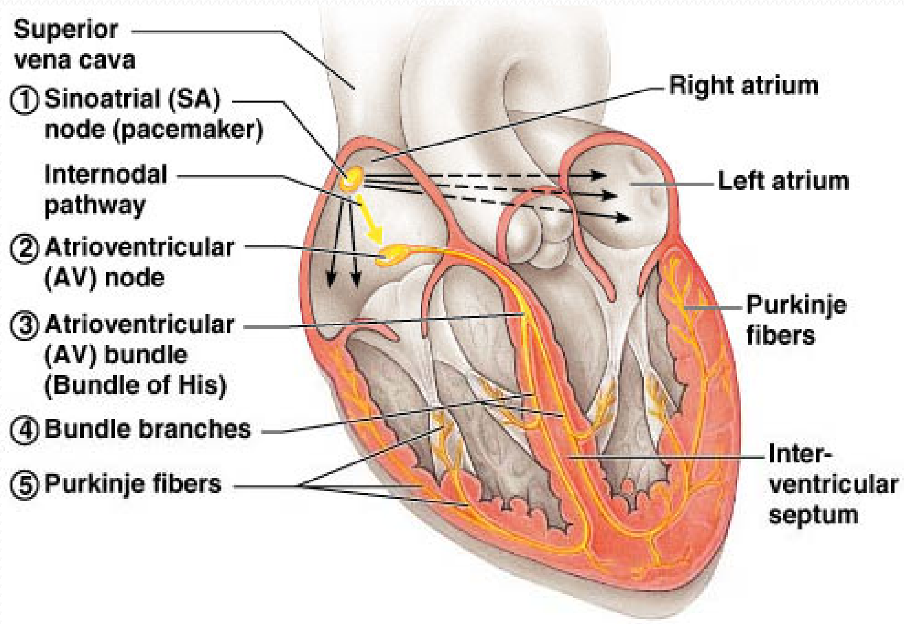


The Cardiac Cycle

- Heart at rest
  - Blood flows from large veins into atria
  - Passive flow from atria into ventricles
- Atria (R & L) contract simultaneously
  - Blood forced into ventricles
- Ventricles (R & L) contract simultaneously
  - Atrioventricular valves close → "lubb" sound
  - Blood forced into large arteries
- Ventricles relax
  - Semilunar valves close → "dub" sound
- Heart at rest

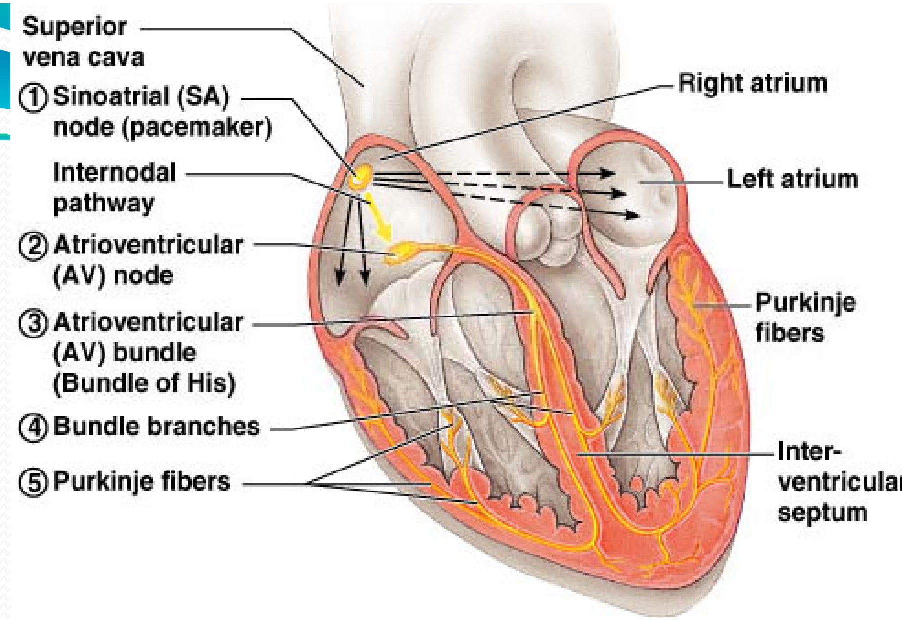
Depolarization and Impulse Conduction

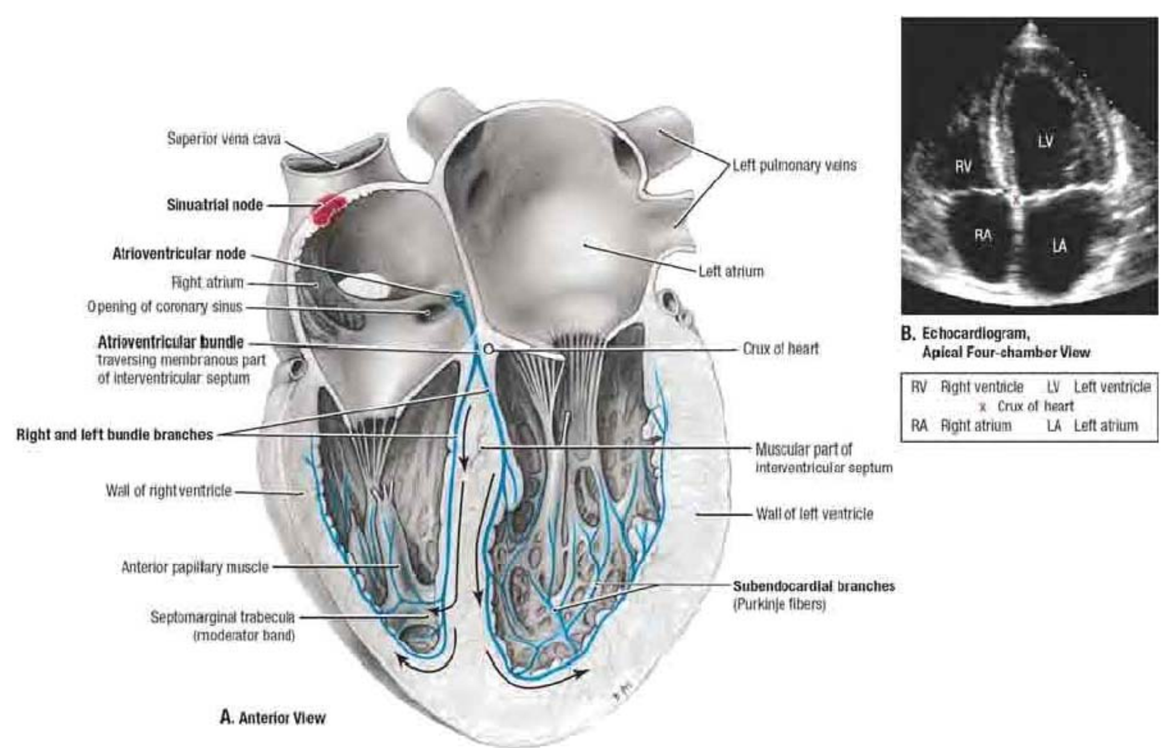
- Heart is autorhythmic
- Depolarization begins in sinoatrial (SA) node
- Spread through atrial myocardium
- Delay in atrioventricular (AV) node



Depolarization and Impulse Conduction

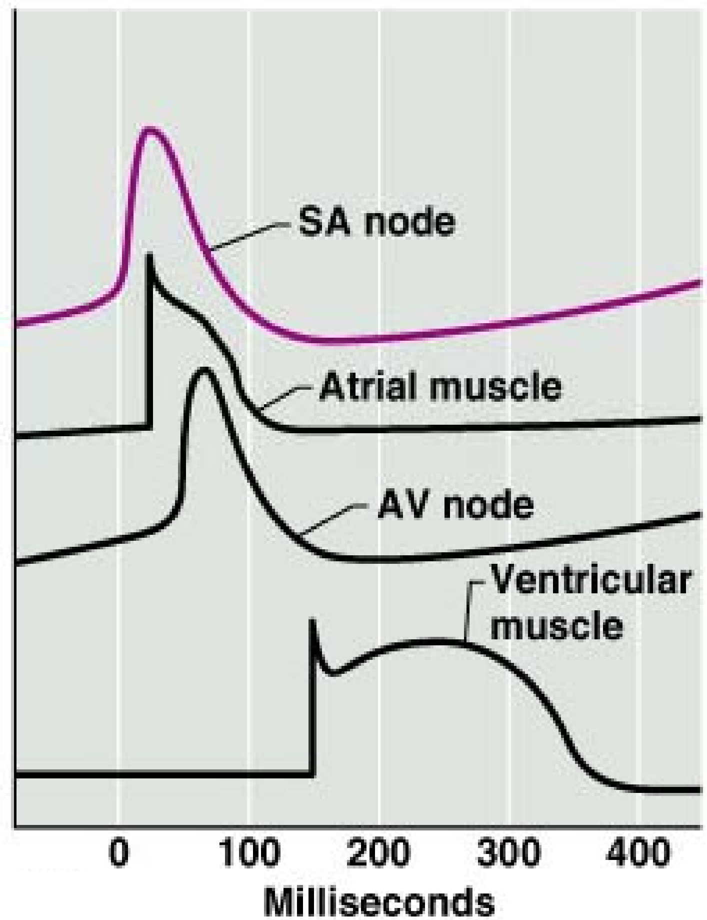
- Spread from atrioventricular (AV) node
  - AV bundle
  - Bundle branc
  - Purkinje fiber



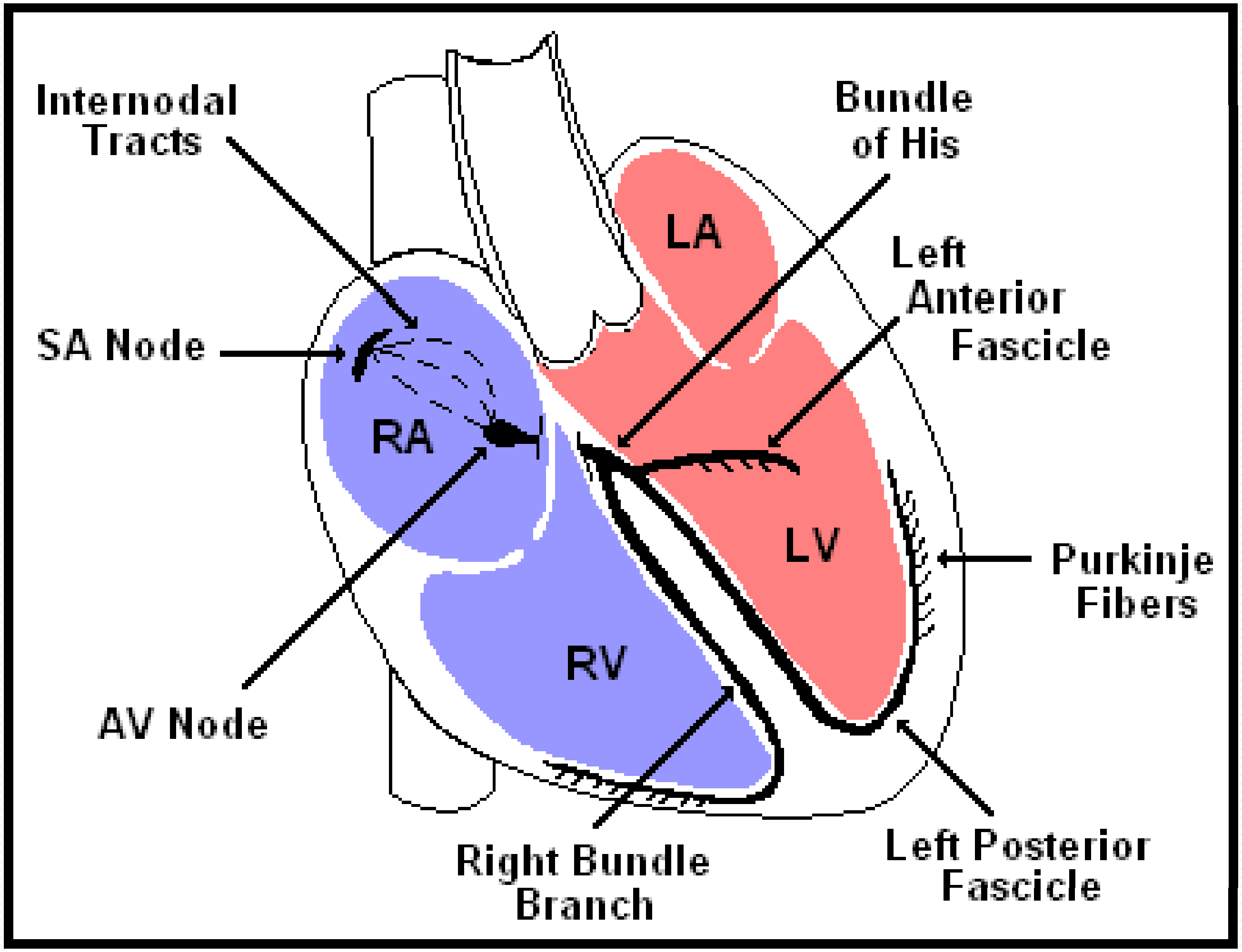


Depolarization and Impulse Conduction

- Depolarization in SA node precedes depolarization in atria, AV node, ventricles



The Normal Conduction System



What is an EKG?

The electrocardiogram (EKG) is a representation of the electrical events of the cardiac cycle.

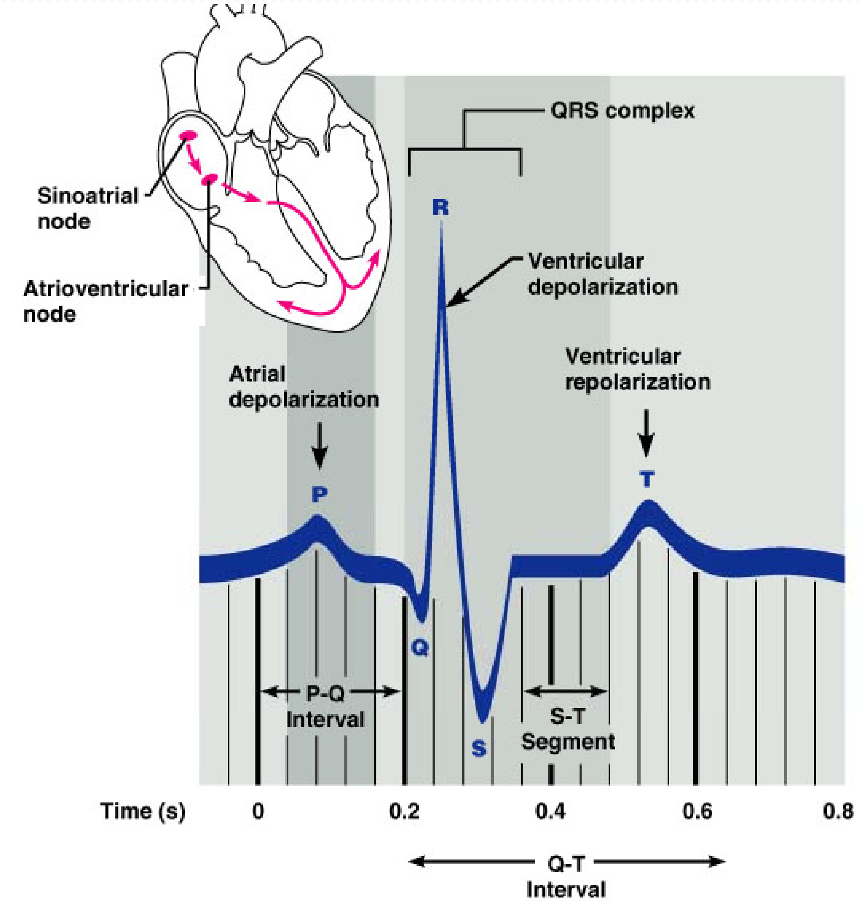
Each event has a distinctive waveform, the study of which can lead to greater insight into a patient's cardiac pathophysiology.

Electrocardiogram

- Method developed by Wilhelm Einthoven
  - Dutch “Elektrokardiogram” (EKG)
  - Now usually “ECG.”
- Records electrical events (movements of ions) in heart.
  - Variations in electrical potential radiate from heart; detectable at wrists, ankles.

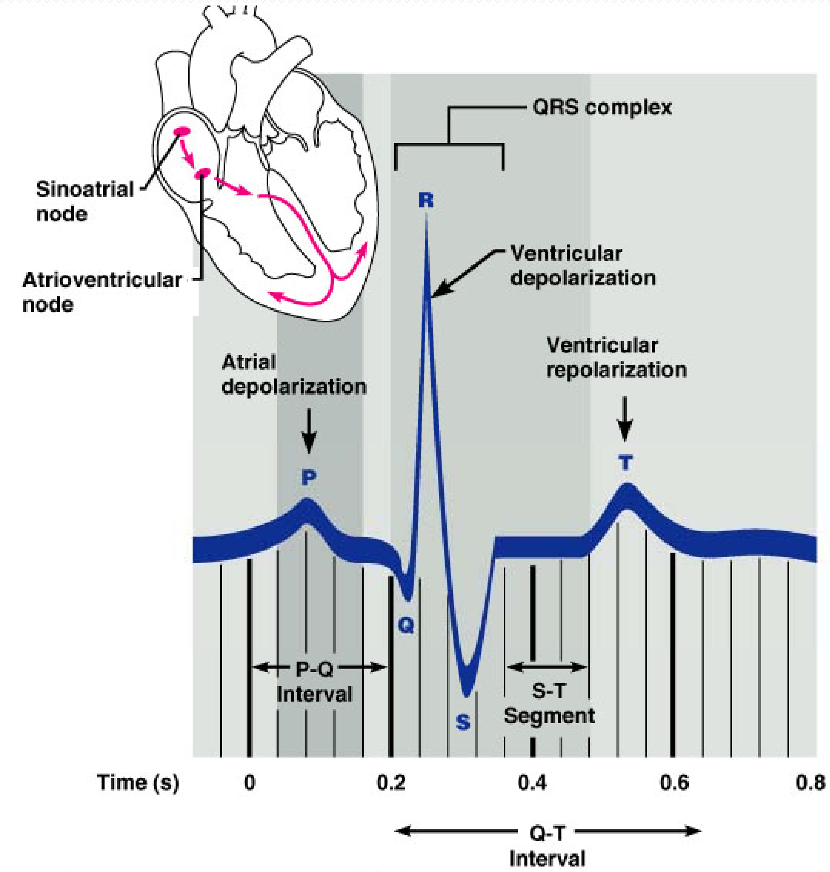
Electrocardiogram

- P wave
  - Depolarization of atria
  - Followed by contraction
- QRS complex
  - 3 waves (Q, R, & S)
  - Depolarization of ventricles
  - Followed by contraction
- T wave
  - Repolarization of ventricles



Electrocardiogram

- P-Q interval
  - Time atria depolarize & remain depolarized
- Q-T interval
  - Time ventricles depolarize & remain depolarized

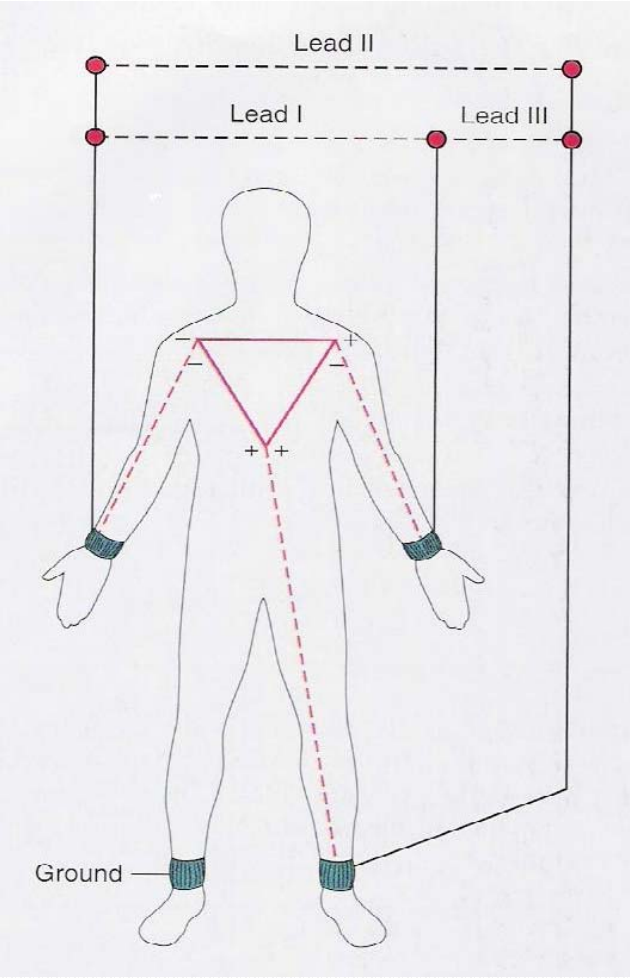


Intervals

- **P wave - atrial depolarization**
- **PR interval - time from sinoatrial** node (S-A) to atrioventricular node (A-Vnode)
- **QRS Complex – ventricular** depolarization
- **ST Segment - beginning of** ventricular repolarization
- **T Wave - later stages of** ventricular repolarization
- **U Wave - final component of** ventricular repolarization
- **RR Interval - represents the** time for one complete cardiac cycle

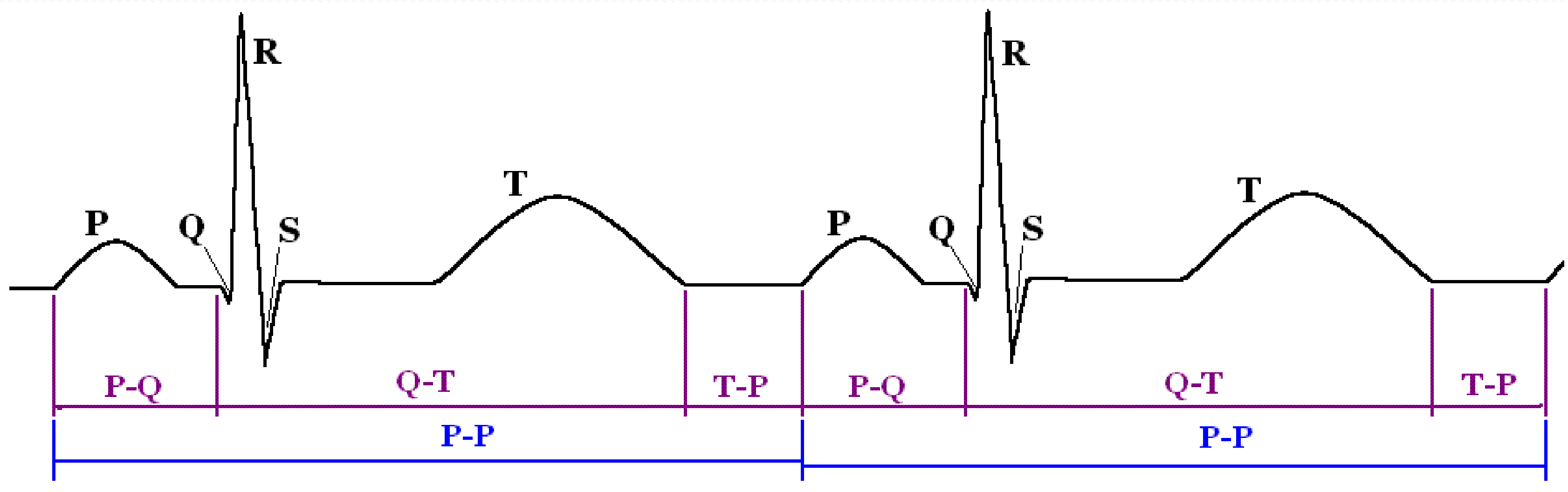
Electrocardiogram

- Einthoven's triangle
  - Three standard limb leads
  - Voltage differences between corners of triangle
  - We will use "Lead II"
    - Right shoulder to left leg



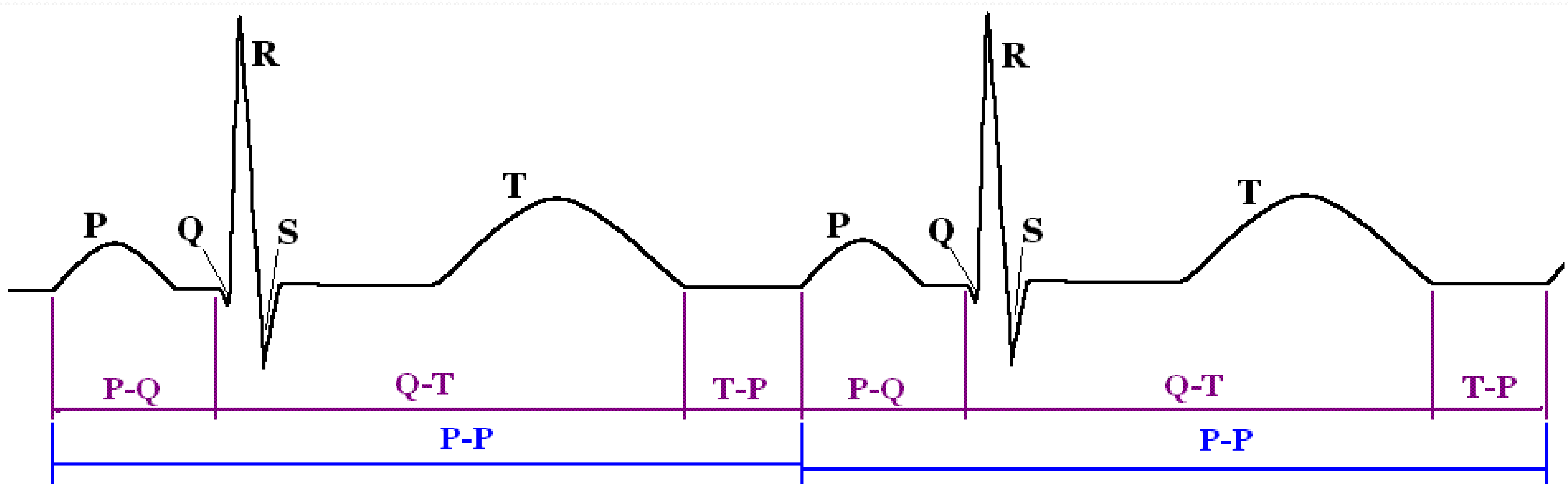
Electrocardiogram

- Intervals show timing of cardiac cycle
  - P-P = one cardiac cycle
  - P-Q = time for atrial depolarization
  - Q-T = time for ventricular depolarization
  - T-P = time for relaxation



Electrocardiogram

- Intervals show timing of cardiac cycle
- How does timing change with activity?



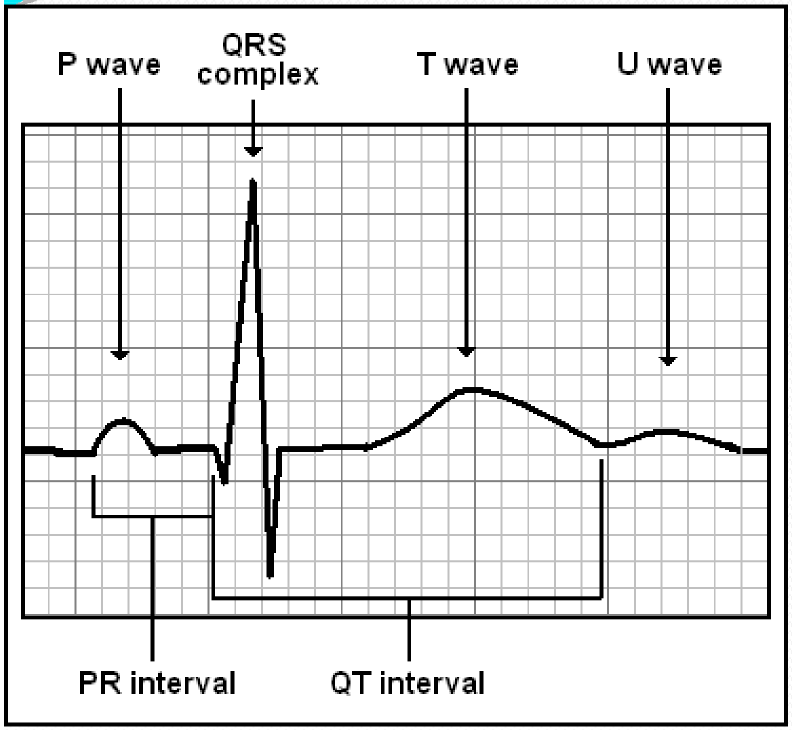
Electrocardiography

- Null hypothesis
- H_o: Intervals (P-Q, Q-T, T-P) change in proportion to one another from rest to exercise, i.e. ratios (exercise/rest) show NO change.

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 and drugs which prolong the QT interval)

Waveforms and Intervals



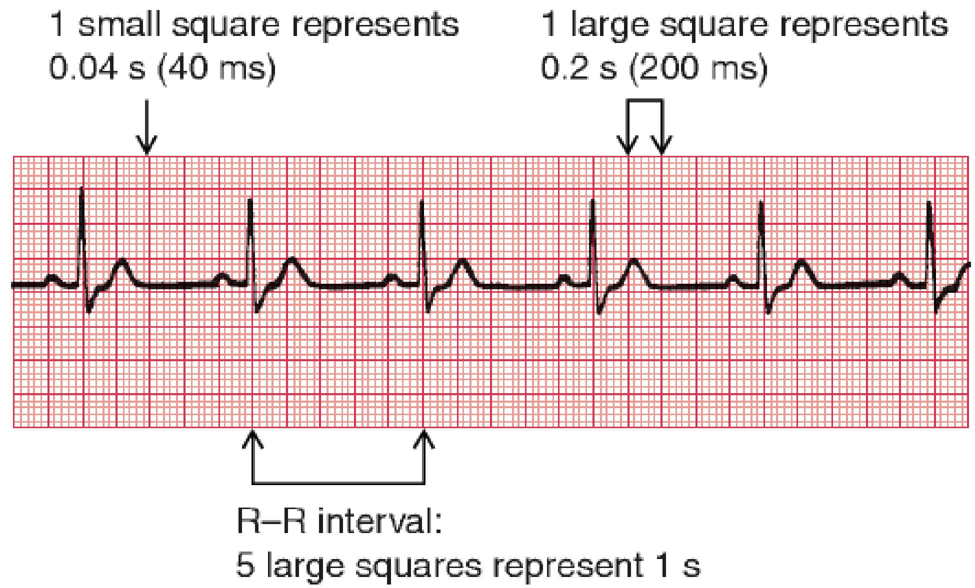


Fig. 1.4 Relationship between the squares on ECG paper and time. Here, there is one QRS complex per second, so the heart rate is 60 beats/min

- Q waves
  - Can occur normally in several leads
    - Normal Q waves called physiologic
  - Physiologic Q waves
    - < .04 sec (40ms)
  - Pathologic Q
    - >.04 sec (40ms)

Table 1.1 Relationship between the number of large squares covered by the R–R interval and the heart rate

R–R interval (large squares)	Heart rate (beats/min)
1	300
2	150
3	100
4	75
5	60
6	50

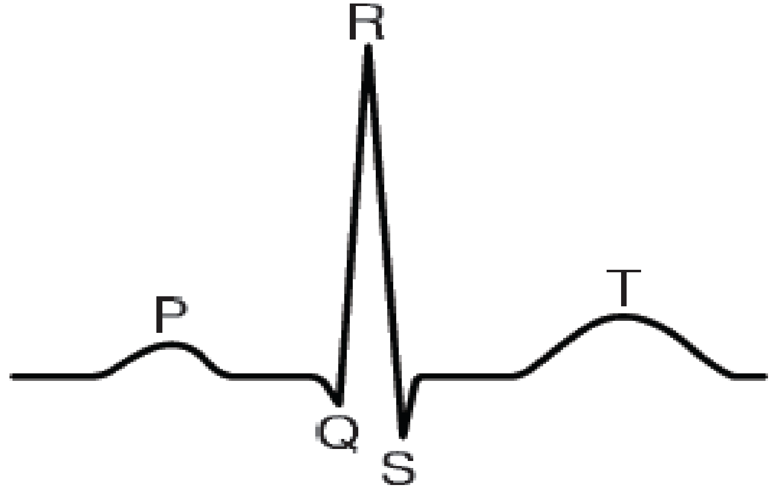


Fig. 1.2 **Basic shape of the normal ECG**

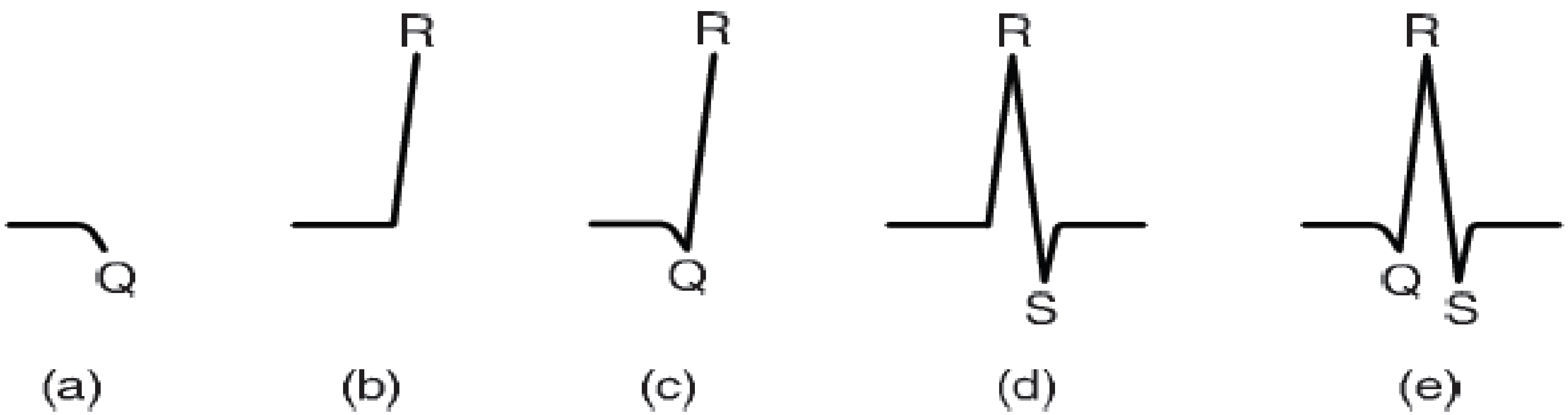
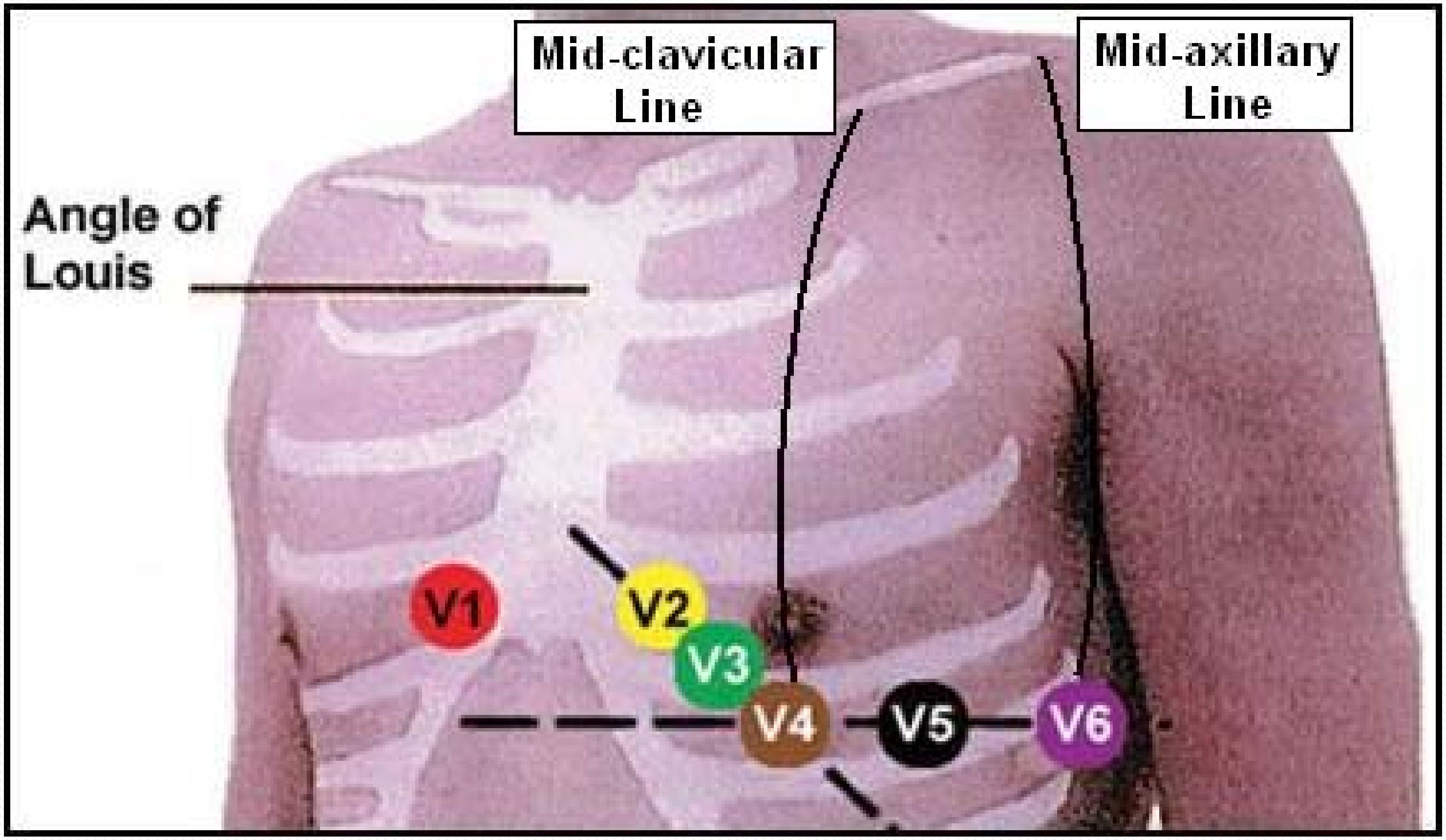


Fig. 1.3 **Parts of the QRS complex. (a) Q wave. (b, c) R waves. (d, e) S waves**

Precordial Leads



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

Lead Placement

V1 = 4th intercostal space, right border of sternu

V2 = 4th intercostal space, left border of sternu

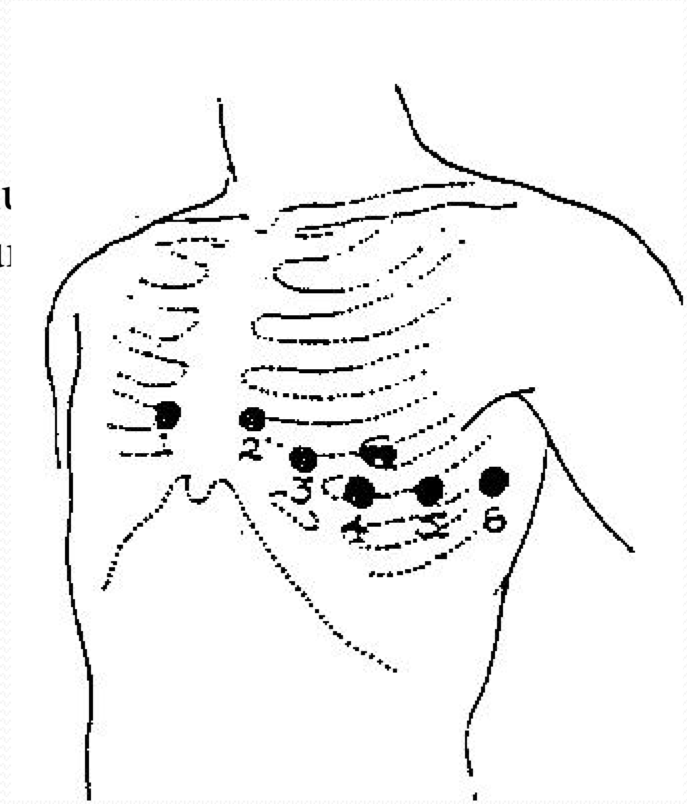
V3 = midway between V2 and V4

V4 = 5th intercostal space, midclavicular line

V5 = anteroaxillary line at level of V4

V6 = midaxillary line at level of V4 and V5

Electrocardiography



The ECG reading

- • Paper is in 1mm intervals (horizontal and
- vertical)
- • Every 5mm the line is accentuated
- • **Speed of the record** = 25mm/sec

– 5mm distance = 0.2sec

– 1mm distance = 0.04sec

– 1 sec = 5 bold lines = 25mm=1 large box

- • **Calibration**

– 1.0mV=10mm vertical deflection on the grid

Heart Rate (measurement strategies)

• When the HR is irregular – mark off a 6sec time

period on the grid (30 heavy lines), count the

number of QRS complexes in that interval and

multiply by 10

• When the HR is regular – measure the RR

interval between two successive heart beats then

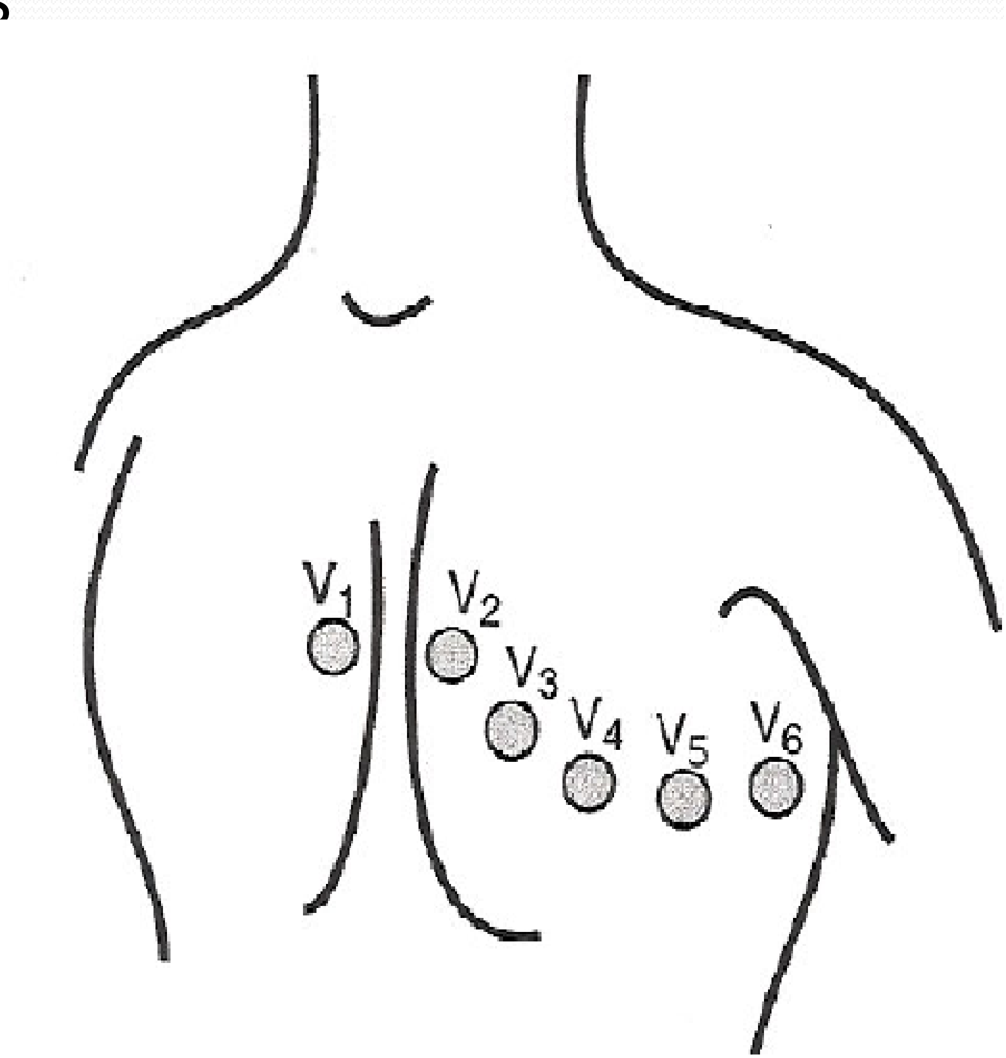
divide this value into 1500 (there are 1500 mm in

1 minute)

BPM = 1500 / RR interval (msec)

Lead Placement

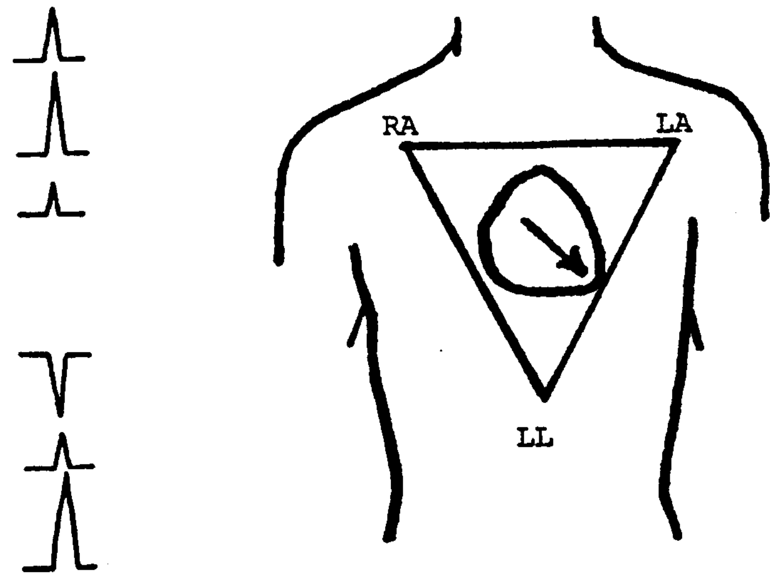
- V1 – Right Sternal Border – 4th ICS
- V2 – Left Sternal Border – 4th ICS
- V3 Midway Between V2 and V4
- V4 Midclavicular line – 5th ICS
- V5 Anterior Axillary line – 5th I
- V6 Mid axillary line – 5th ICS



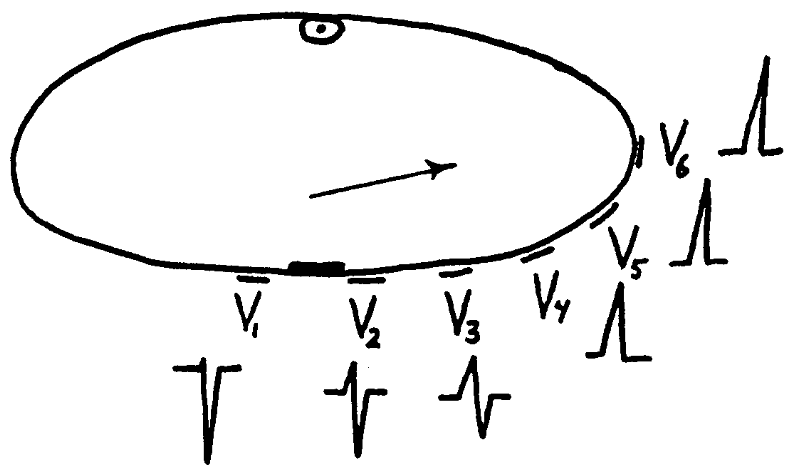
ECG Recordings: (QRS vector---leftward, inferiorly and posteriorly

3 Bipolar Limb Leads
- I = RA vs. LA(+)
- II = RA vs. LL(+)
- III = LA vs. LL(+)

3 Augmented Limb Leads
- aVR = (LA-LL) vs. RA(+)
- aVL = (RA-LL) vs. LA(+)
- aVF = (RA-LA) vs. LL(+)



6 Precordial (Chest) Leads: Indifferent electrode (RA-LA-LL) vs. chest lead moved from position V_1 through position V_6.



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

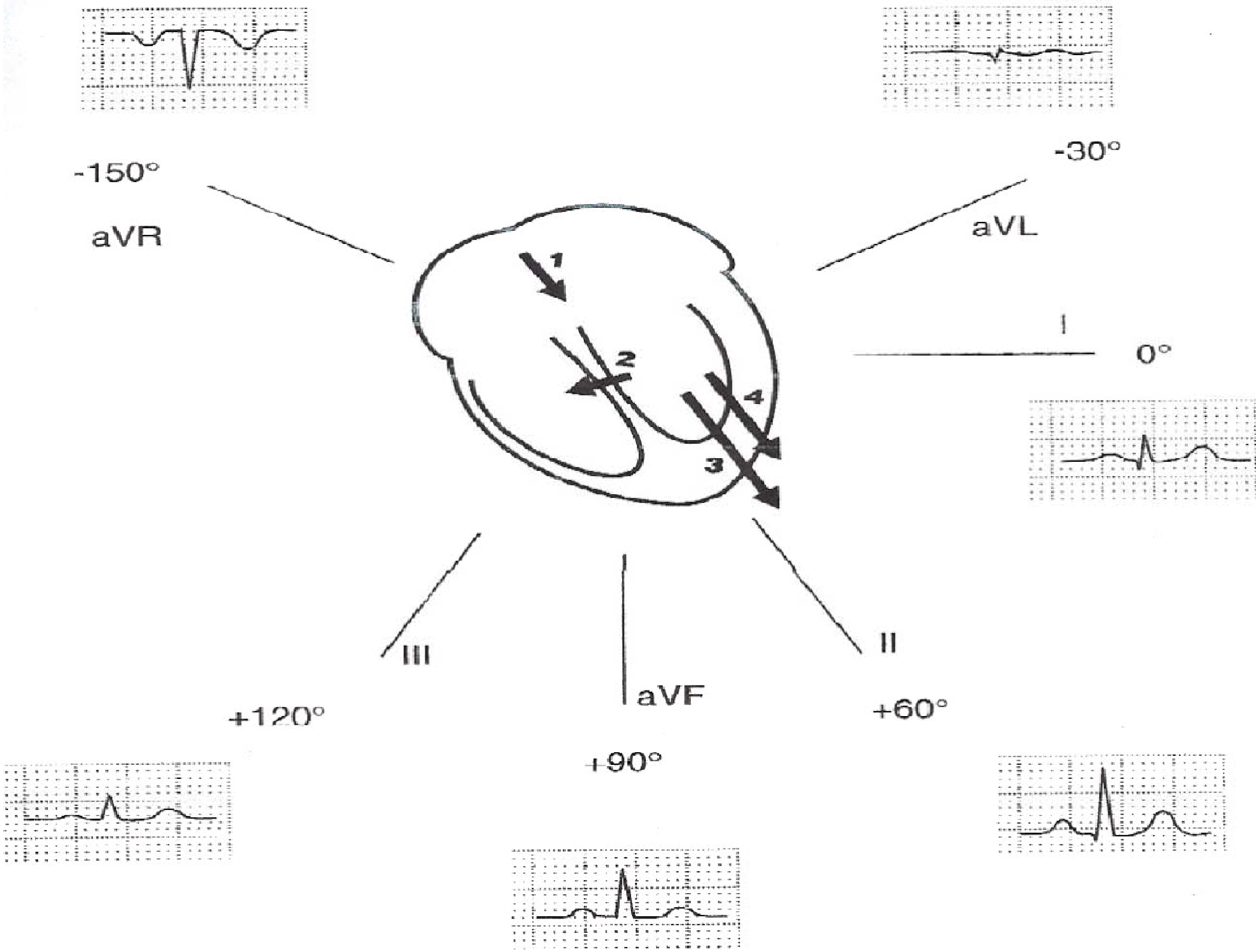
The standard EKG has 12 leads:

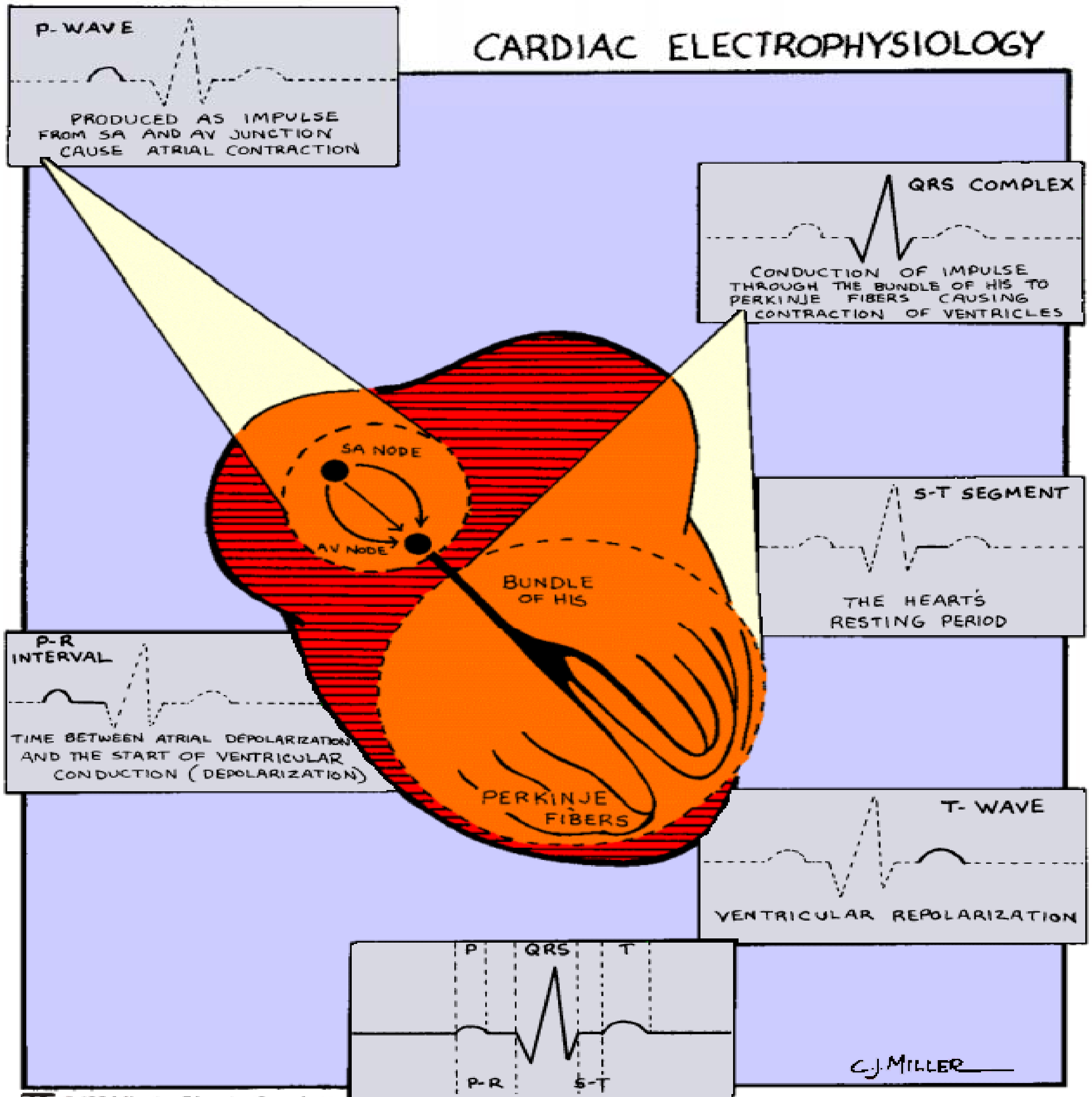
3 Standard Limb Leads

3 Augmented Limb Leads

6 Precordial Leads

The axis of a particular lead represents the viewpoint from which it looks at the heart.

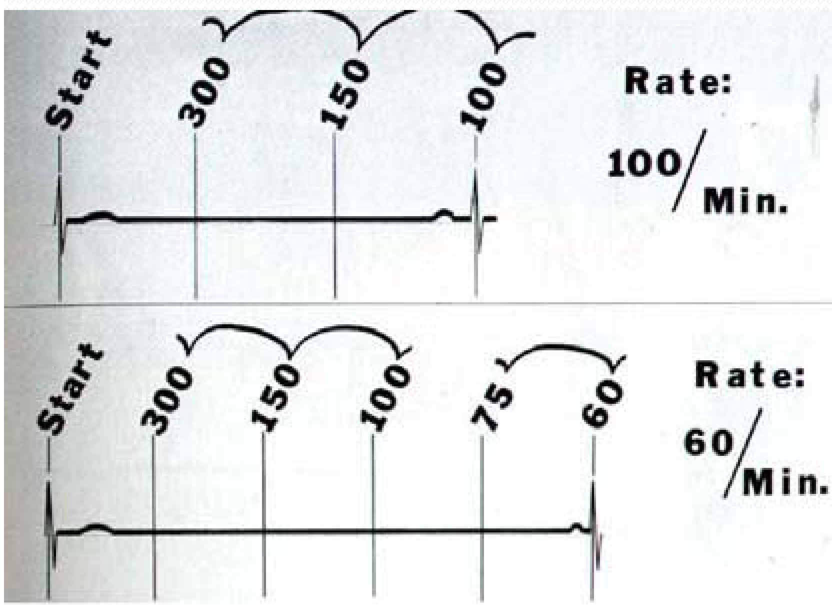

-150°
aVR
-30°
aVL
1
2
3
4
I
0°
III
aVF
II
+120°
+90°
+60°



CARDIAC ELECTROPHYSIOLOGY
P-WAVE
PRODUCED AS IMPULSE FROM SA AND AV JUNCTION CAUSE ATRIAL CONTRACTION
QRS COMPLEX
CONDUCTION OF IMPULSE THROUGH THE BUNDLE OF HIS TO PERKINJE FIBERS CAUSING CONTRACTION OF VENTRICLES
SA NODE
AV NODE
BUNDLE OF HIS
S-T SEGMENT
THE HEART'S RESTING PERIOD
P-R INTERVAL
TIME BETWEEN ATRIAL DEPOLARIZATION AND THE START OF VENTRICULAR CONDUCTION (DEPOLARIZATION)
PERKINJE FIBERS
T- WAVE
VENTRICULAR REPOLARIZATION
P
QRS
T
P-R
S-T
C.J. MILLER

Axis Deviation

- Normal Axis = 60 Degrees (0-90)
- Further counter clockwise than 0 = Left Axis Deviation
- Further clockwise than 90 = Right Axis Deviation
- > -30 Marked LAD
- >-120 Marked RAD



HOW TO REPORT AN ECG

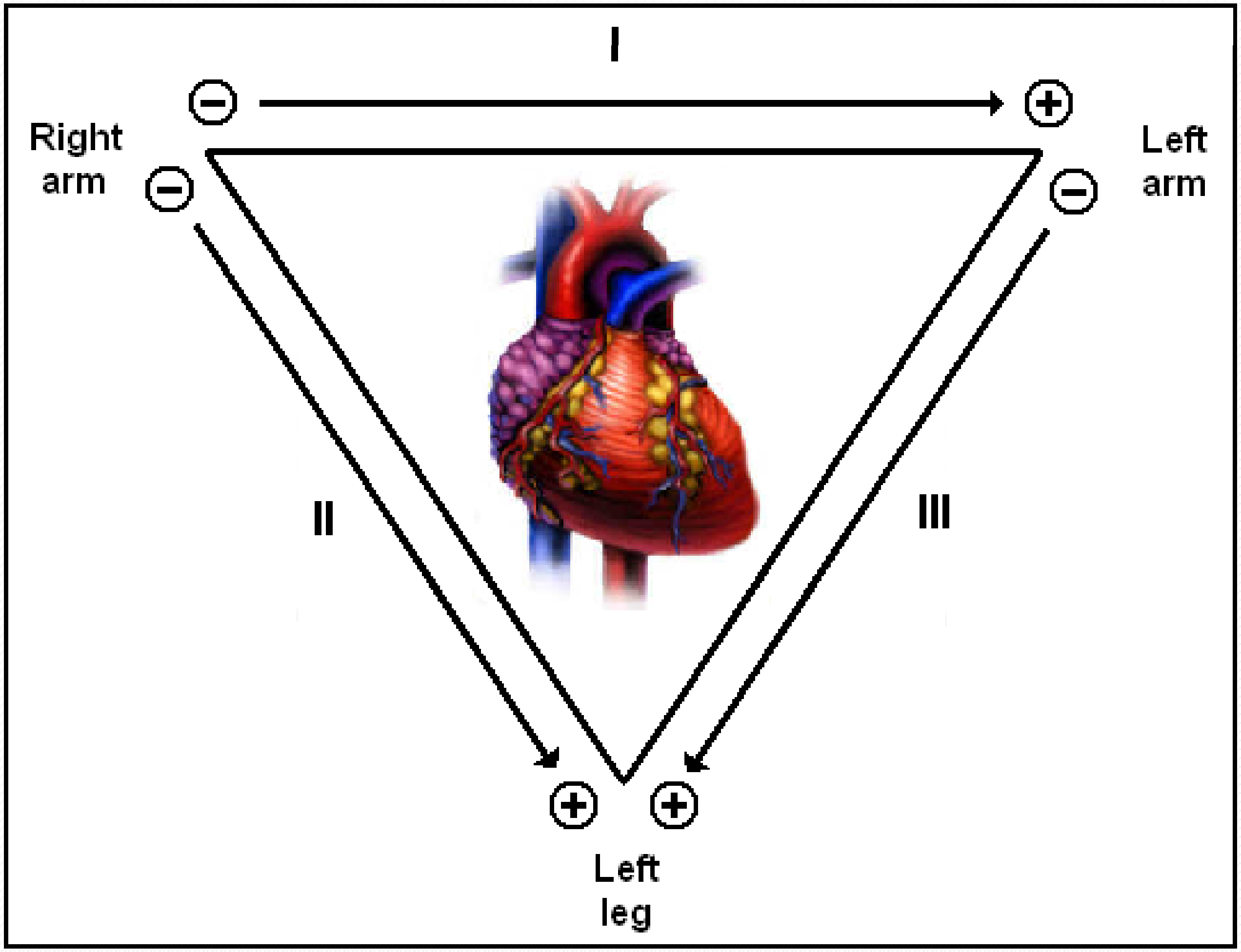
You now know enough about the ECG to understand the basis of a report. This should take the form of a description, followed by an interpretation.

The description should always be given in the same sequence:

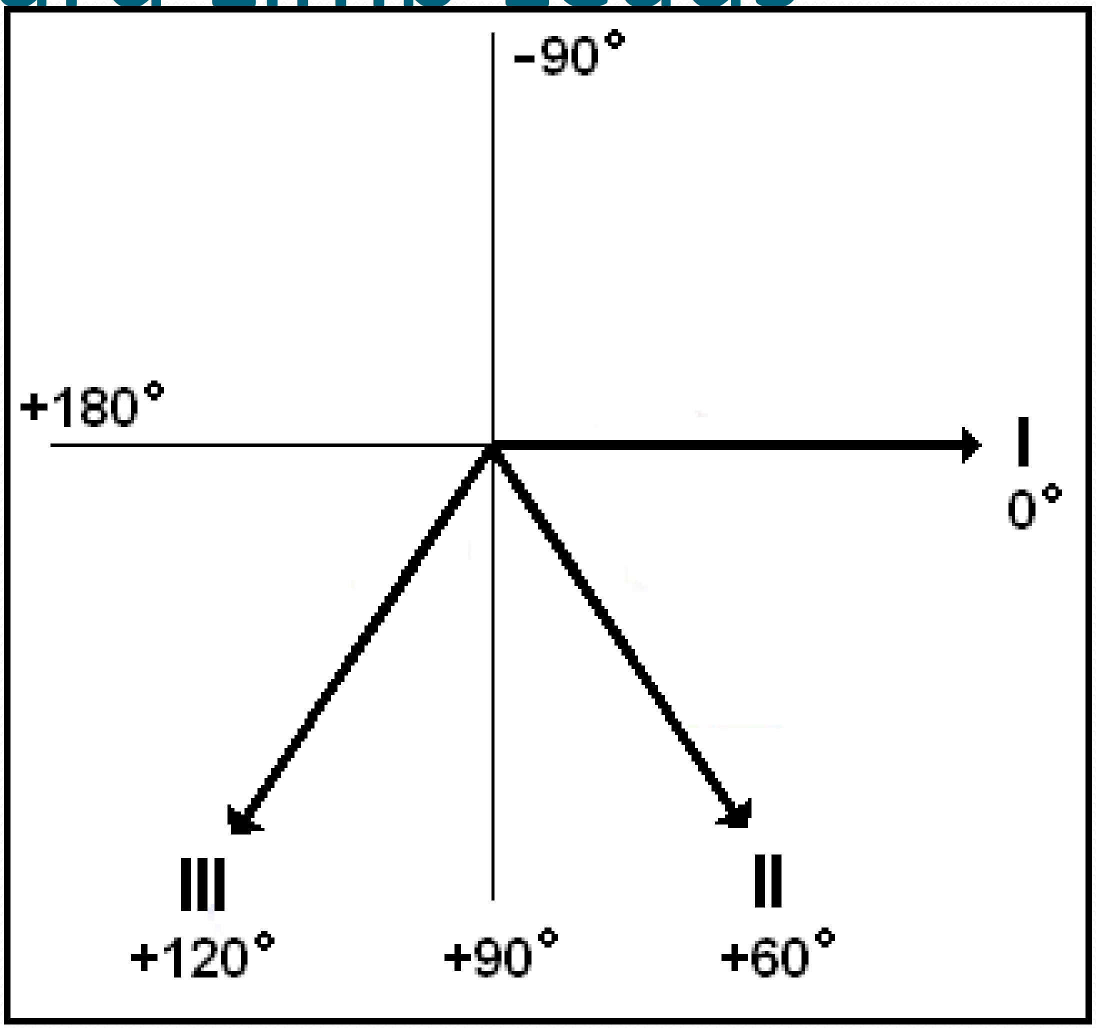
1. Rhythm
2. Conduction intervals
3. Cardiac axis
4. A description of the QRS complexes
5. A description of the ST segments and T waves.

Reporting a series of totally normal findings is possibly pedantic, and in real life is frequently not done. However, you must think about all the findings every time you interpret an ECG.

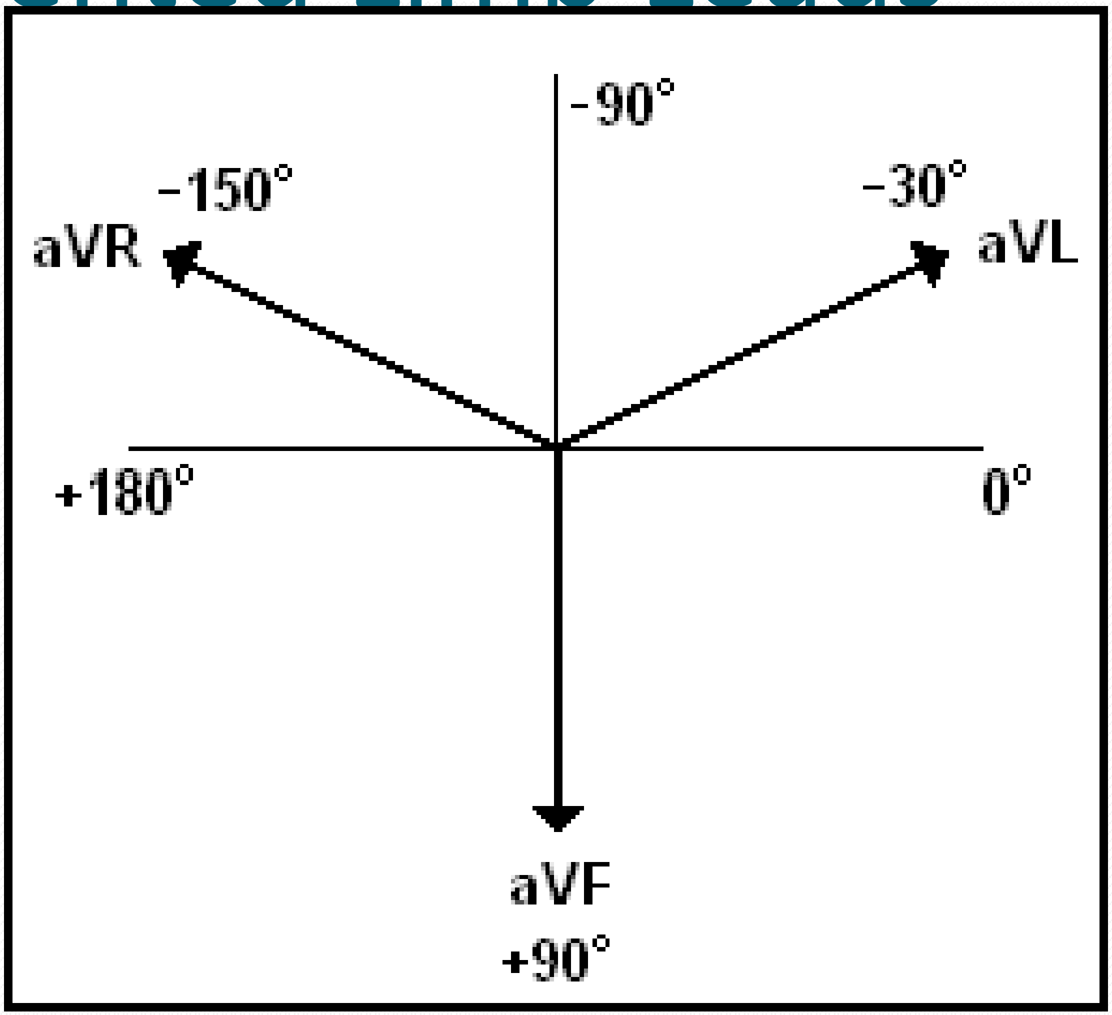
Standard Limb Leads



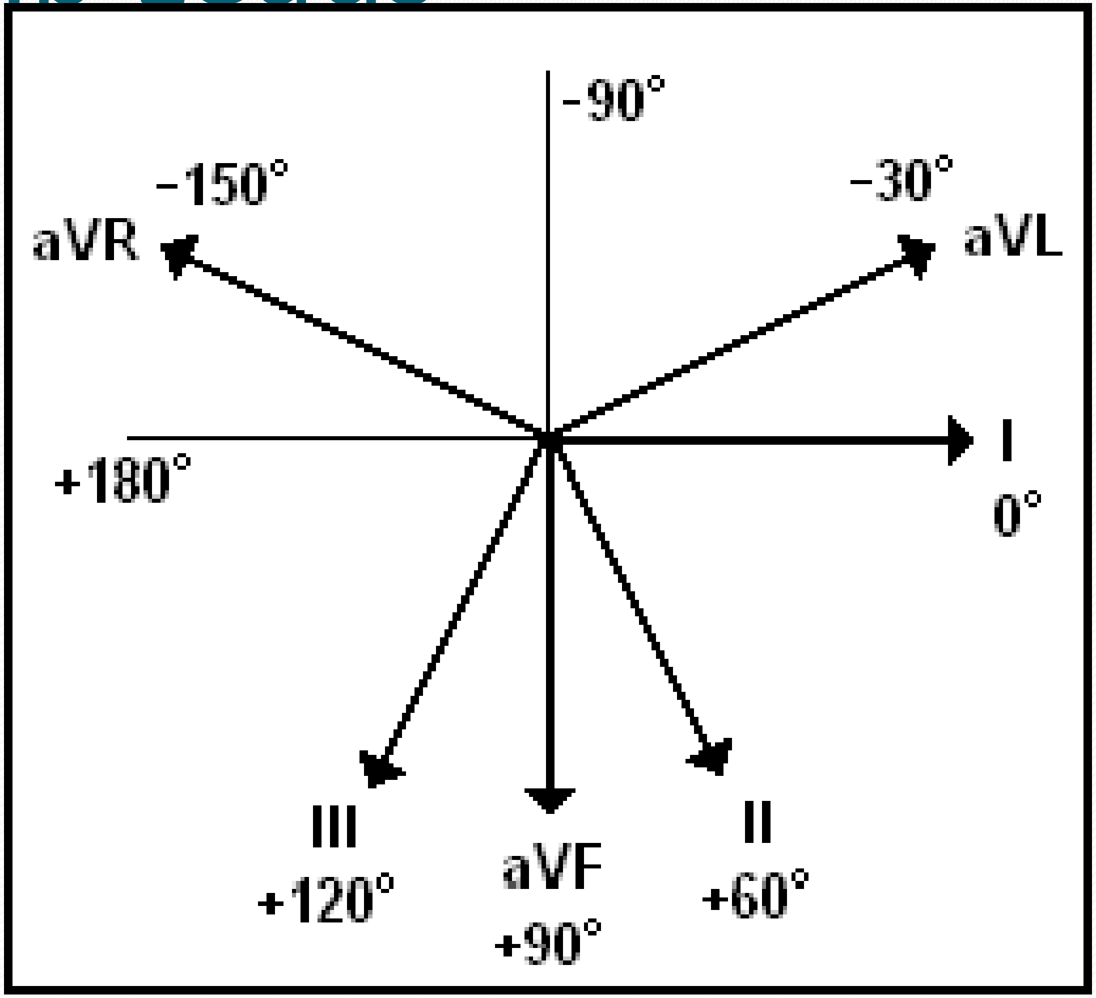
Standard Limb Leads



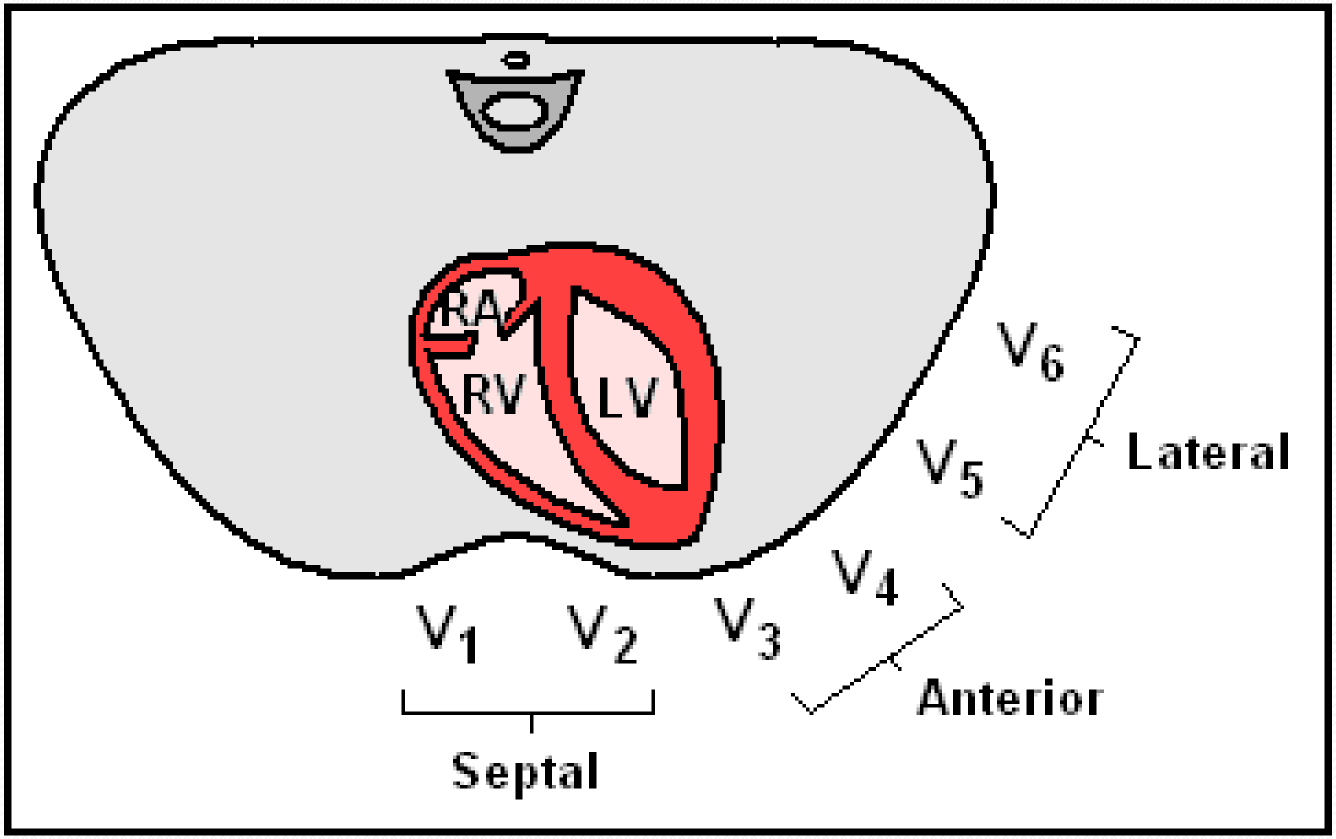
Augmented Limb Leads



All Limb Leads



Precordial Leads



Summary of Leads

	Limb Leads	Precordial Leads
Bipolar	I, II, III (standard limb leads)	-
Unipolar	aVR, aVL, aVF (augmented limb leads)	V_1-V_6

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
(Septum)

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

Anatomic Groups
(Anterior Wall)

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

Anatomic Groups
(Lateral Wall)

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

Anatomic Groups
(Inferior Wall)

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

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

Determining the Heart Rate

- Rule of 300

- 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.

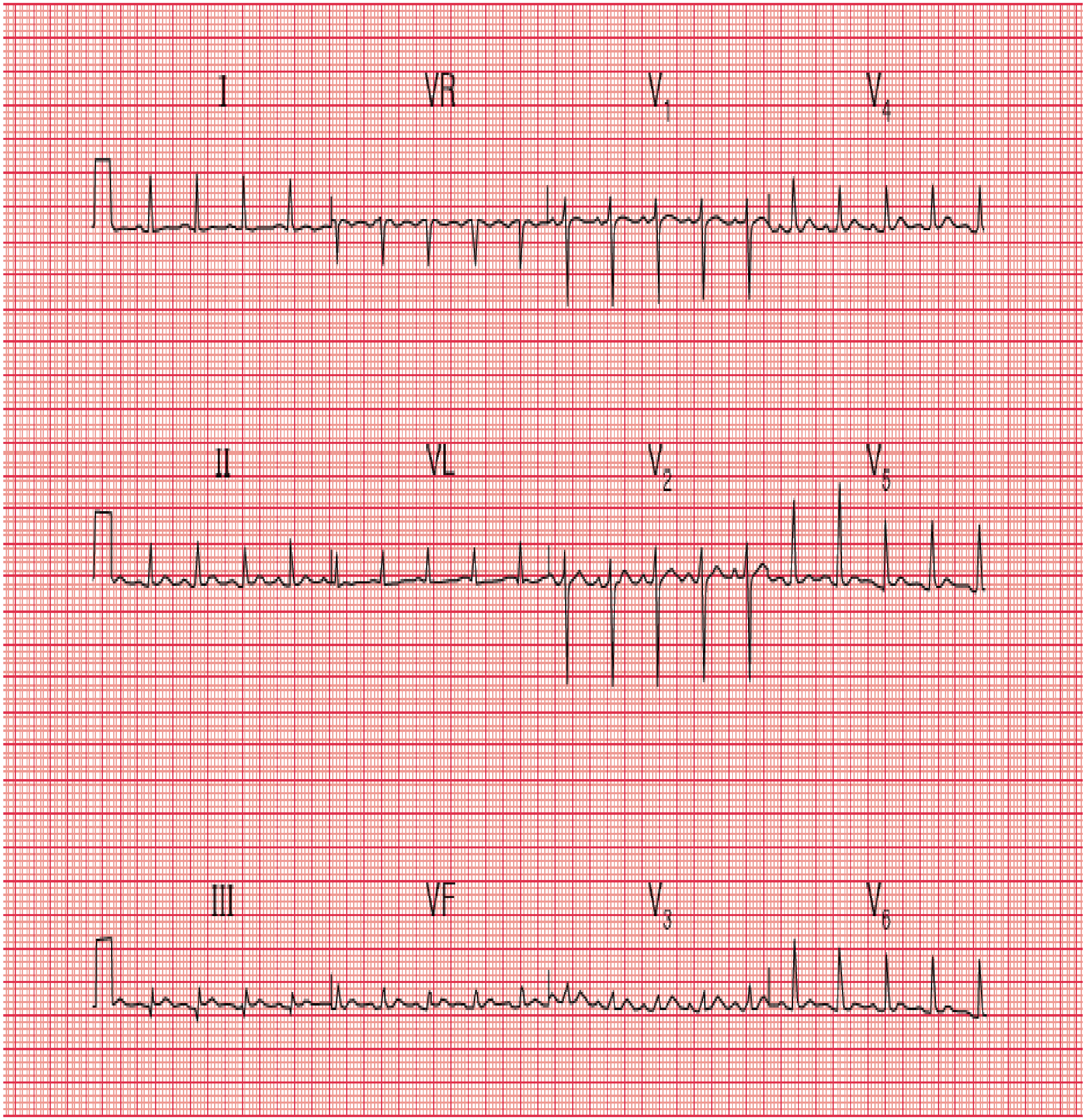


Fig. 1.23 12-lead ECG: example 1

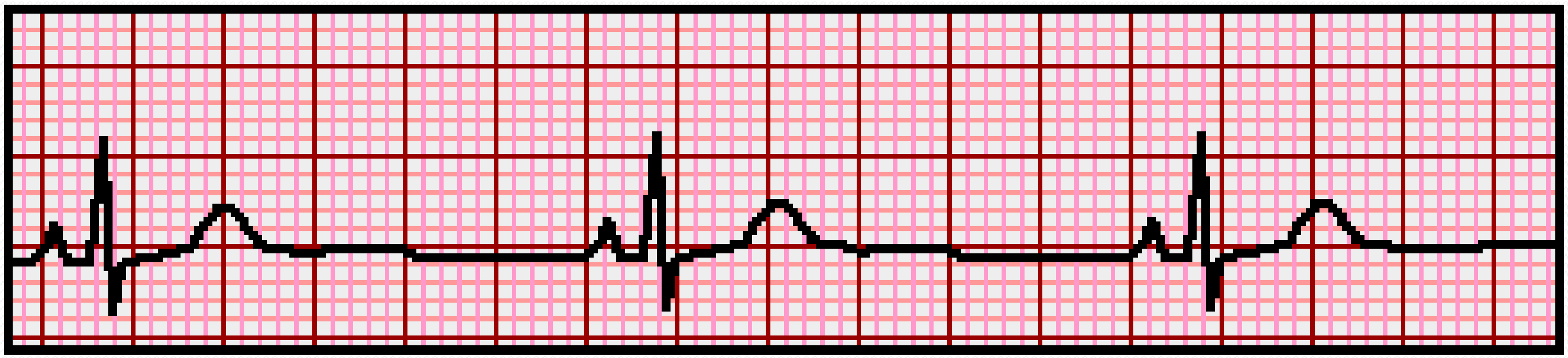
Description

- Sinus rhythm, rate 110/min
- Normal PR interval (140 ms)
- Normal QRS duration (120 ms)
- Normal cardiac axis
- Normal QRS complexes
- Normal T waves (an inverted T wave in lead VR is normal)

Interpretation

- Normal ECG

What is the heart rate?



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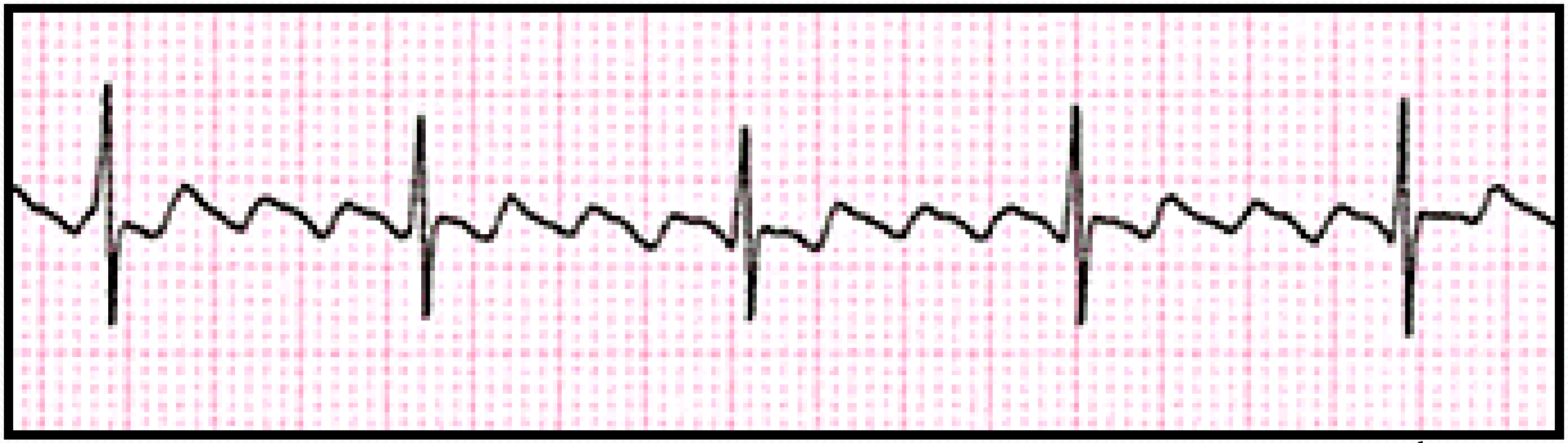
(300 / 6) = 50 bpm

What is the heart rate?



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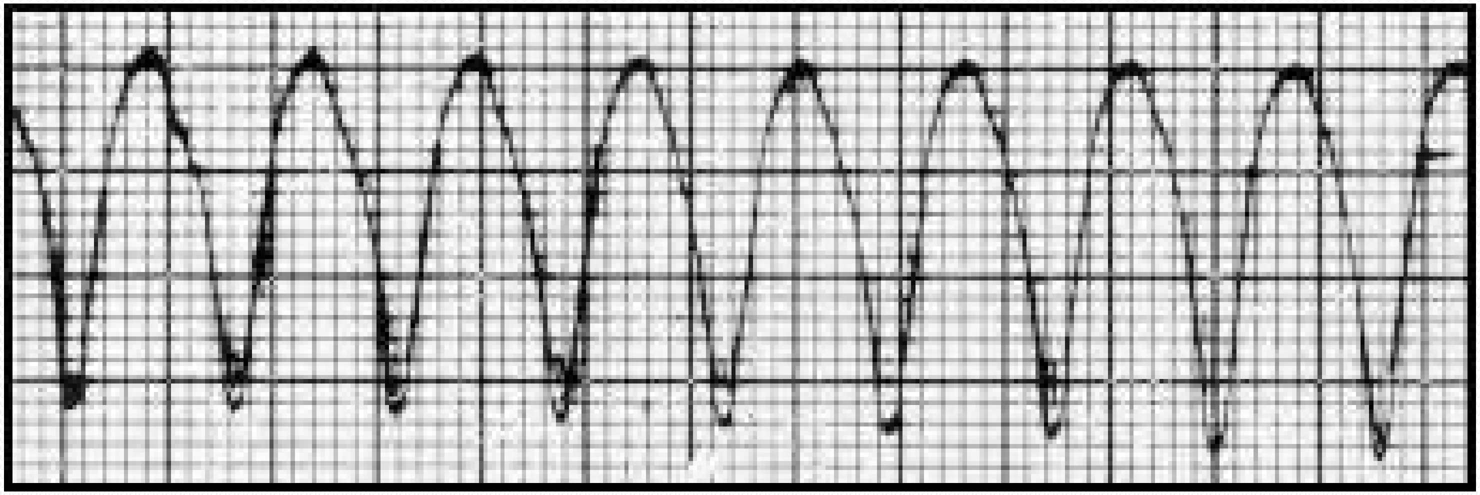
(300 / ~ 4) = ~ 75 bpm

What is the heart rate?



(300 / 1.5) = 200 bpm

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

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.

What is the heart rate?

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

33 x 6 = 198 bpm

The QRS Axis

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

Abnormalities of axis can hint at:

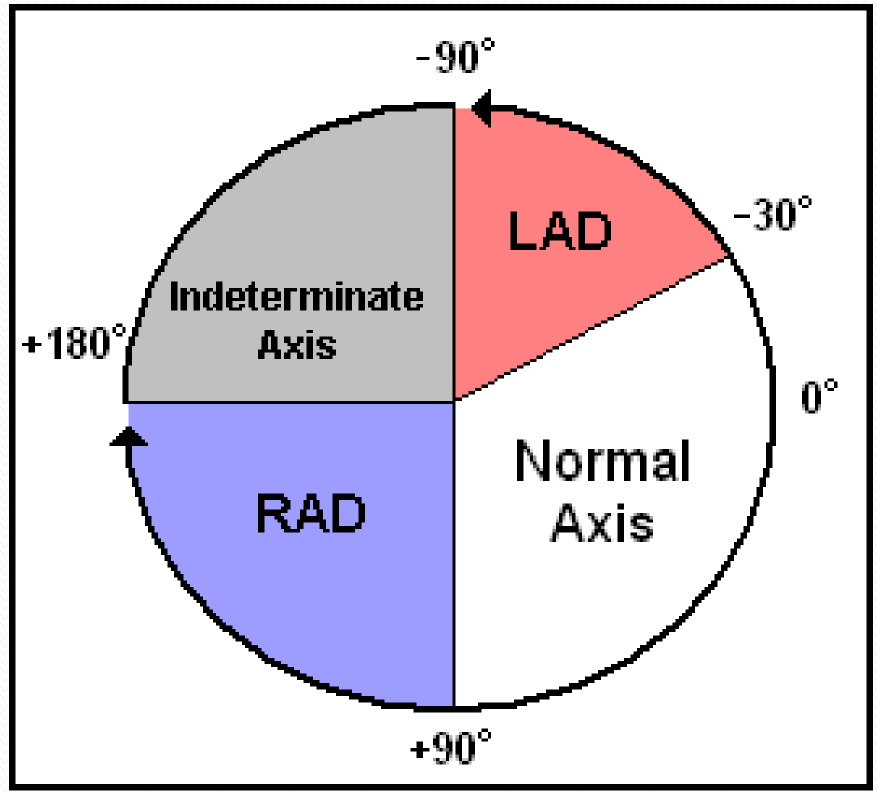
- Ventricular enlargement
- Conduction blocks (i.e. hemiblocks)

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)



Determining the Axis

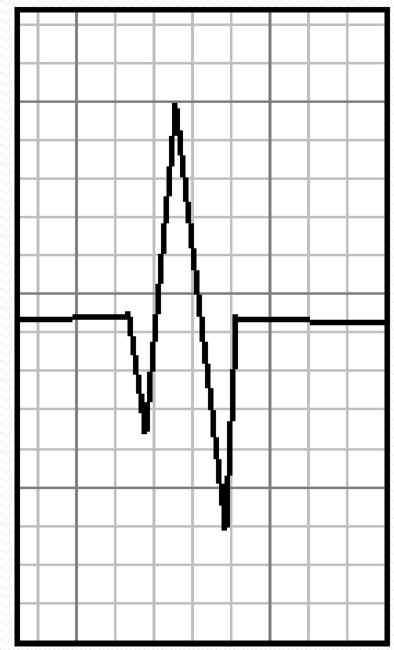
- The Quadrant Approach

- 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. The combination should place the axis into one of the 4 quadrants below.

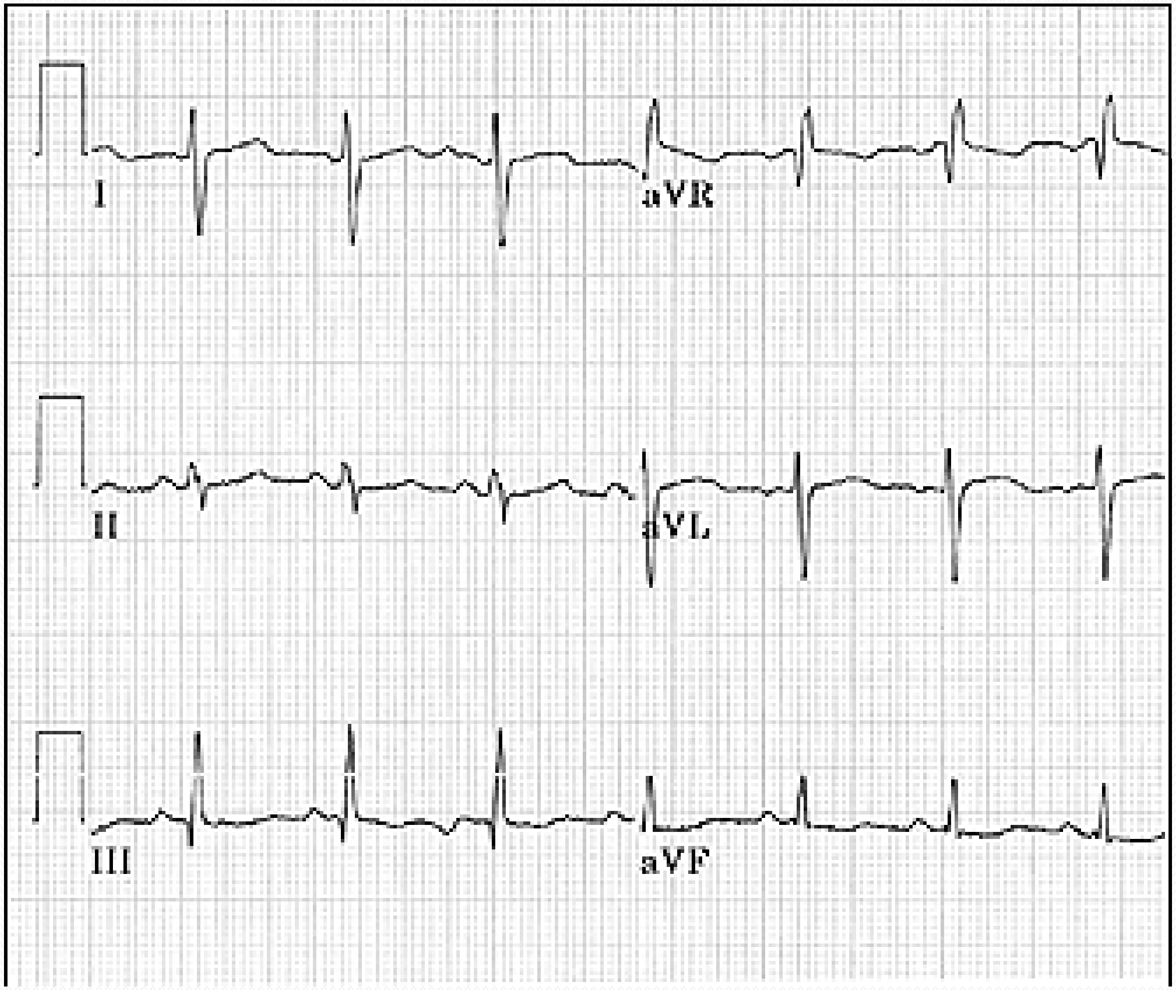
		Lead aVF	
		Positive	Negative
Lead I	Positive	Normal Axis	LAD
	Negative	RAD	Indeterminate Axis

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

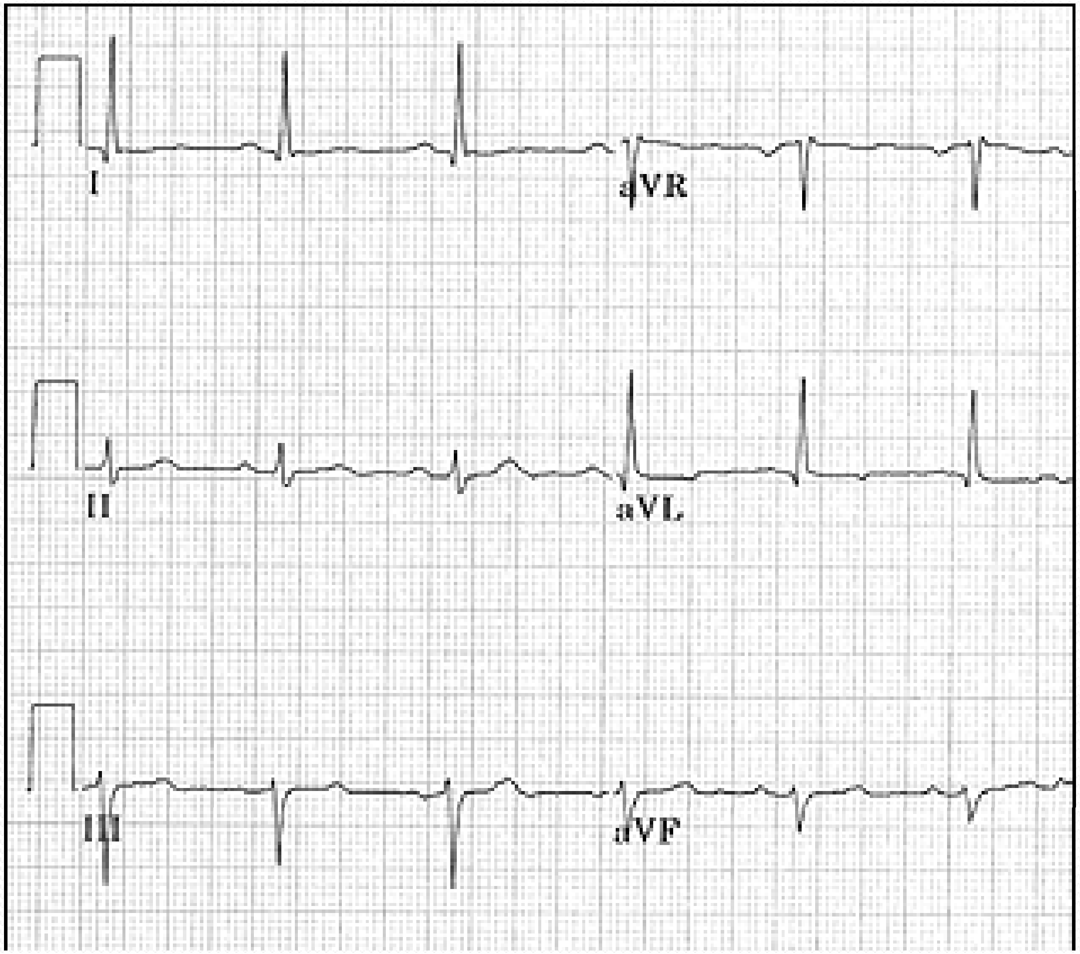
Quadrant Approach: Example 1



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

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 →

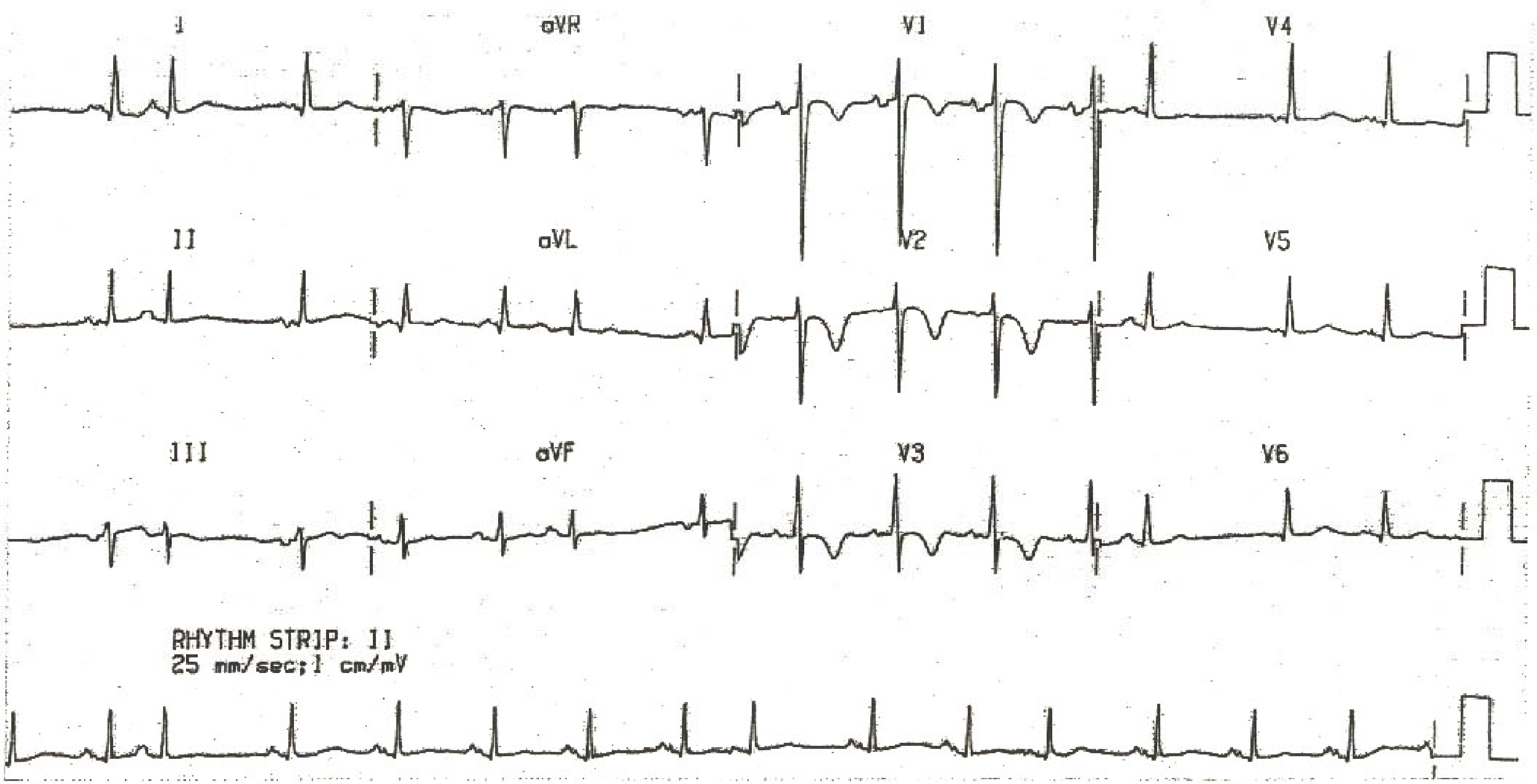
Normal Axis (non-pathologic LAD)

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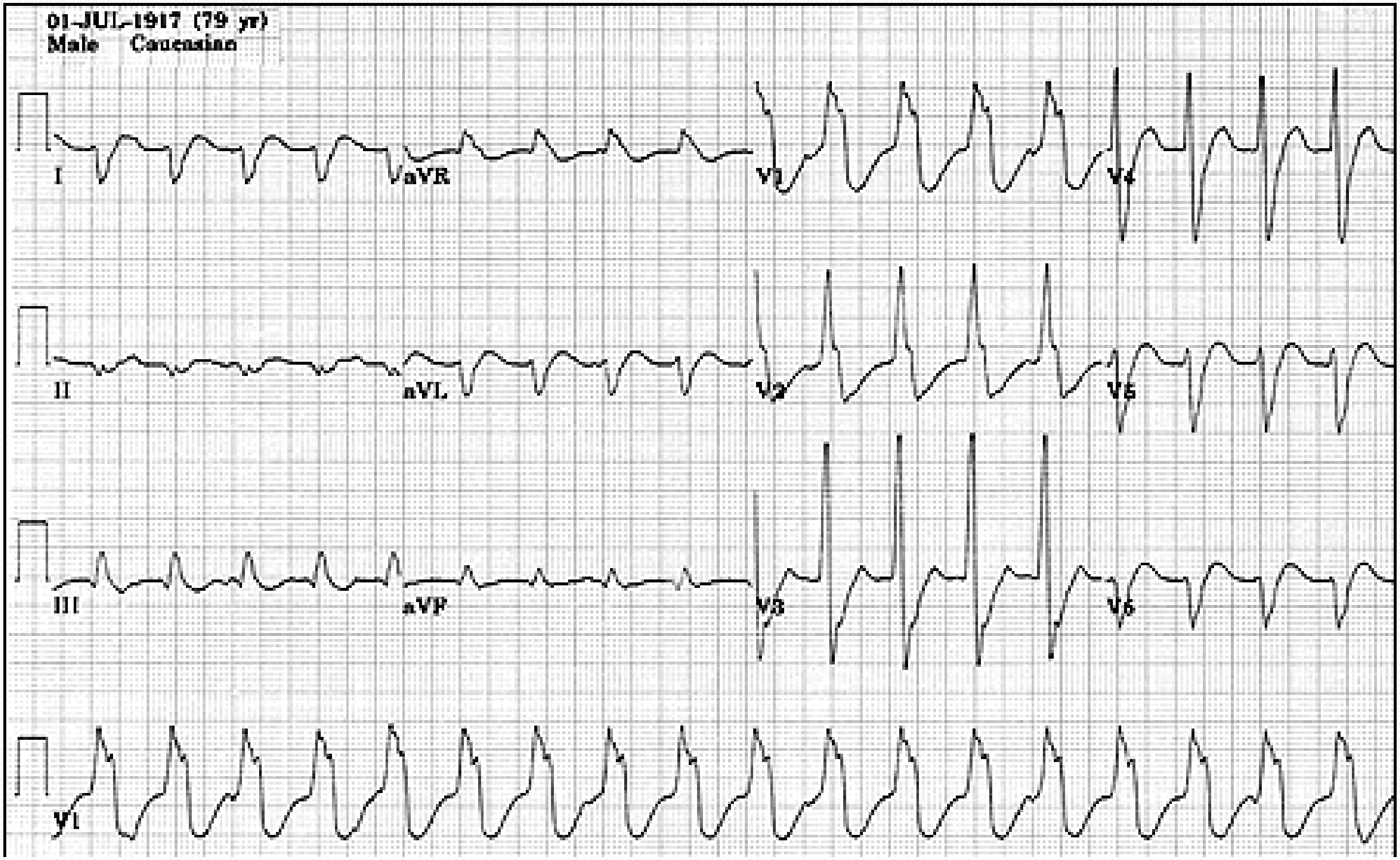
Equiphasic in aVF → Predominantly positive in I → QRS axis ≈ 0°

Equiphasic Approach: Example 2



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

Normal Changes in ECG during exercise

- P wave – increases in amplitude above resting level
- PR interval – shortens
- Q wave – amplitude increases
- R wave – amplitude decreases
- QT interval – shortens
- ST segment – depression of first part of segment, turning

into upsloping ST segment

- T wave – amplitude decreases
- Arrythmias - -more common at peak

- If monitoring an ECG during a graded exercise
- test it is imperative to terminate the test if the
- following occurs:
- • Ventricular tachycardia (3 or more premature
- ventricular contractions)
- • Downsloping ST depression exceeding 1.0mm or
- elevation exceeding 4.0mm
- • Exercise induced AV indicated by a extended PR
- interval
- • Failure of HR to increase (chronotropic response)