جامعة الملك سعود
King Saud University

ECG med 442

Dr. Ahmad S. Hersi, MBBS. MSc. FRCPC

Professor of Cardiac Sciences

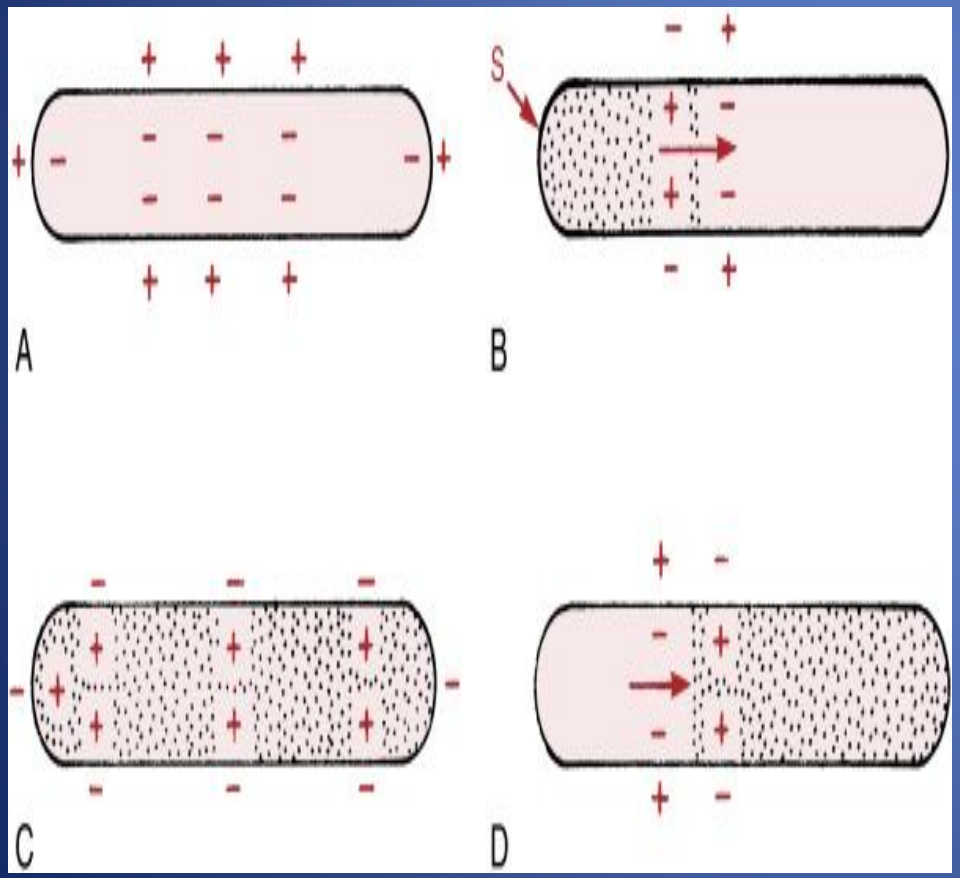
Consultant Electrophysiologist

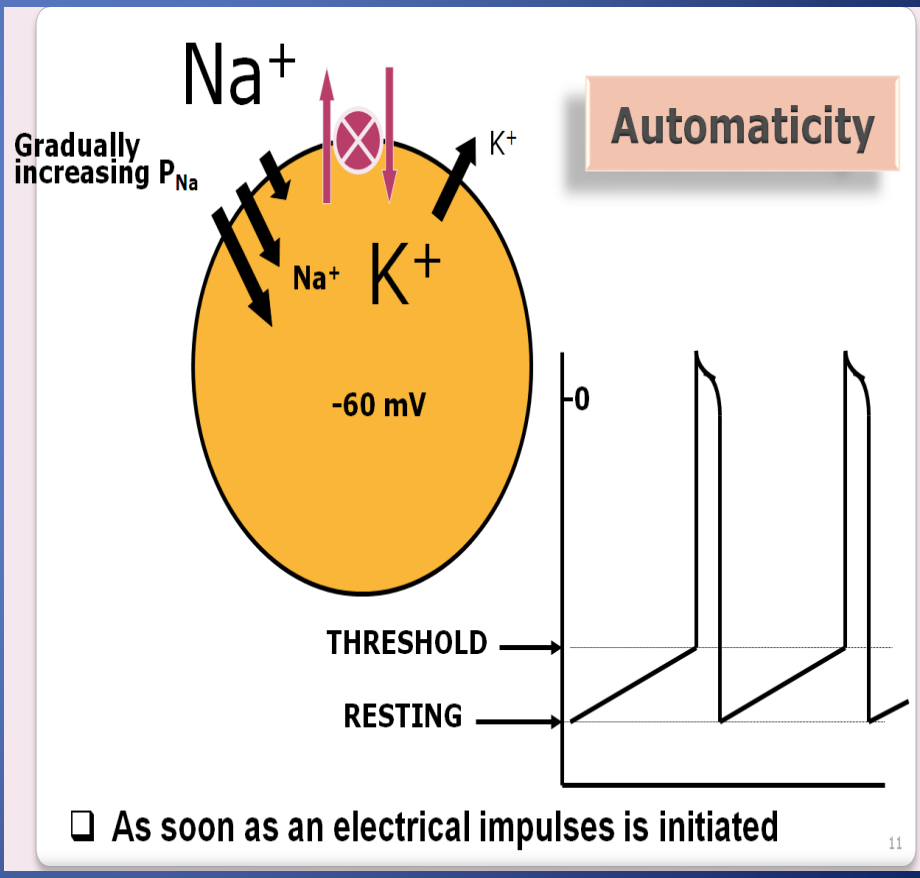
Outlines

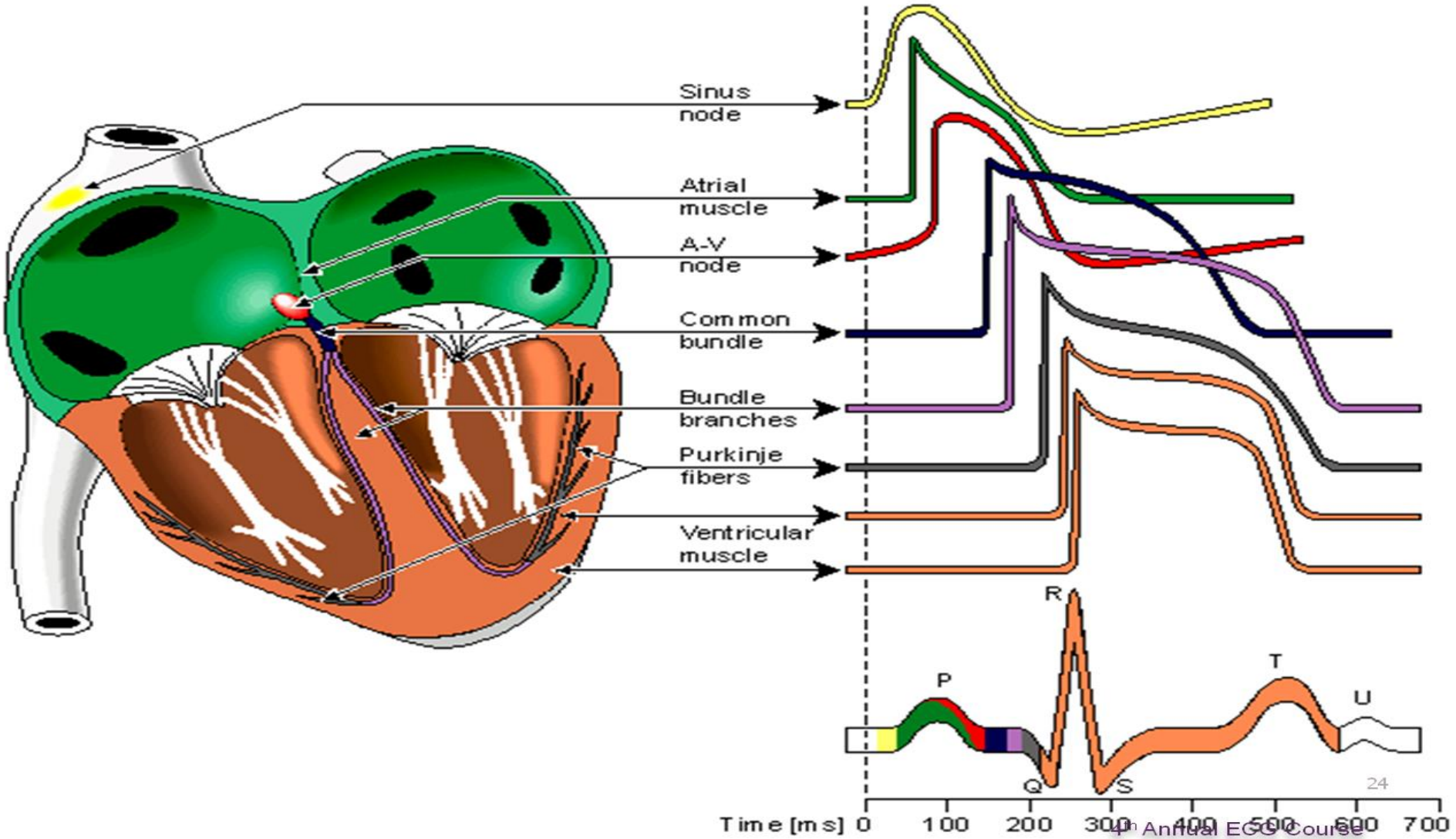
- EKG : waves, intervals, and segments.
- EKG leads
- How to read an EKG

- EKG : waves, intervals, and segments.

Depolarization and Repolarization



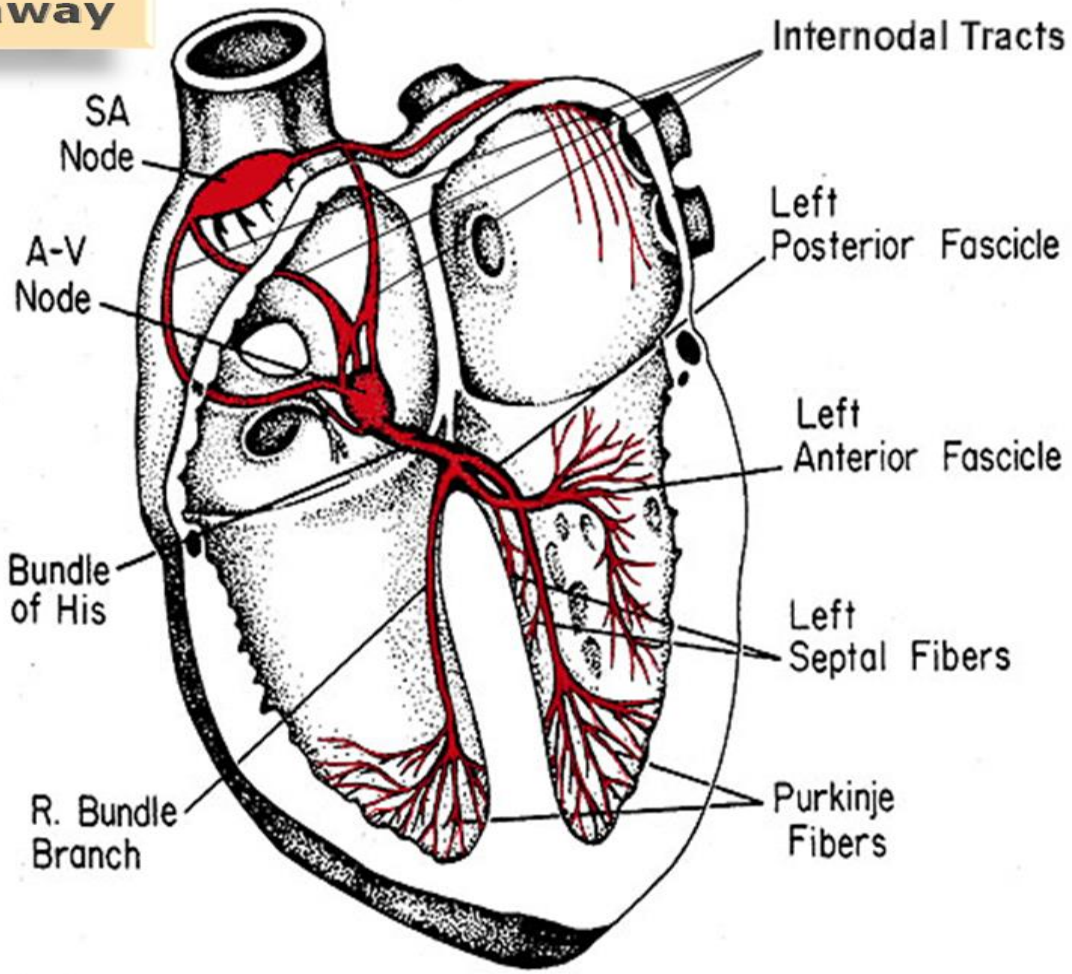



Sinus node
Atrial muscle
A-V node
Common bundle
Bundle branches
Purkinje fibers
Ventricular muscle
R
P
T
U
Q
S
Time [ms] 0
100
200
300
400
500
600
700

The conduction system

Electrical Conduction Pathway

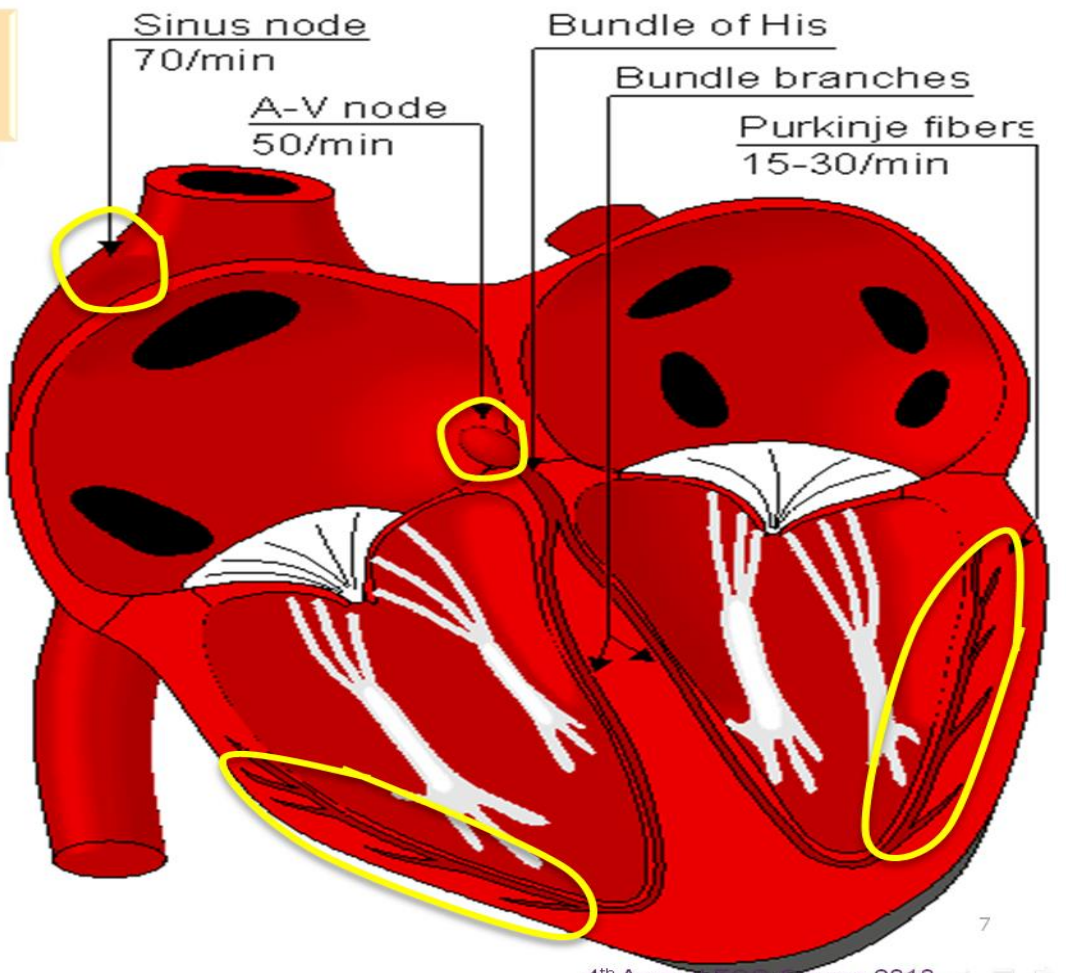
- **Sinoatrial (SA) node**
- **Internodal & Interatrial pathways**
  - Anterior internodal tract
  - Middle internodal tract (Wenckebach's tract)
  - Posterior internodal tract (Thorel's tract)
- **Atrioventricular (AV) node**
- **AV bundle (bundle of His)**
- **Rt & Lt bundle branches**
- **Purkinje fibers**

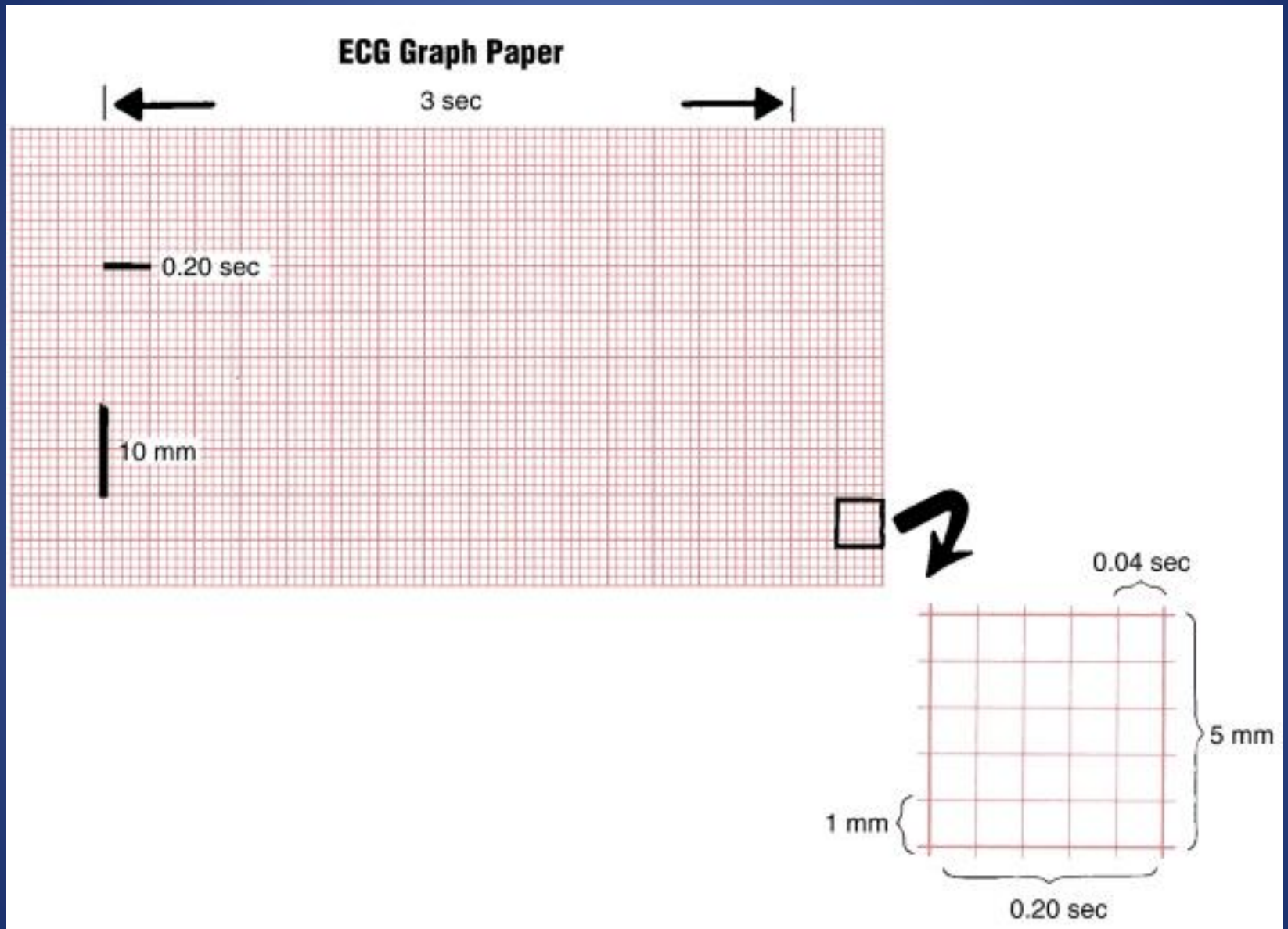


Intrinsic Firing Rates

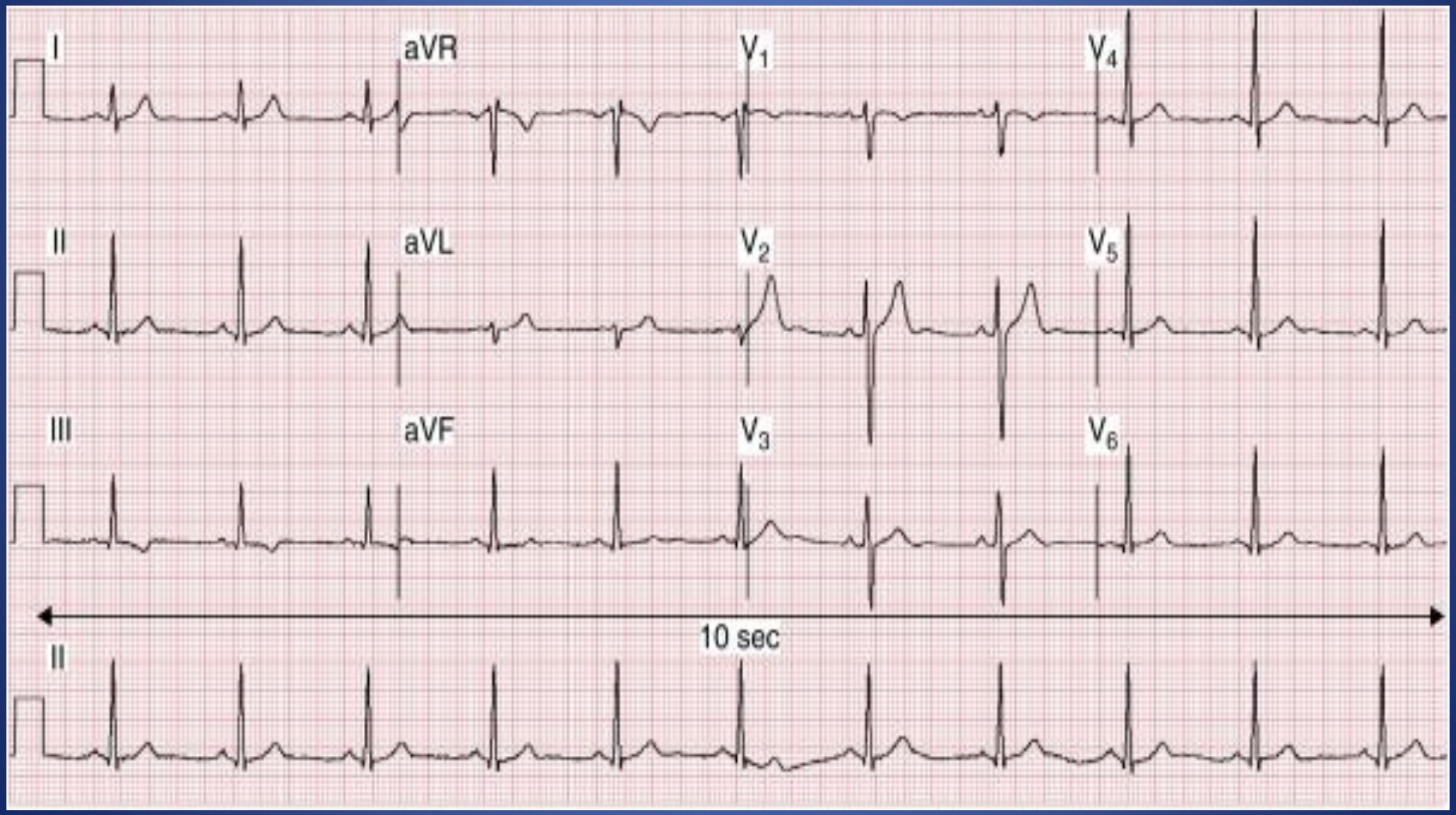
Three potential areas capable of beginning cardiac conduction

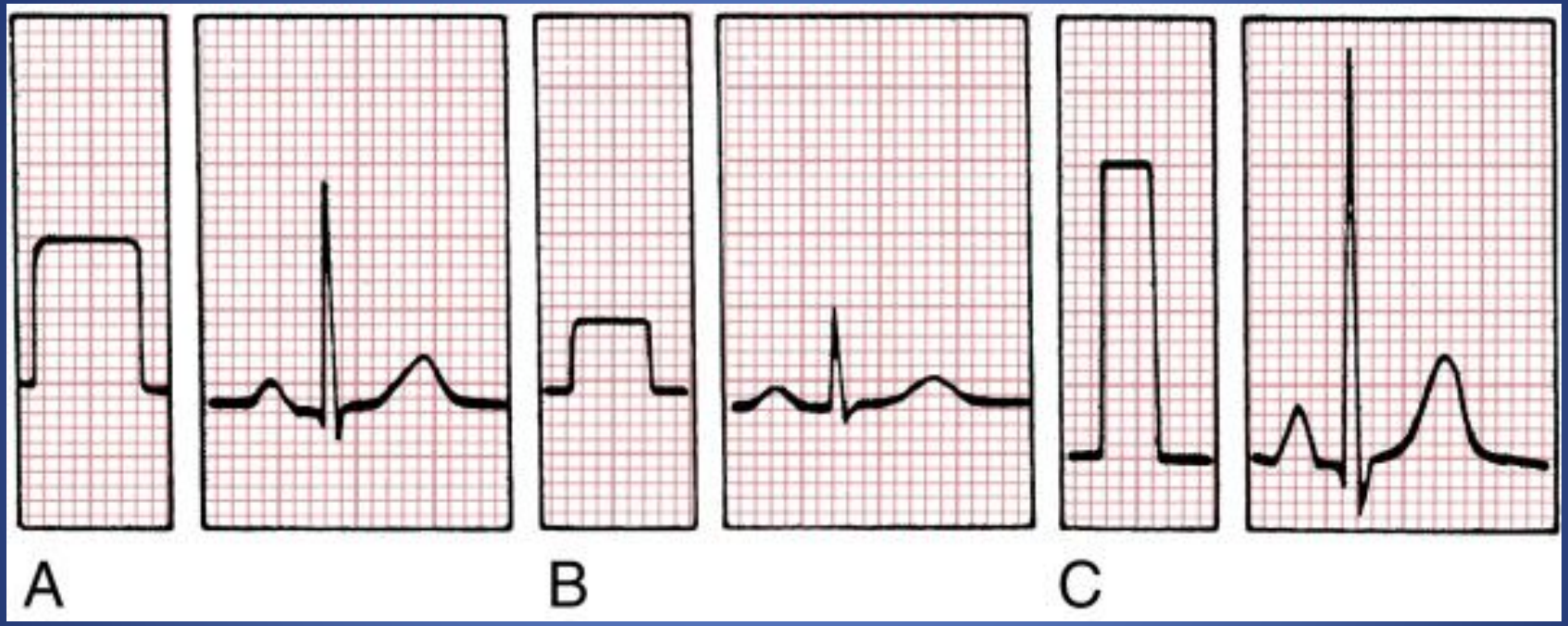
- **SA node:**
  - Cardiac pacemaker
  - Paces at a rate of 60–100 bpm
  - Average of 70 bpm
- **AV node:**
  - 45-60 bpm
- **Purkinje:**
  - 15-45 bpm




ECG Graph Paper
3 sec
0.20 sec
10 mm
0.04 sec
5 mm
1 mm
0.20 sec

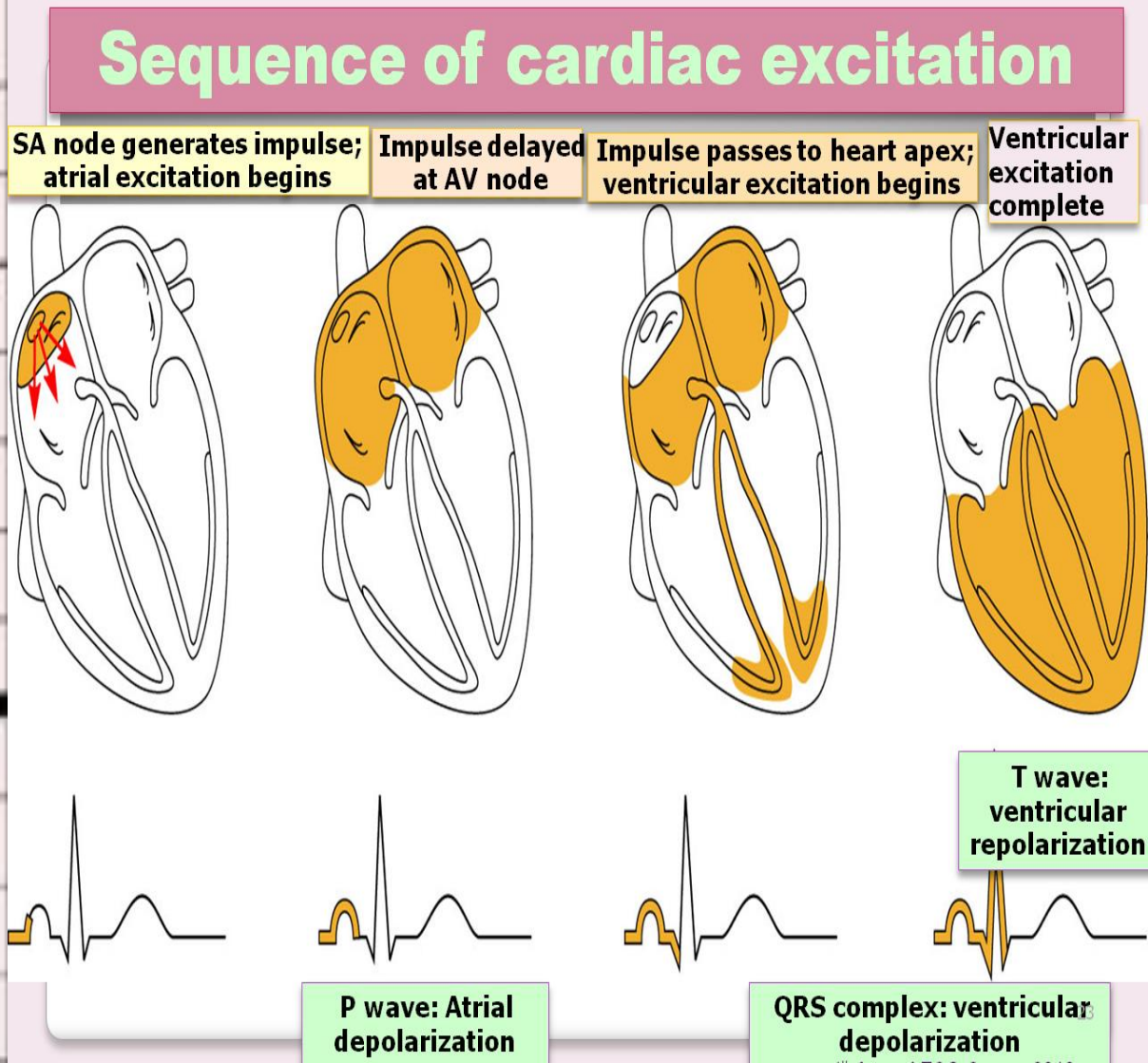
12 Leads EKG



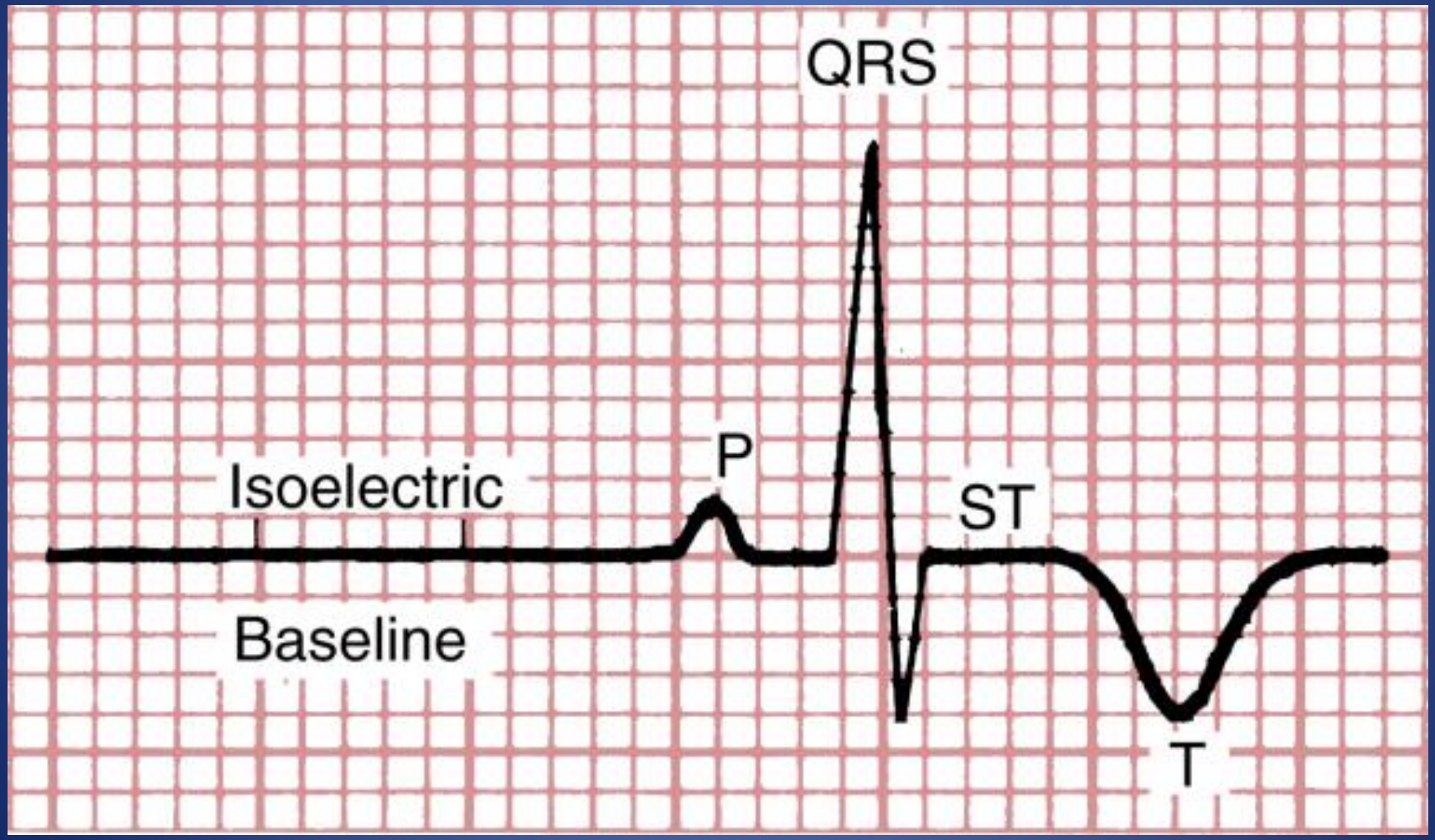

A
B
C

Waves

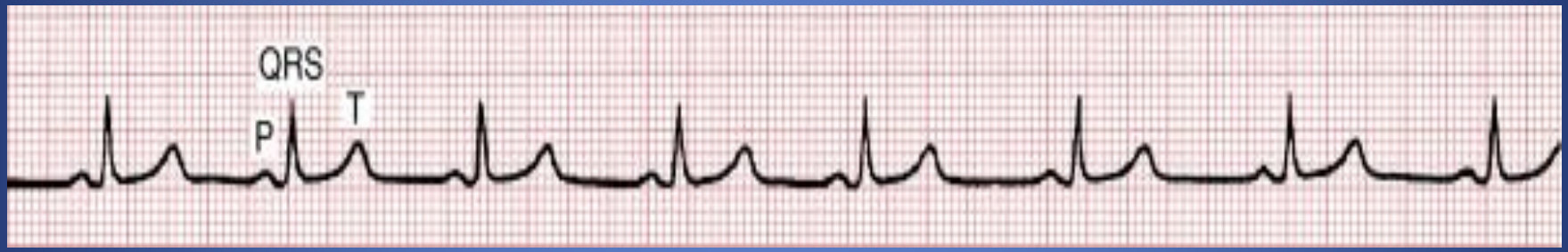

QRS
T
P
ST
U


Sequence of cardiac excitation
SA node generates impulse; atrial excitation begins
Impulse delayed at AV node
Impulse passes to heart apex; ventricular excitation begins
Ventricular excitation complete
T wave: ventricular repolarization
P wave: Atrial depolarization
QRS complex: ventricular depolarization

Waves

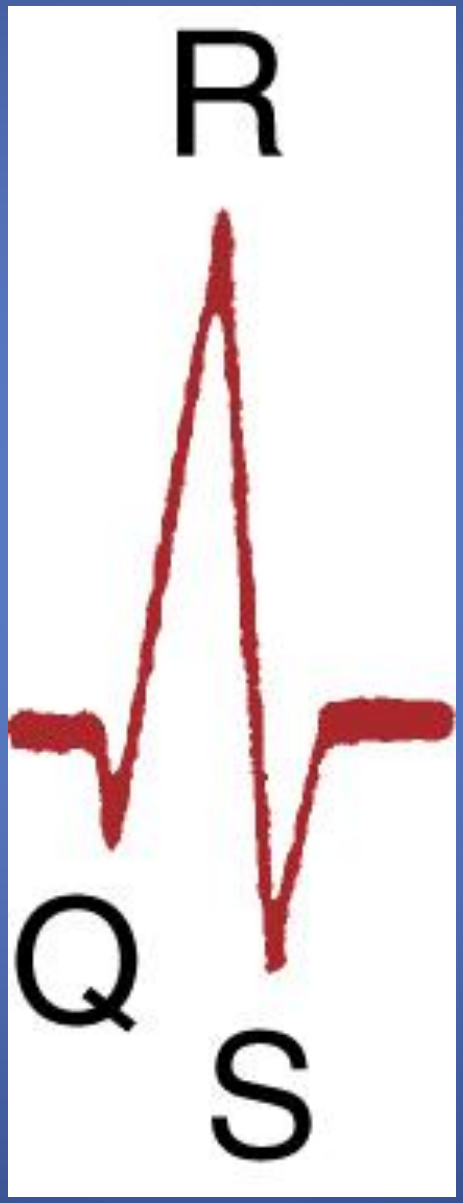


Waves

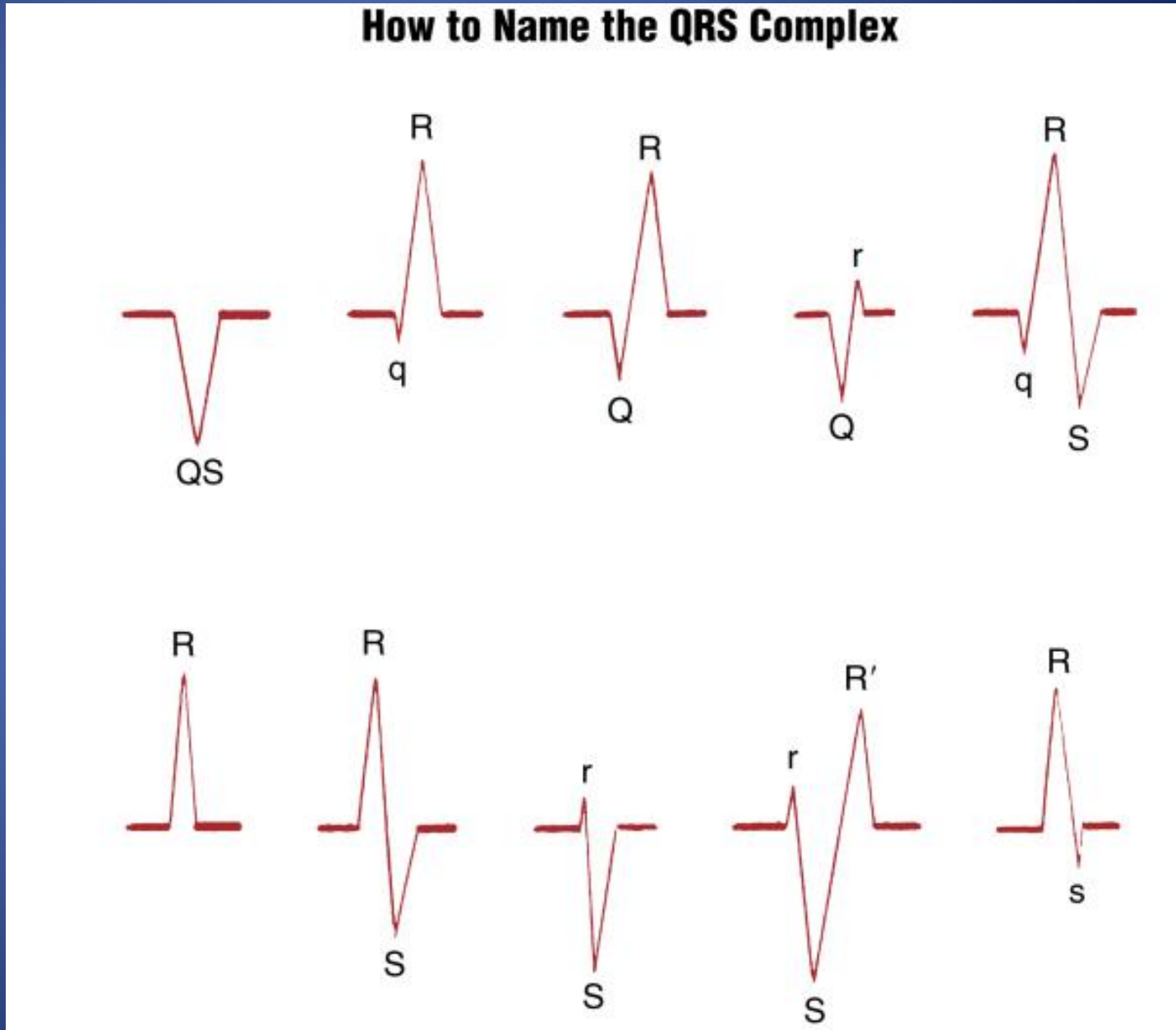


P-wave

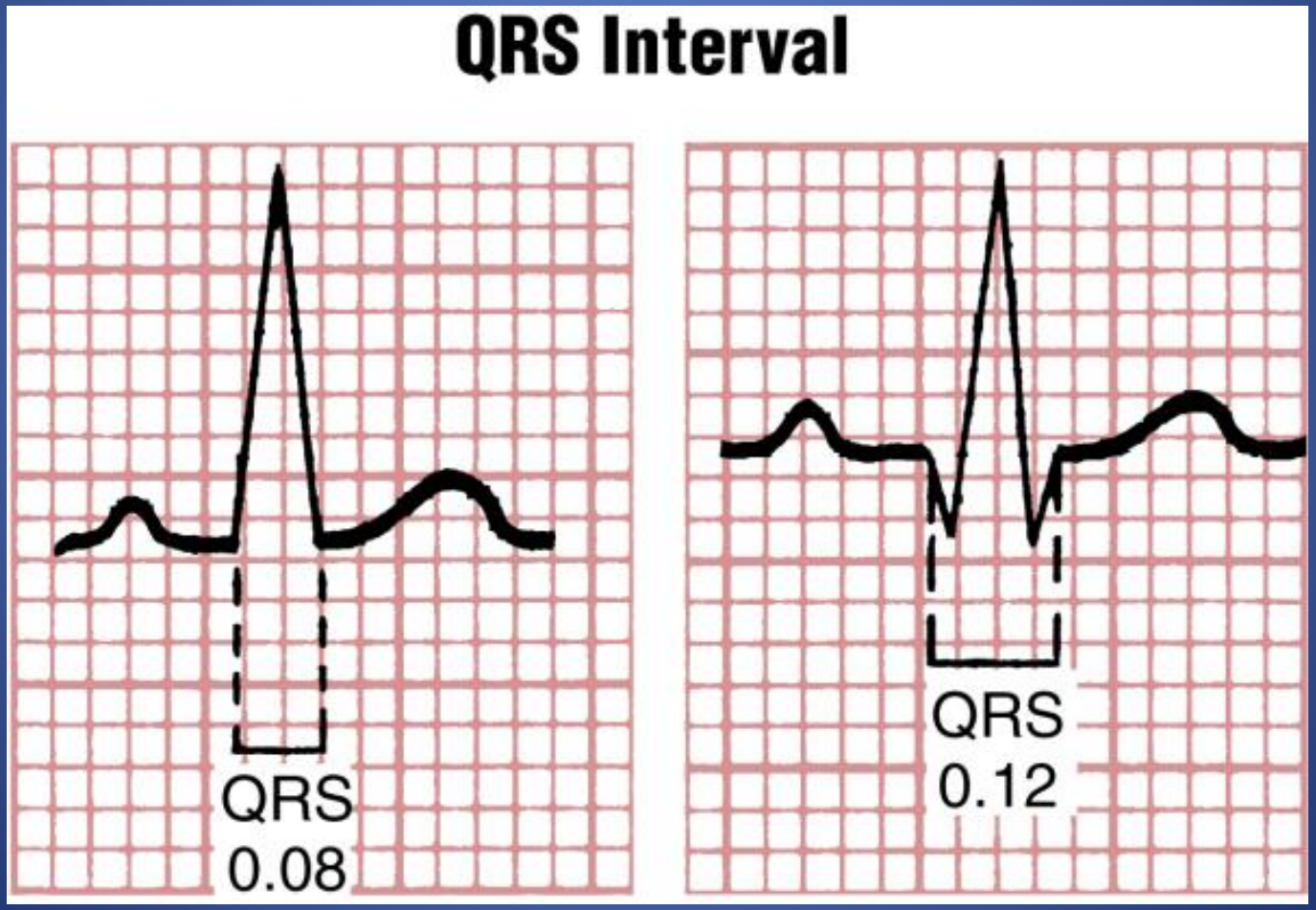
QRS complex



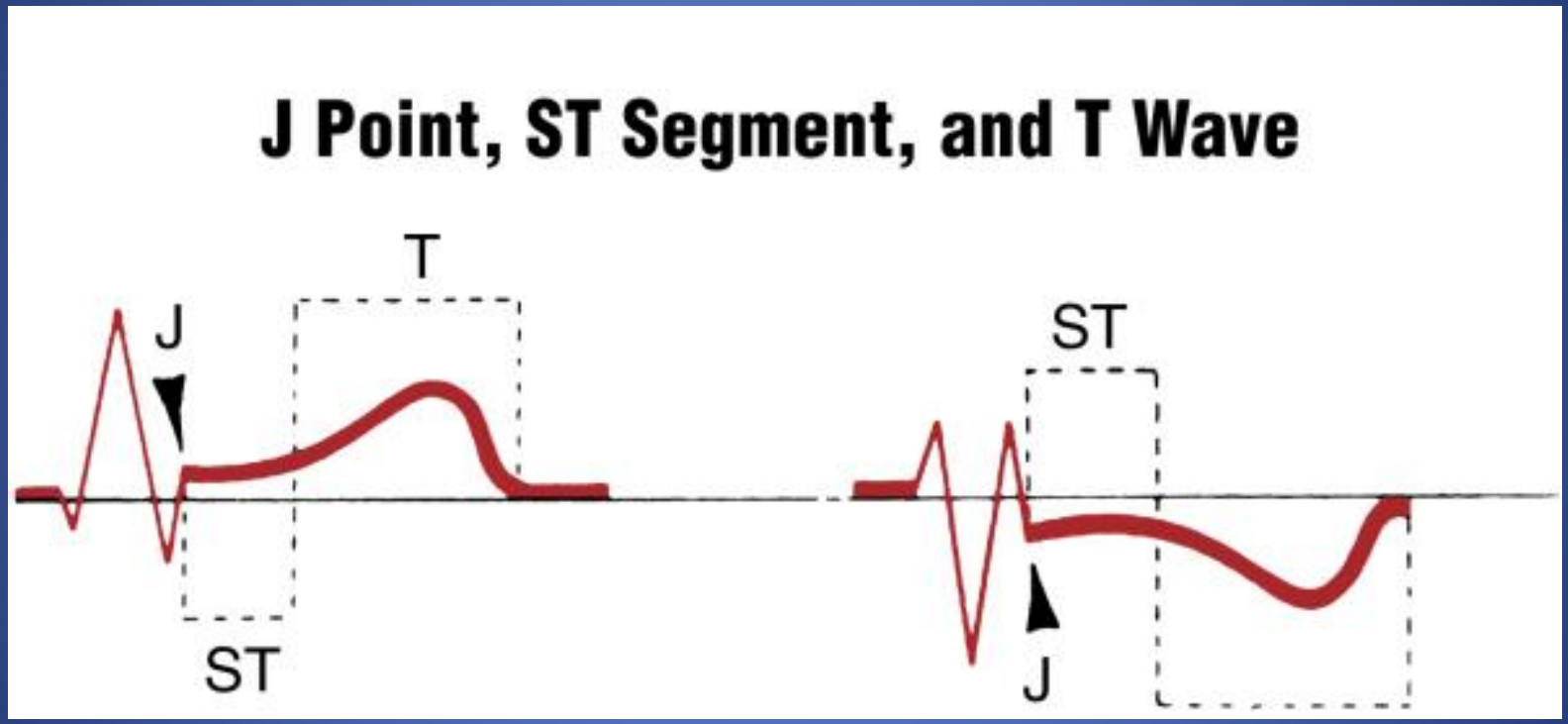
QRS complex



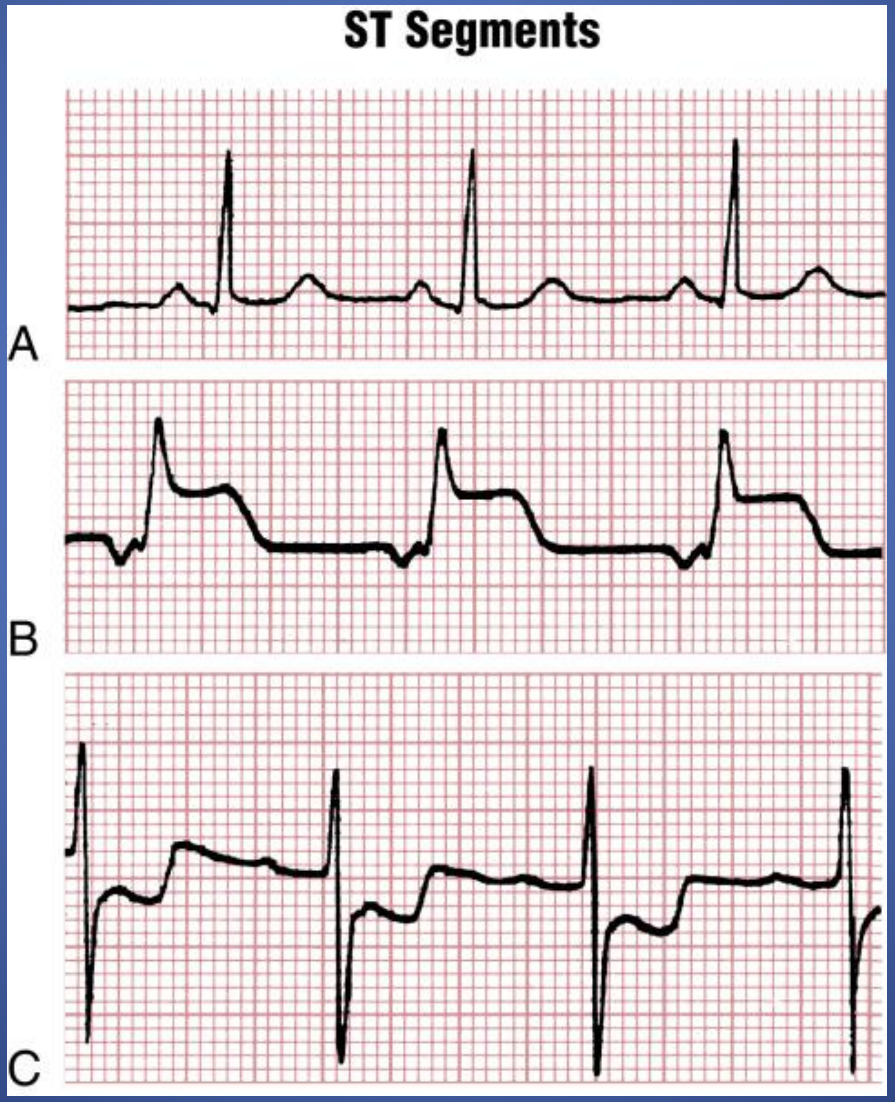
QRS complex



ST segment and T wave



ST segment and T wave



QT interval

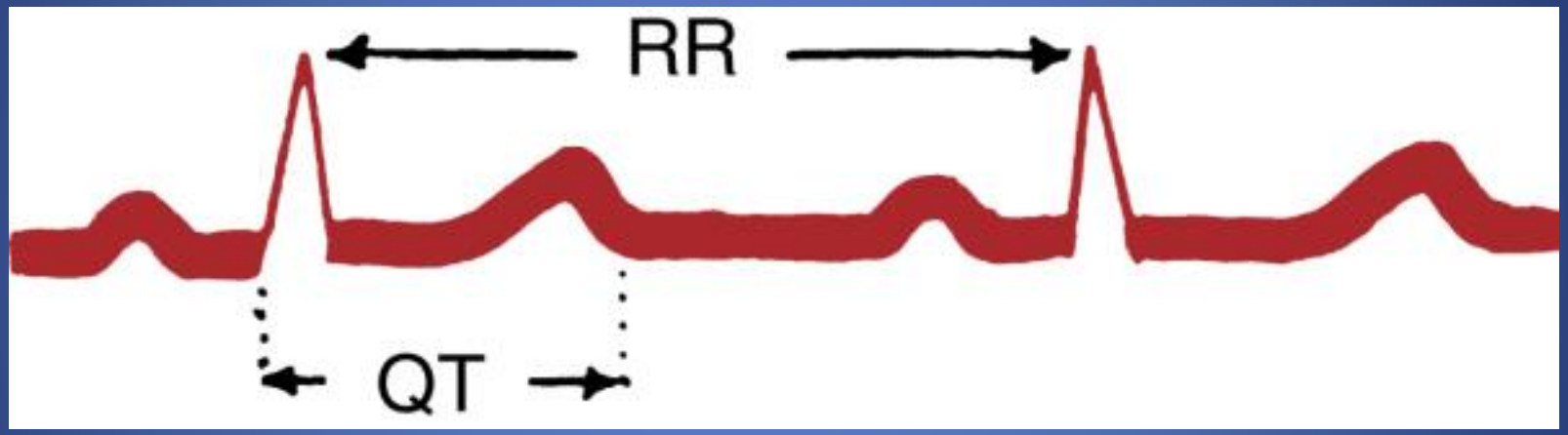
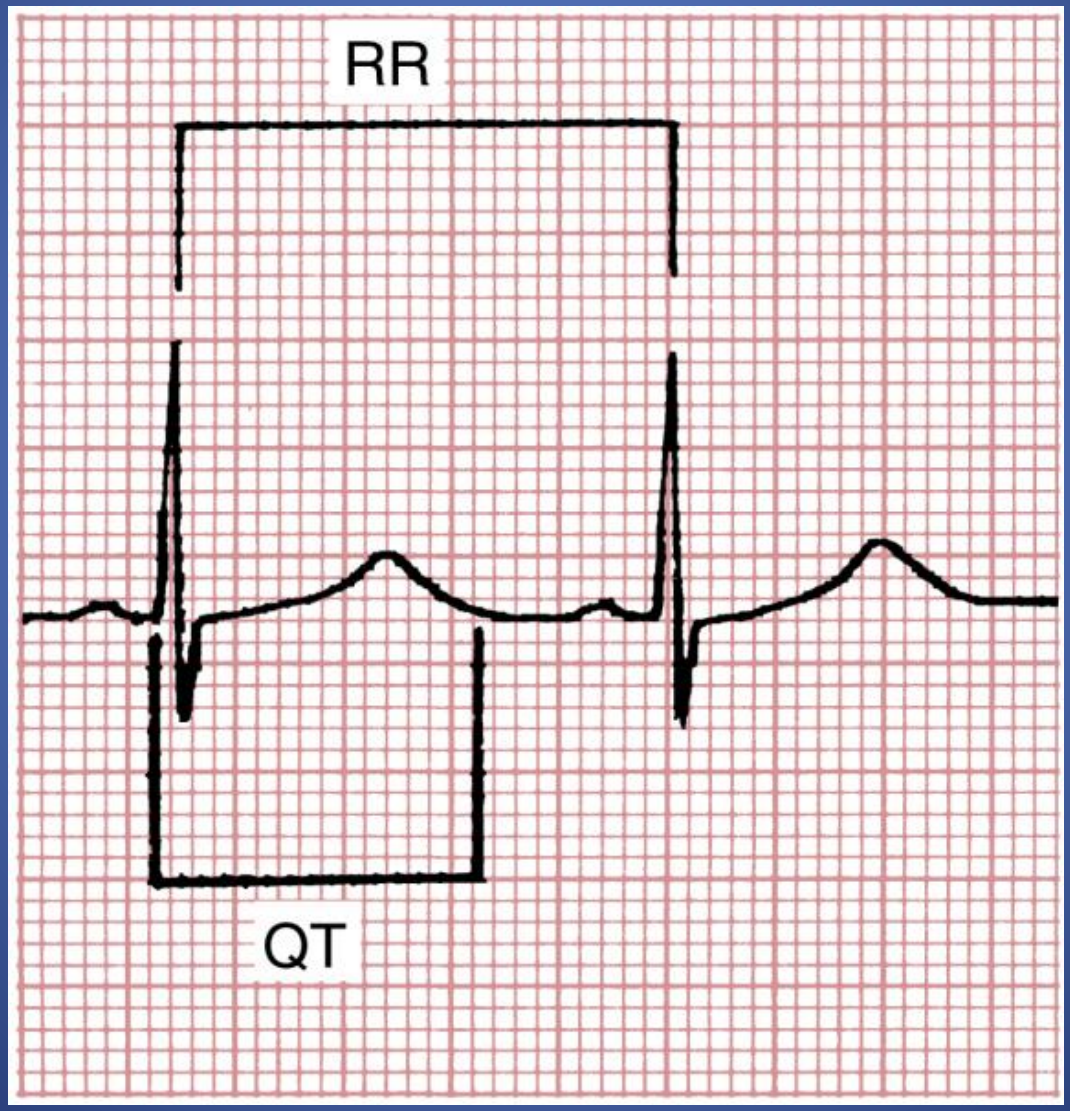


TABLE 2-1 -- QT Interval: *Approximate* Upper Limits of Normal

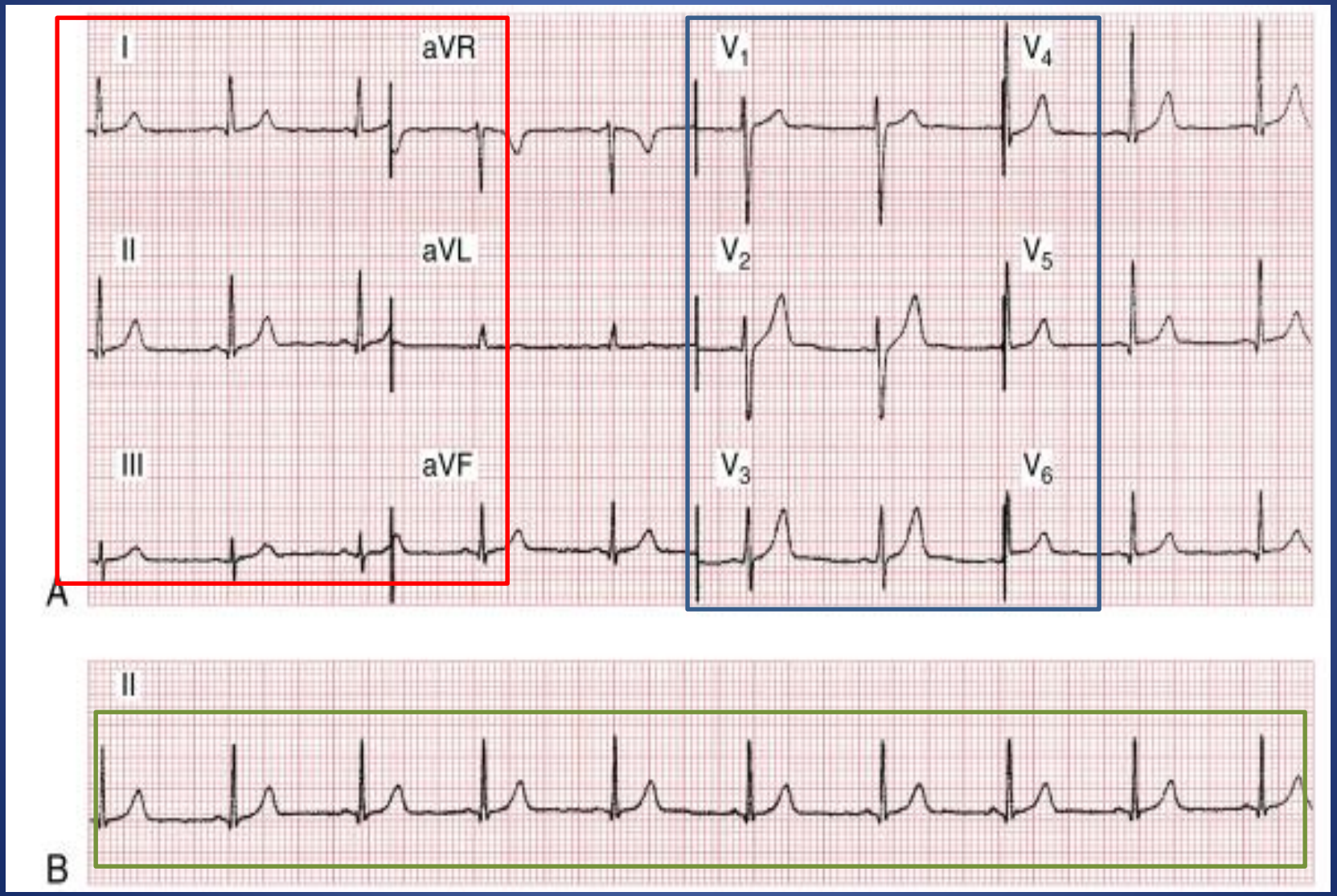
Measured RR Interval (sec)	Heart Rate (beats/min)	QT Interval Upper Normal Limit (sec)
1.50	40	0.50
1.20	50	0.46
1.00	60	0.44
0.86	70	0.40
0.80	75	0.38
0.75	80	0.37
0.67	90	0.35
0.60	100	0.34
0.50	120	0.31
0.40	150	0.25

Prolonged QT interval

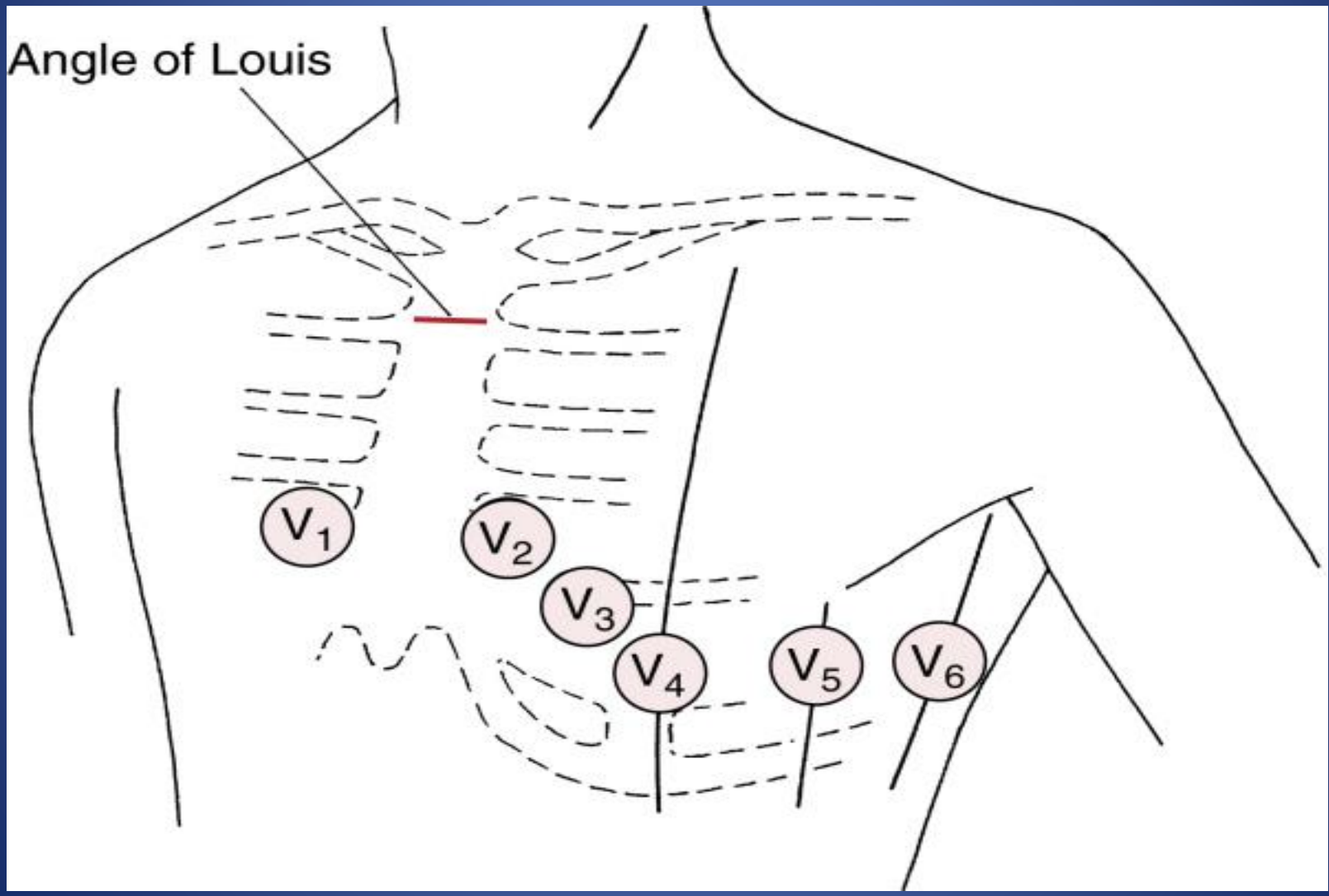


EKG leads

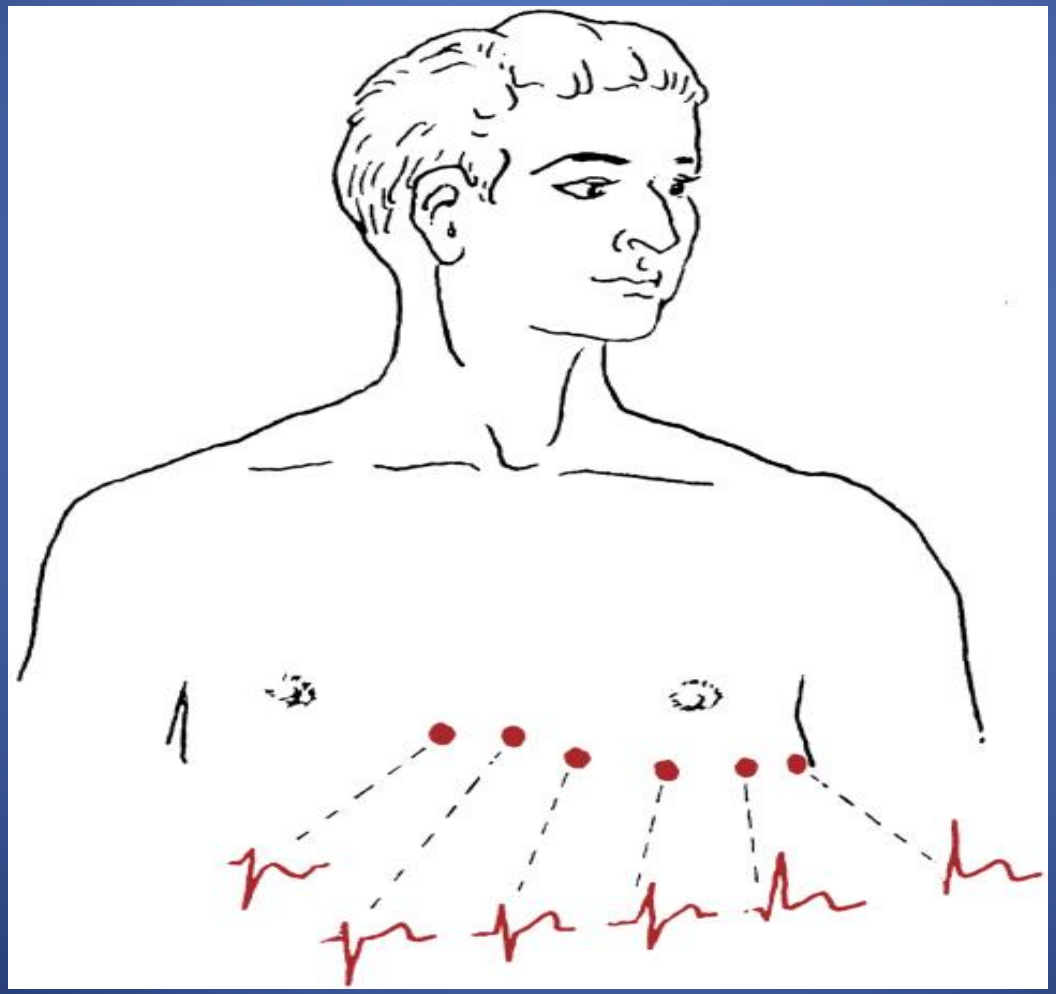
EKG



Chest leads



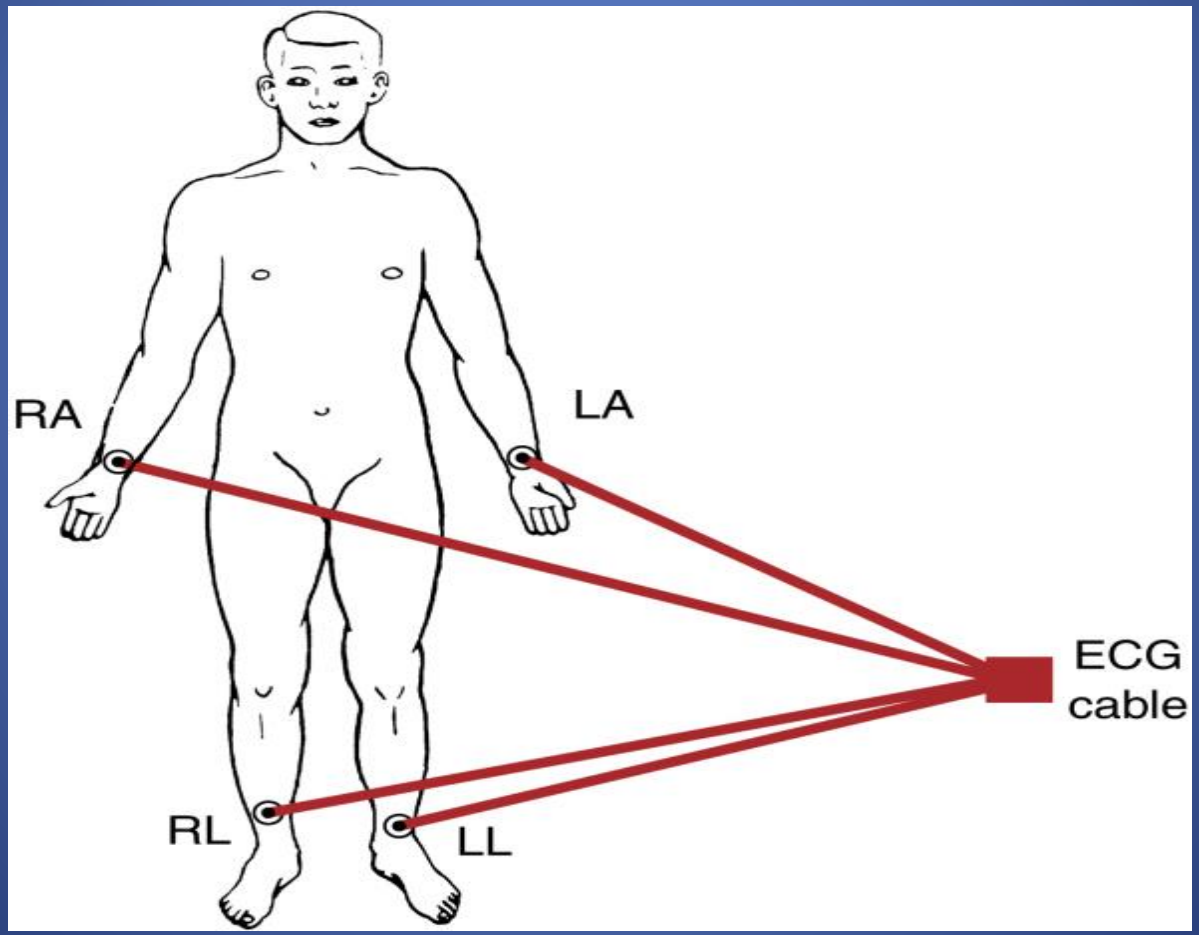
Chest leads



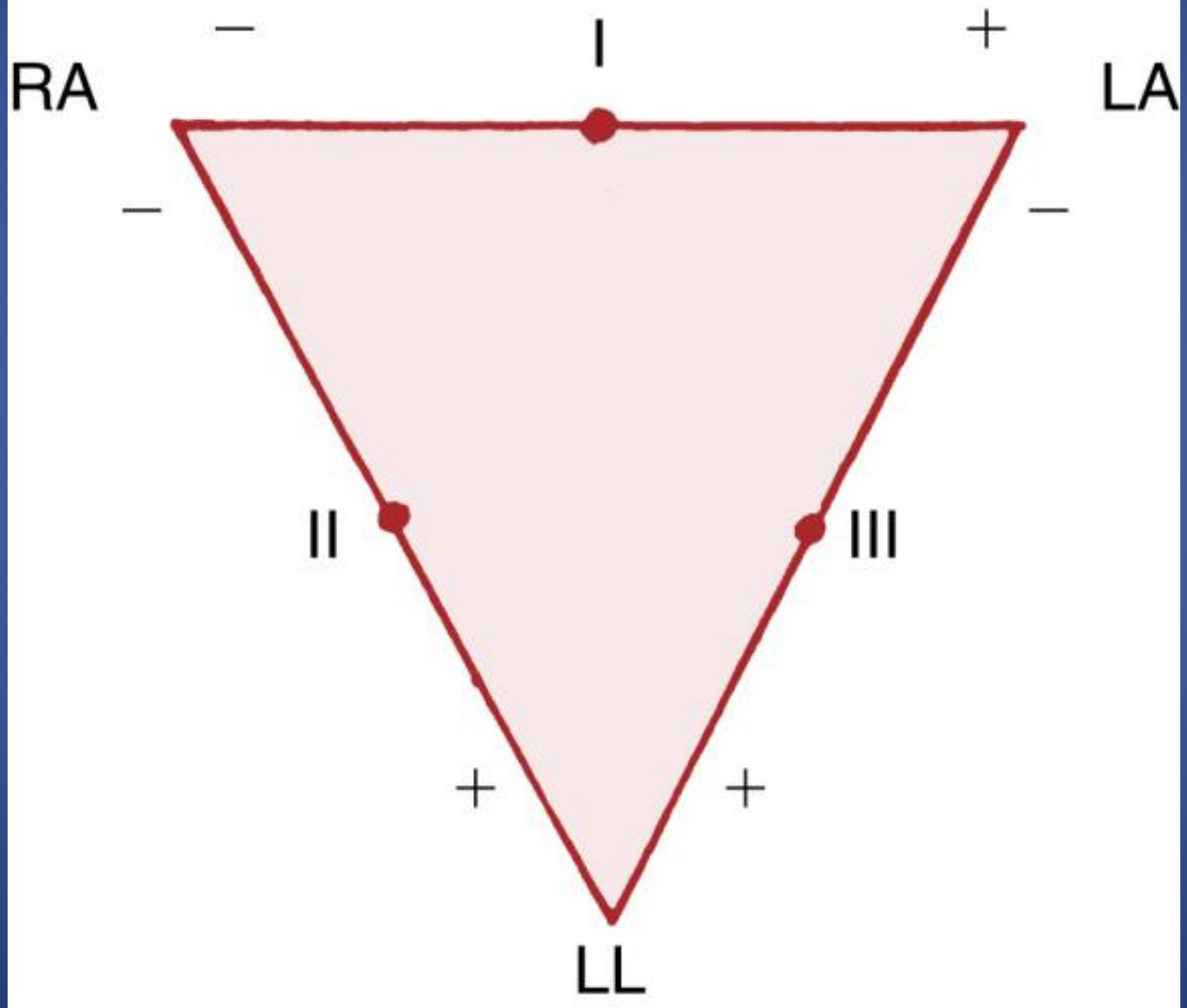
BOX 3-1 Conventional Placement of ECG Chest Leads

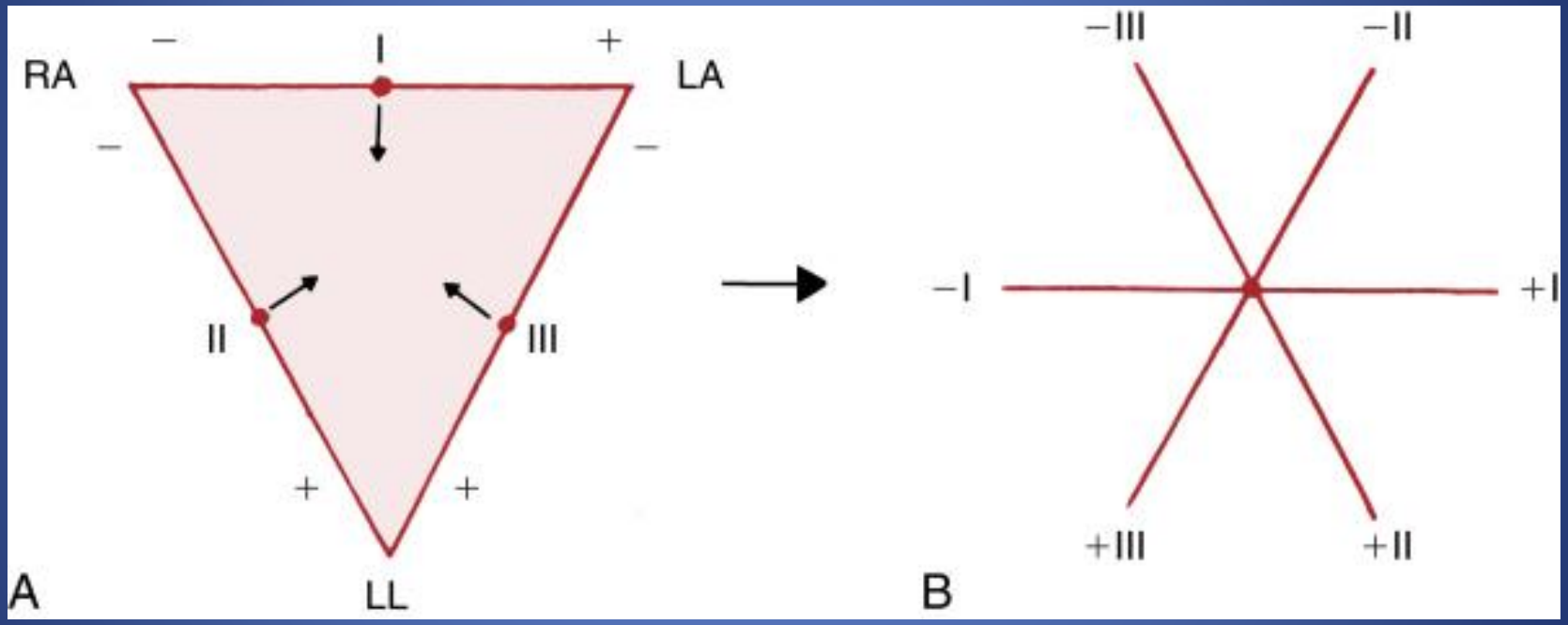
- Lead V_1 is recorded with the electrode in the fourth intercostal space just to the right of the sternum.
- Lead V_2 is recorded with the electrode in the fourth intercostal space just to the left of the sternum.
- Lead V_3 is recorded on a line midway between leads V_2 and V_4.
- Lead V_4 is recorded in the midclavicular line in the fifth interspace.
- Lead V_5 is recorded in the anterior axillary line at the same level as lead V_4.
- Lead V_6 is recorded in the midaxillary line at the same level as lead V_4.

Limb leads

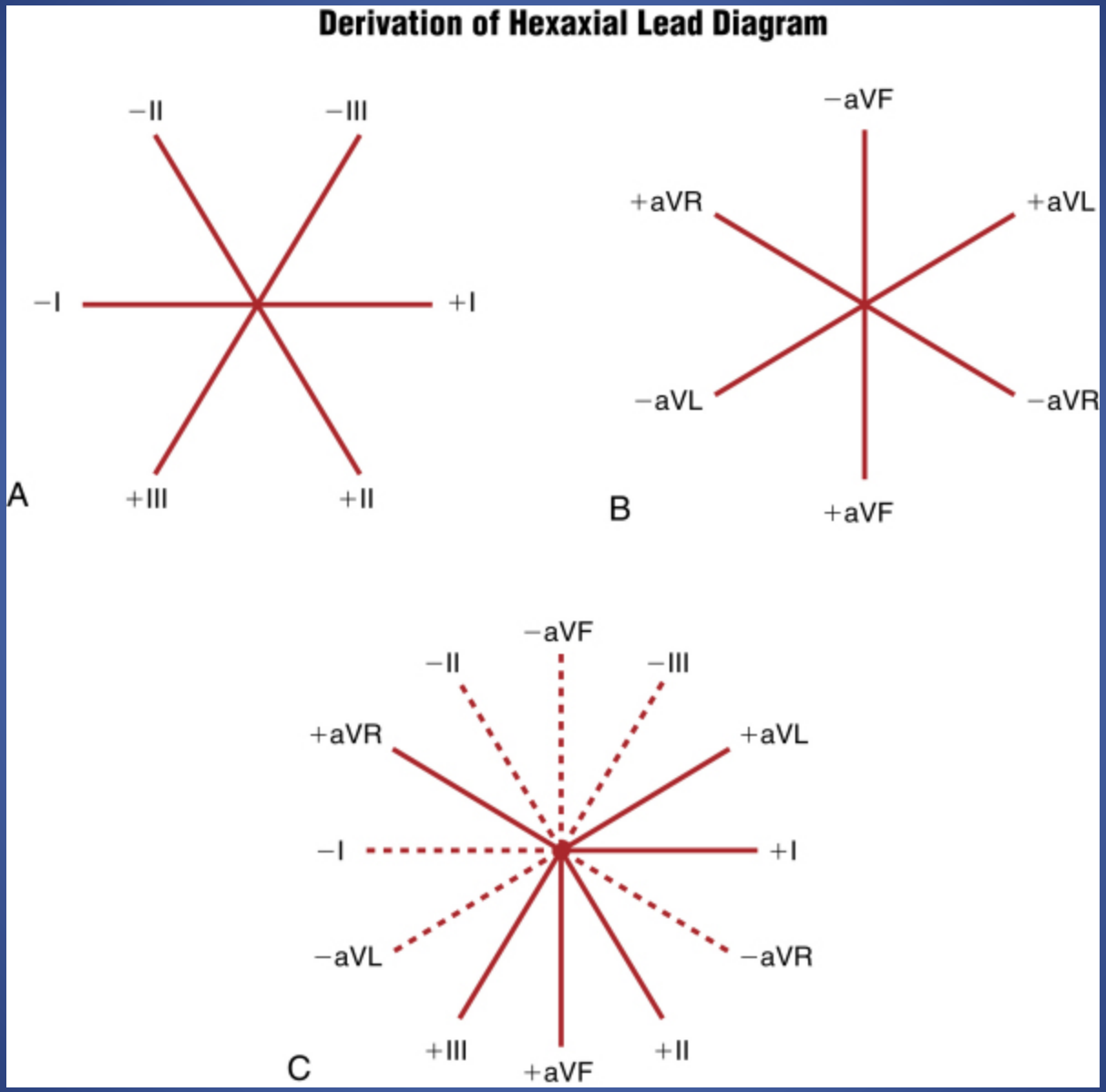


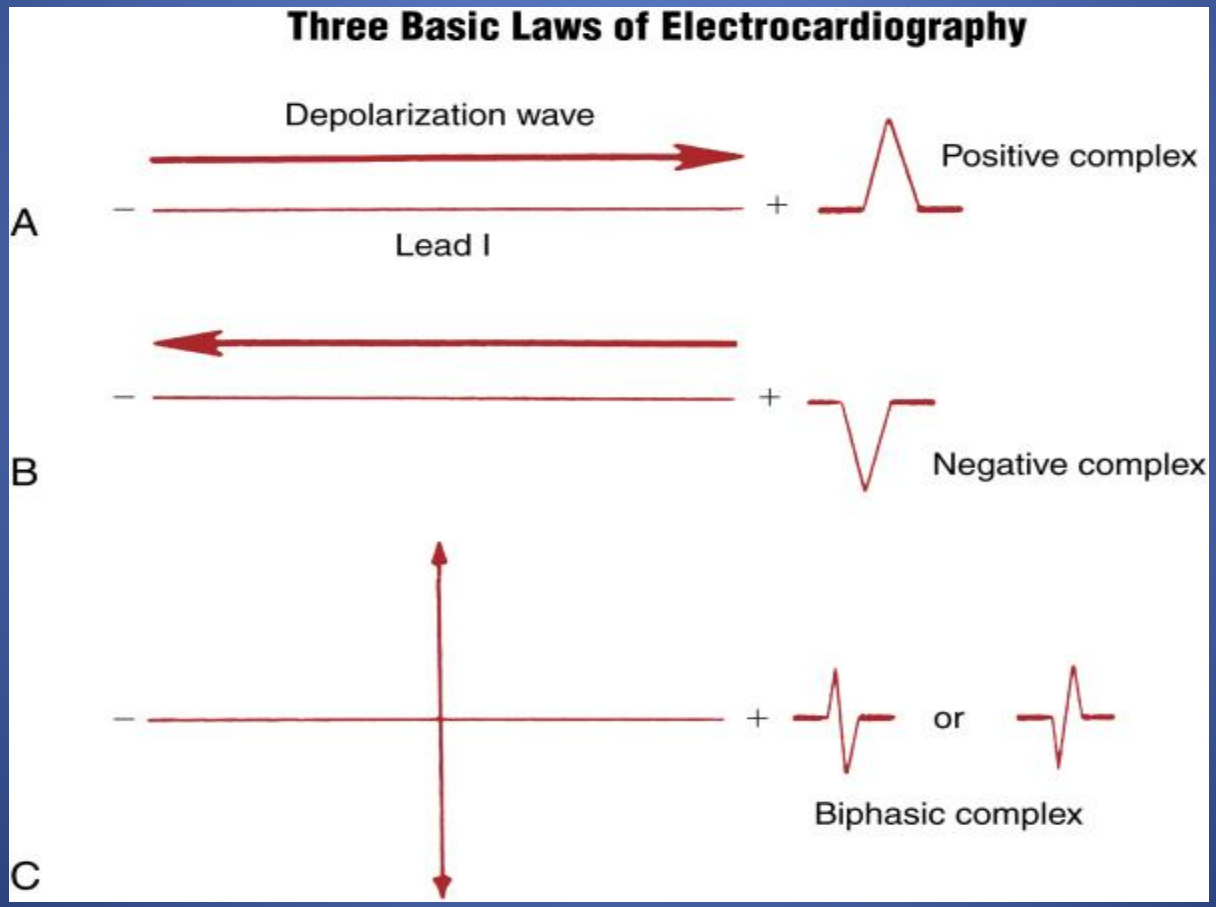
Einthoven's Triangle

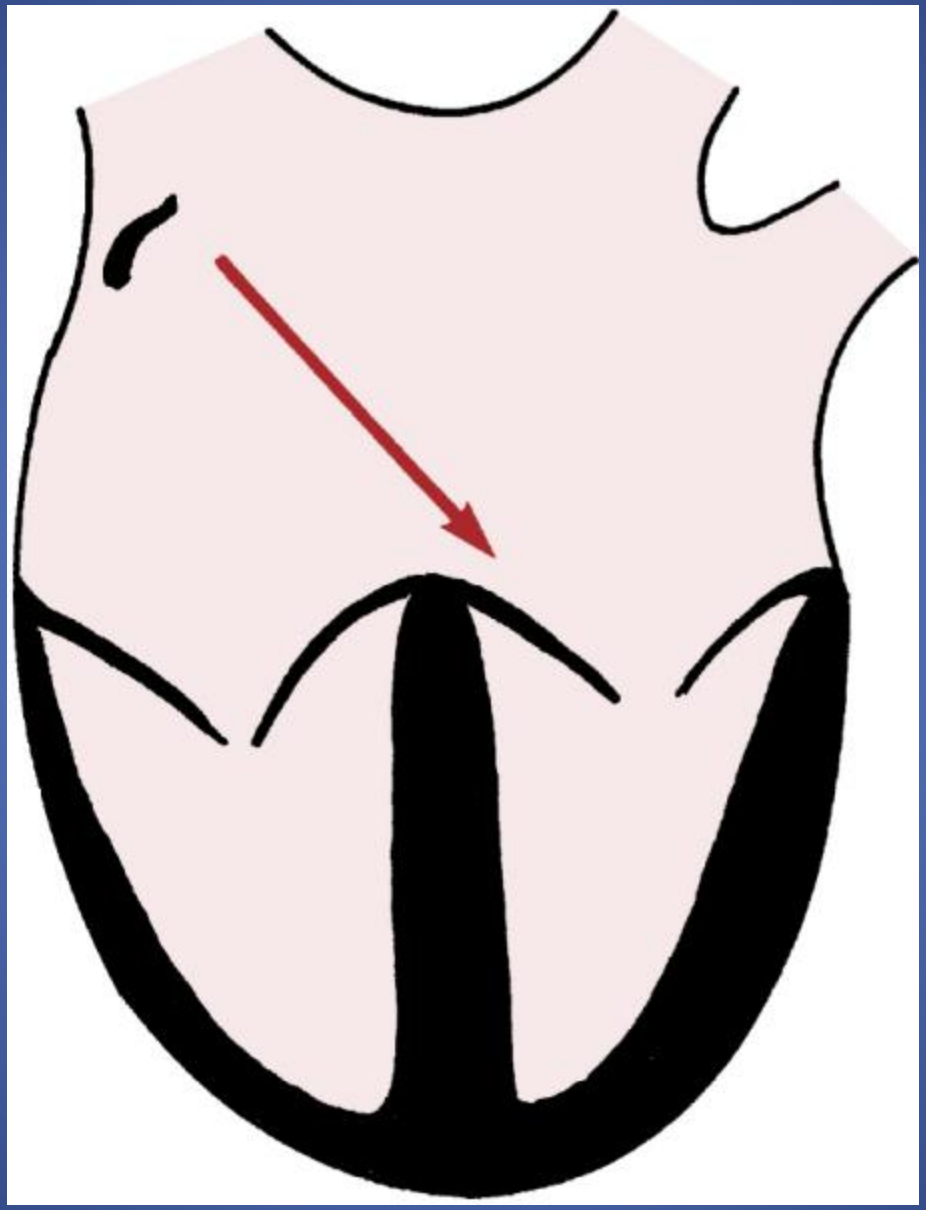



RA
LA
LL
I
II
III
−
+
−
−
+
+
A
−III
−II
−I
+I
+III
+II
B

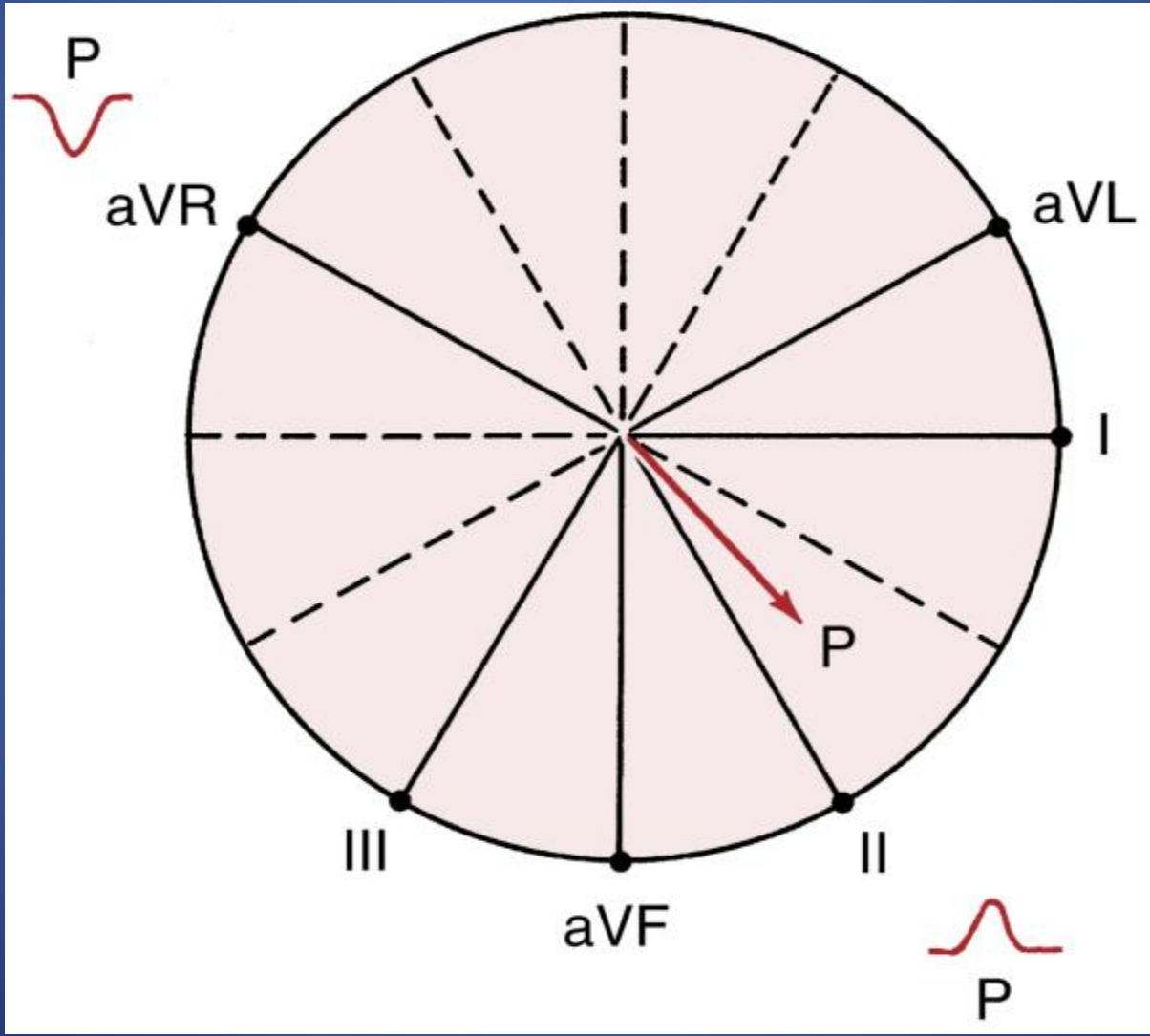
Derivation of Hexaxial Lead Diagram

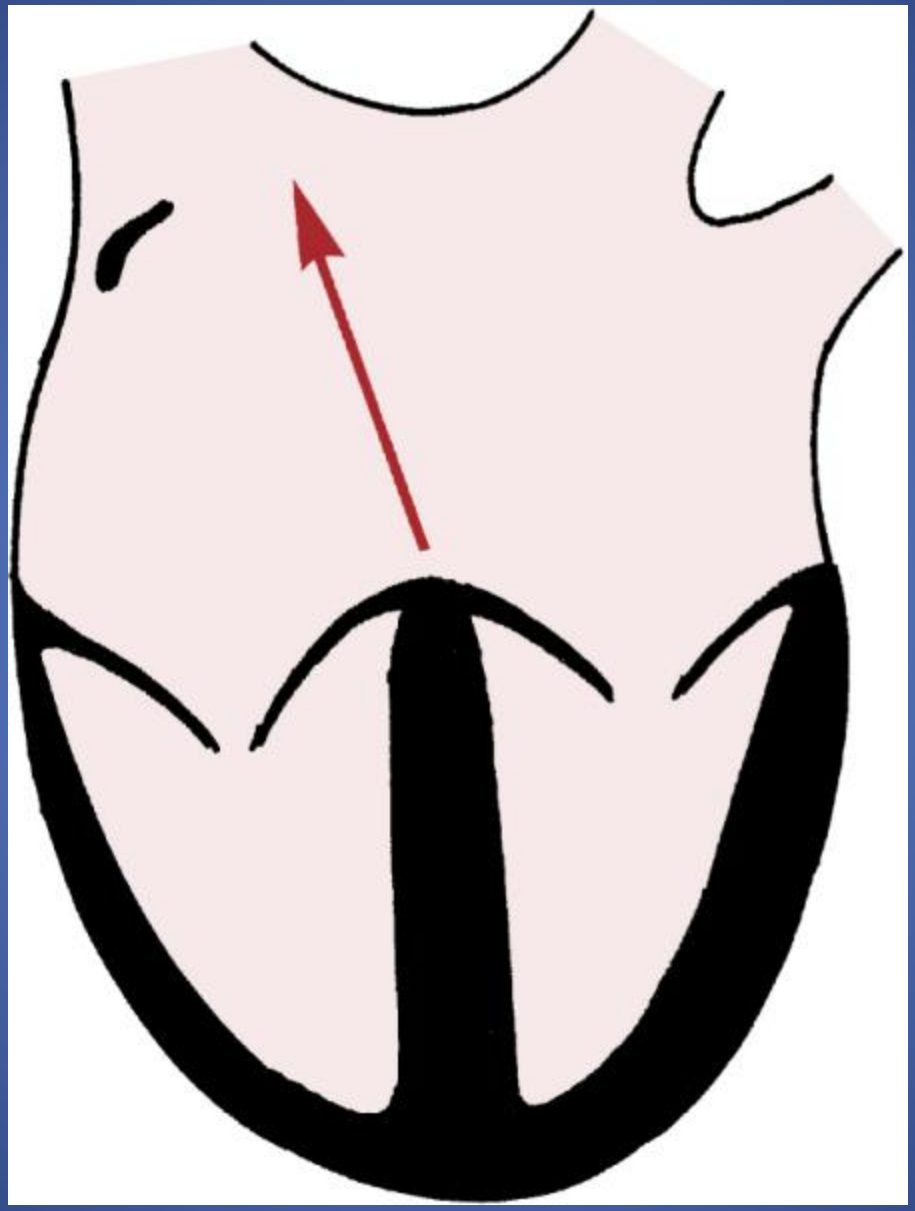


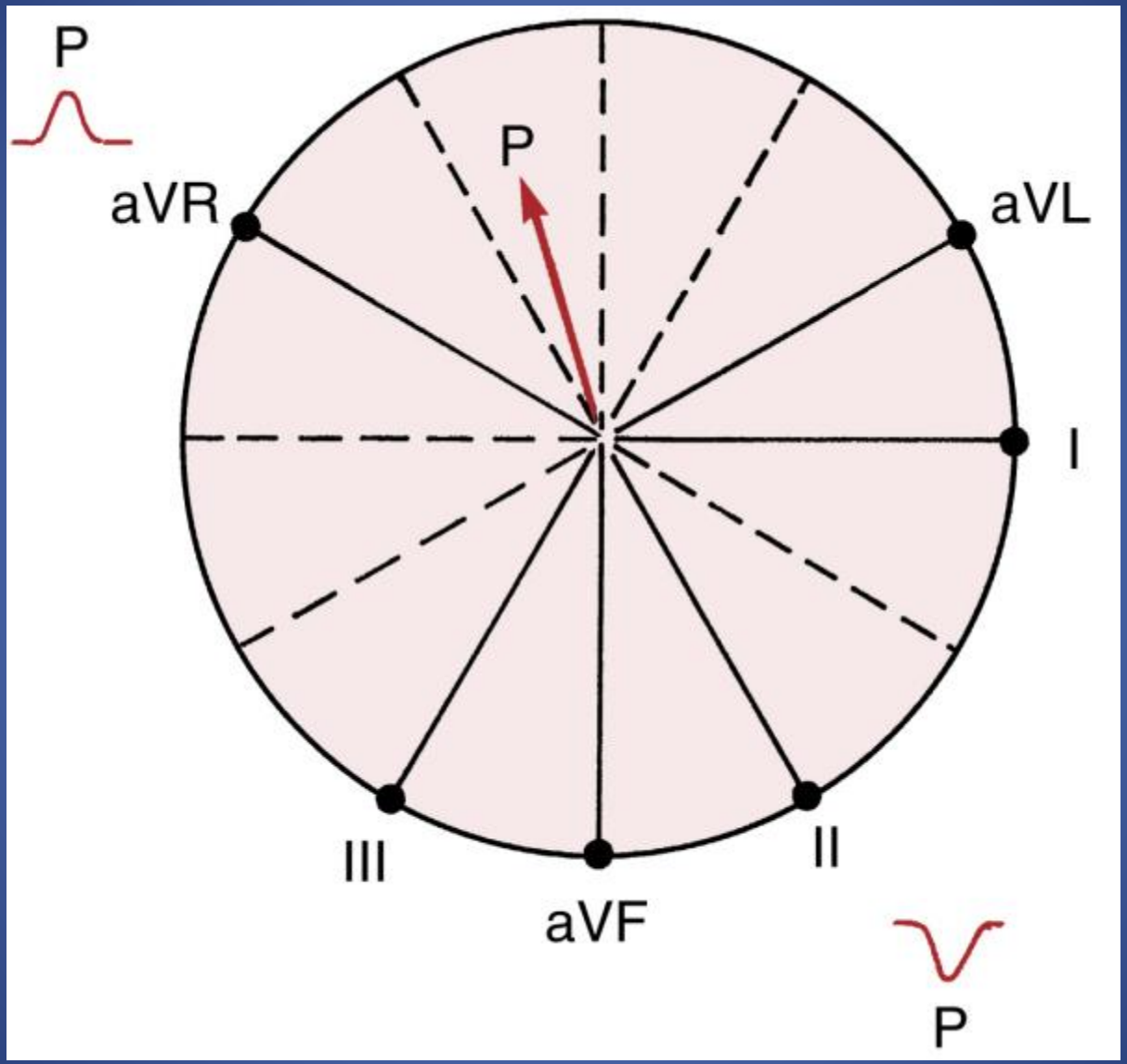

Three Basic Laws of Electrocardiography
Depolarization wave
Positive complex
A
–
+
Lead I
B
–
+
Negative complex
C
–
+
or
Biphasic complex



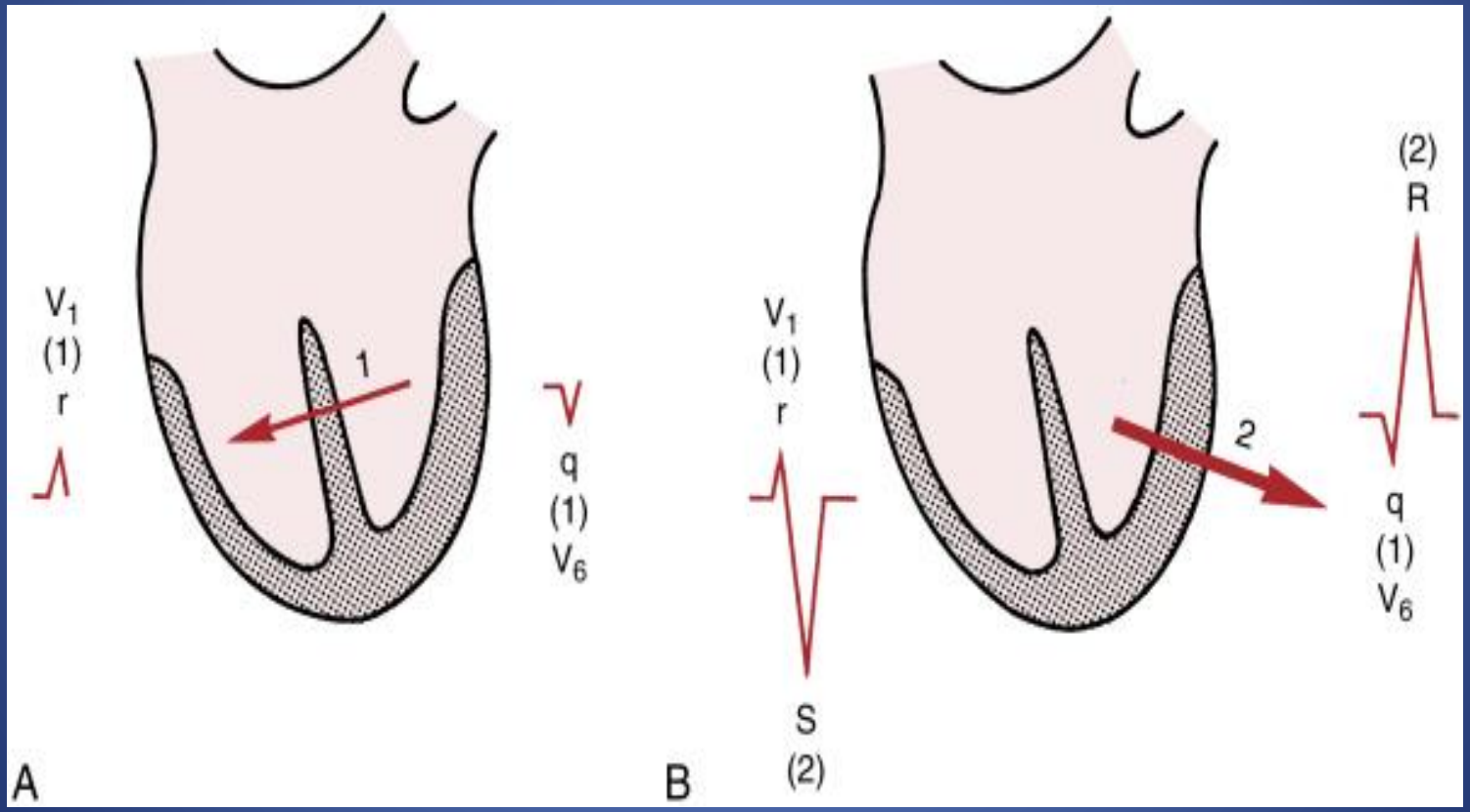
P-wave axis



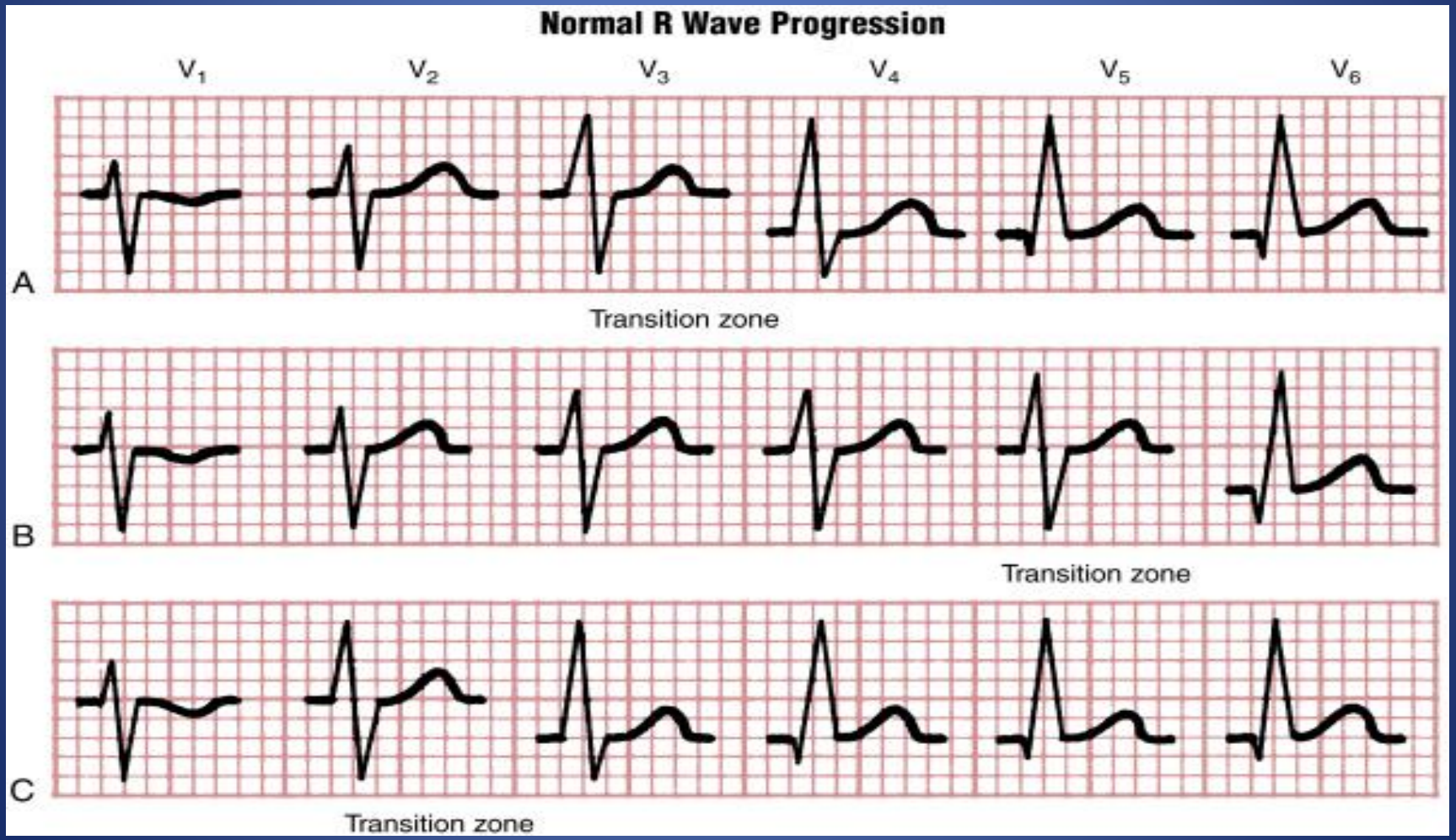



P
P
aVR
aVL
I
III
II
aVF
P

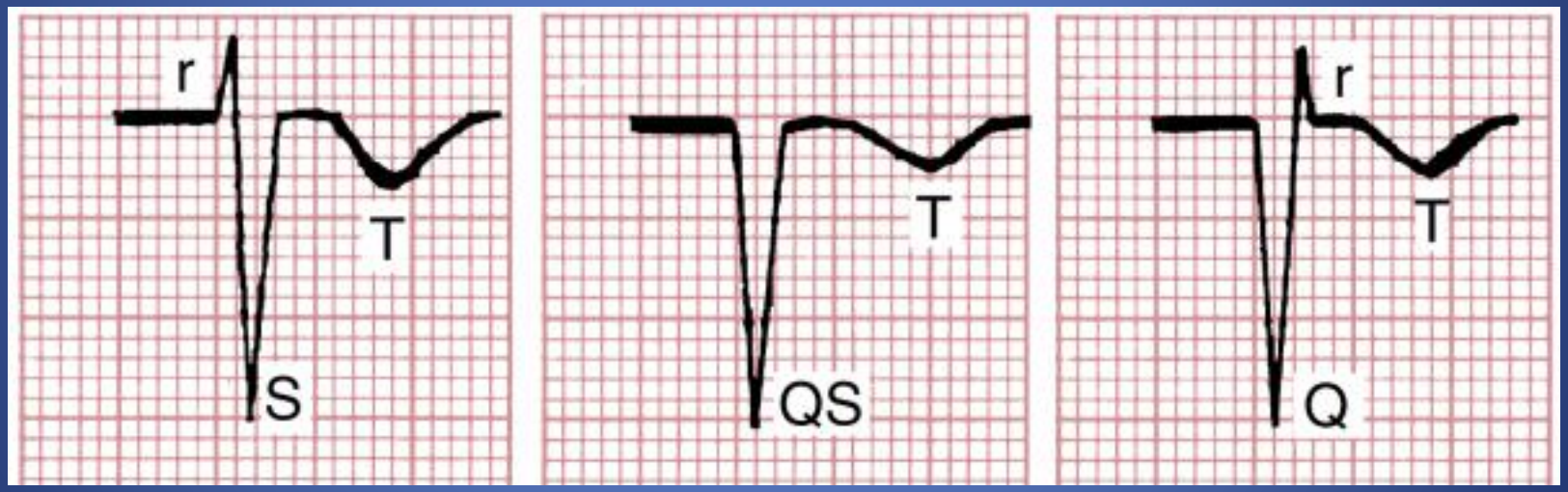
Chest leads



Chest leads


Normal R Wave Progression
V1
V2
V3
V4
V5
V6
A
Transition zone
B
Transition zone
C
Transition zone

aVR



How to read an EKG

How to read an EKG

- Rate
- Rhythm
- Axis
- Waves and intervals

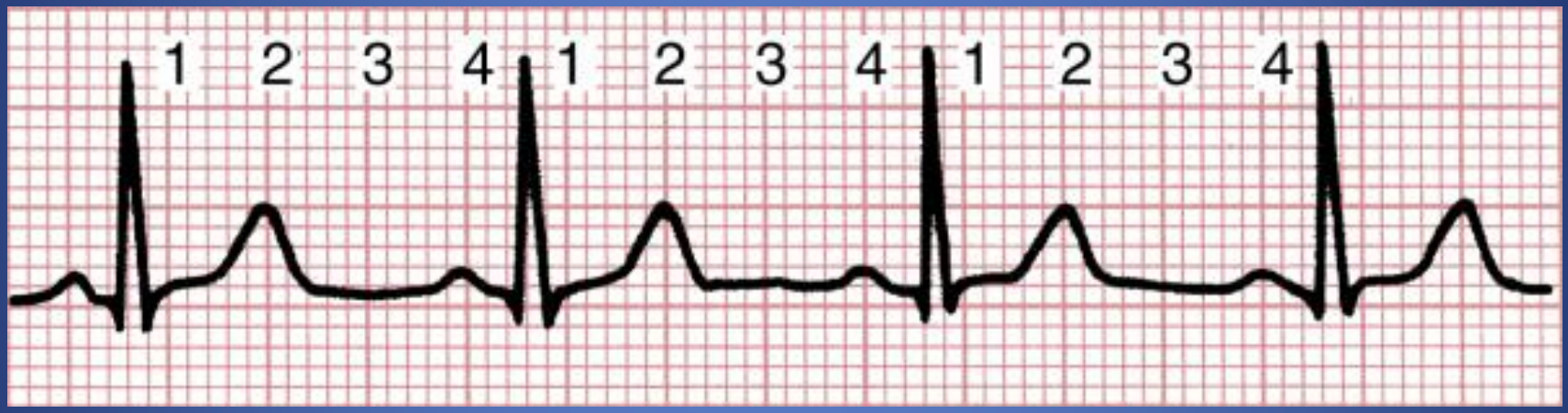
Rate

- **Normal sinus rate:** (60-100).
- **Tachycardia:** >100.
- **Bradycardia:** <60.

How to Calculate Rate

- 300/No. of large squares R-R.
- 1500/No. of small squares R-R.
- No. of (R) waves in the strip×6.
- 300›››150 ›››75 ›››60 ›››55

Rate

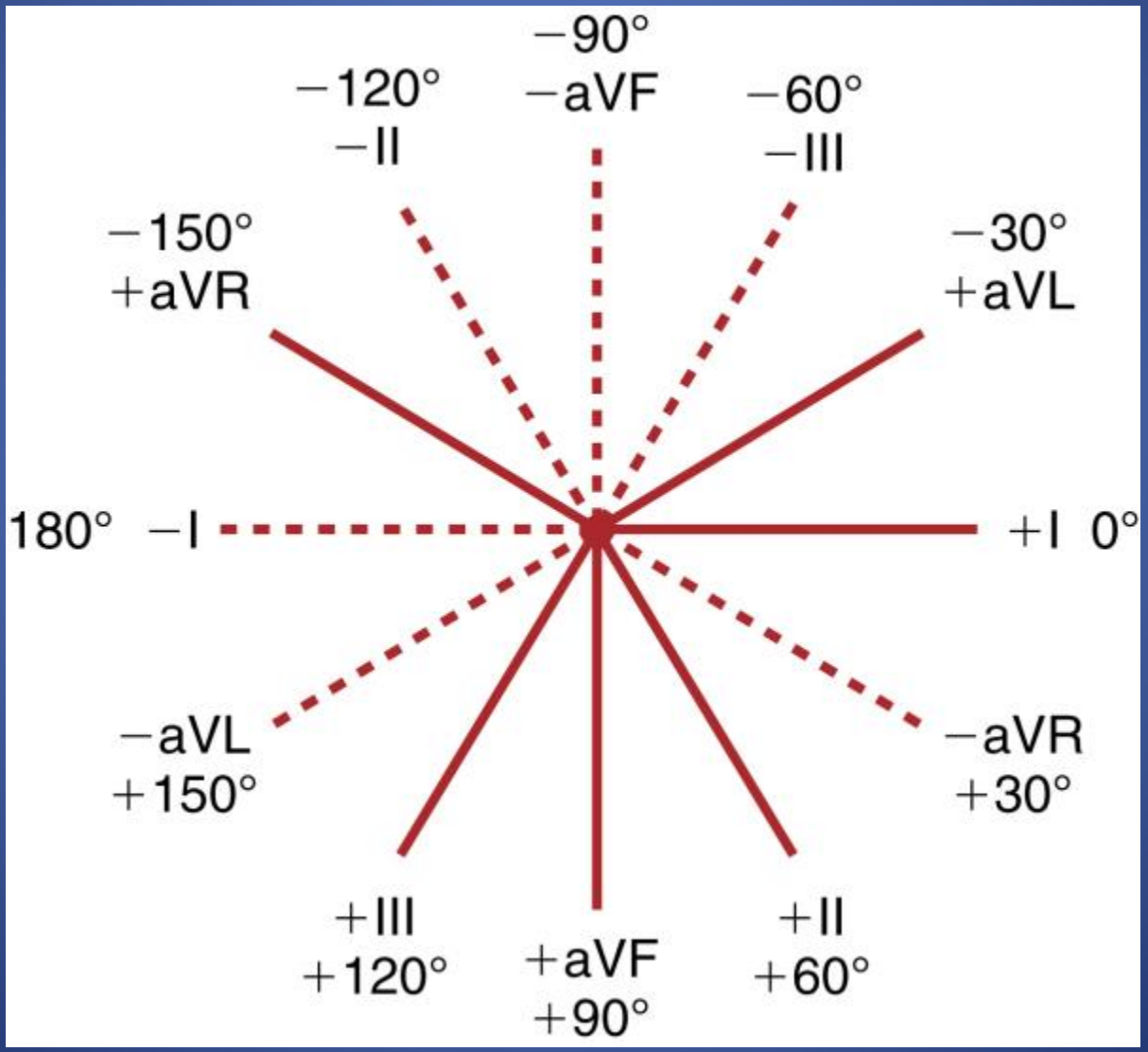


Rhythm

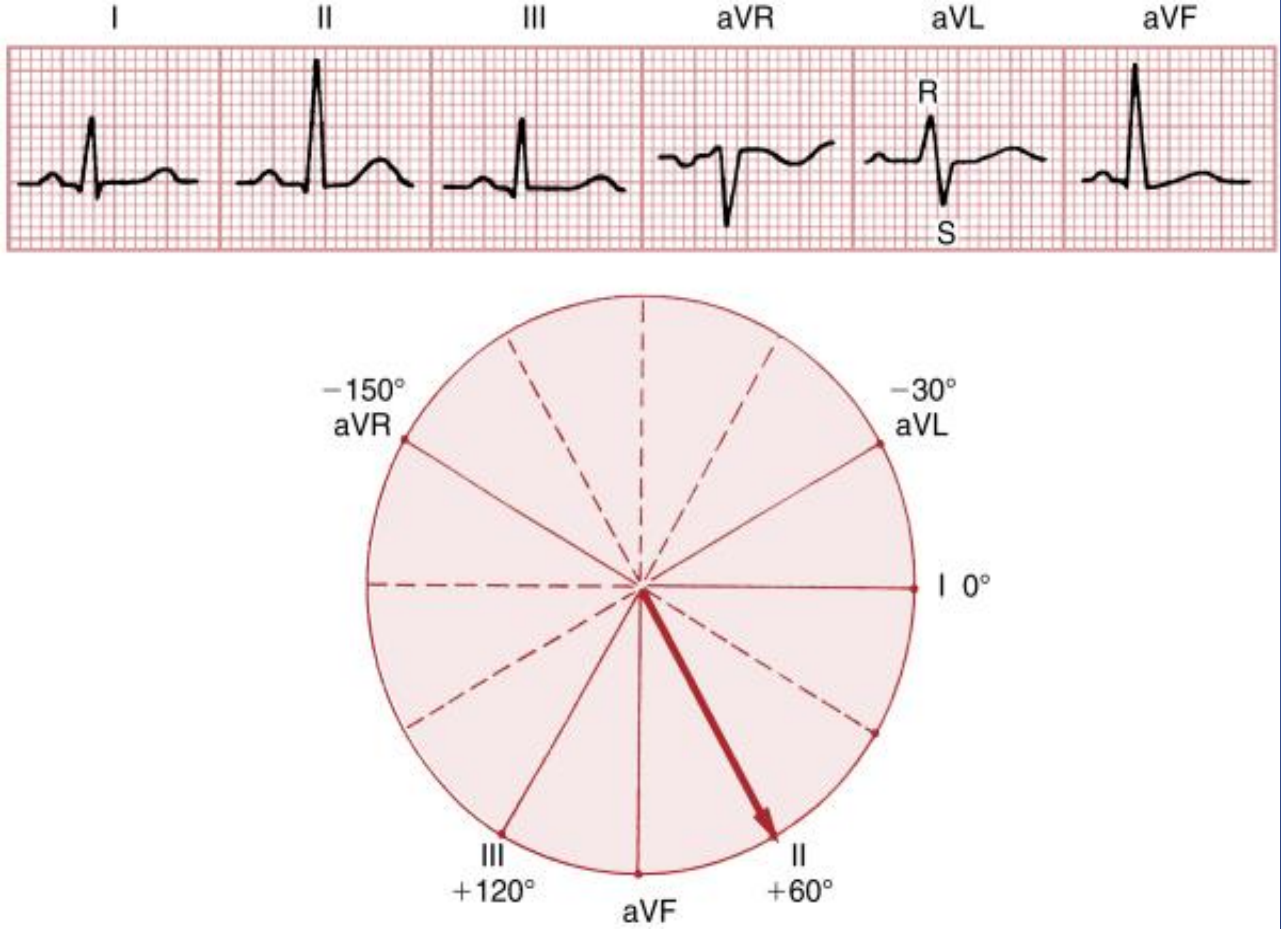
Normal Sinus Rhythm

- **LEDA II:** Positive P wave preceding each QRS.
- **V1:** Biphasic P wave.

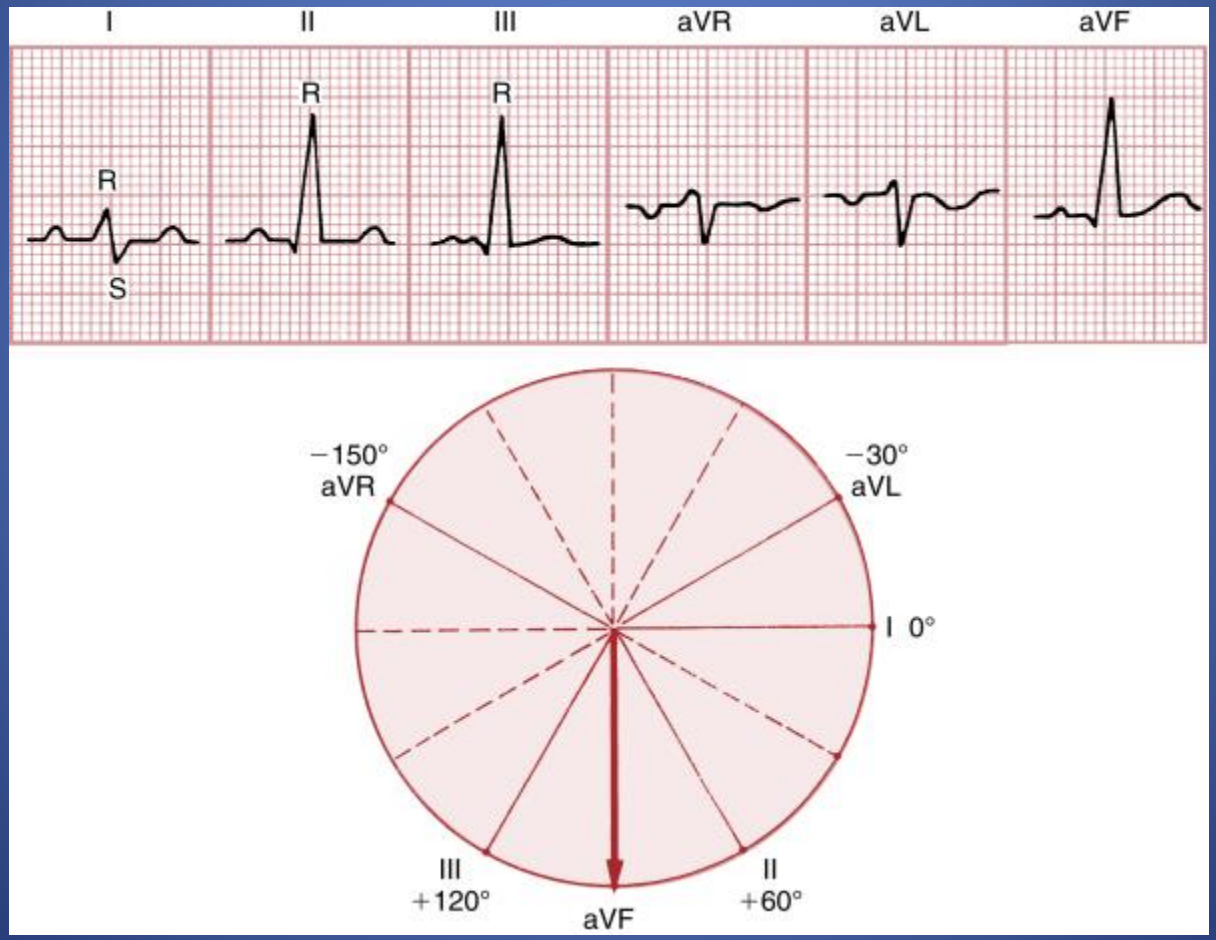
AXIS


−90°
−aVF
−120°
−II
−60°
−III
−150°
+aVR
−30°
+aVL
180°
−I
+I
0°
−aVL
+150°
−aVR
+30°
+III
+120°
+aVF
+90°
+II
+60°

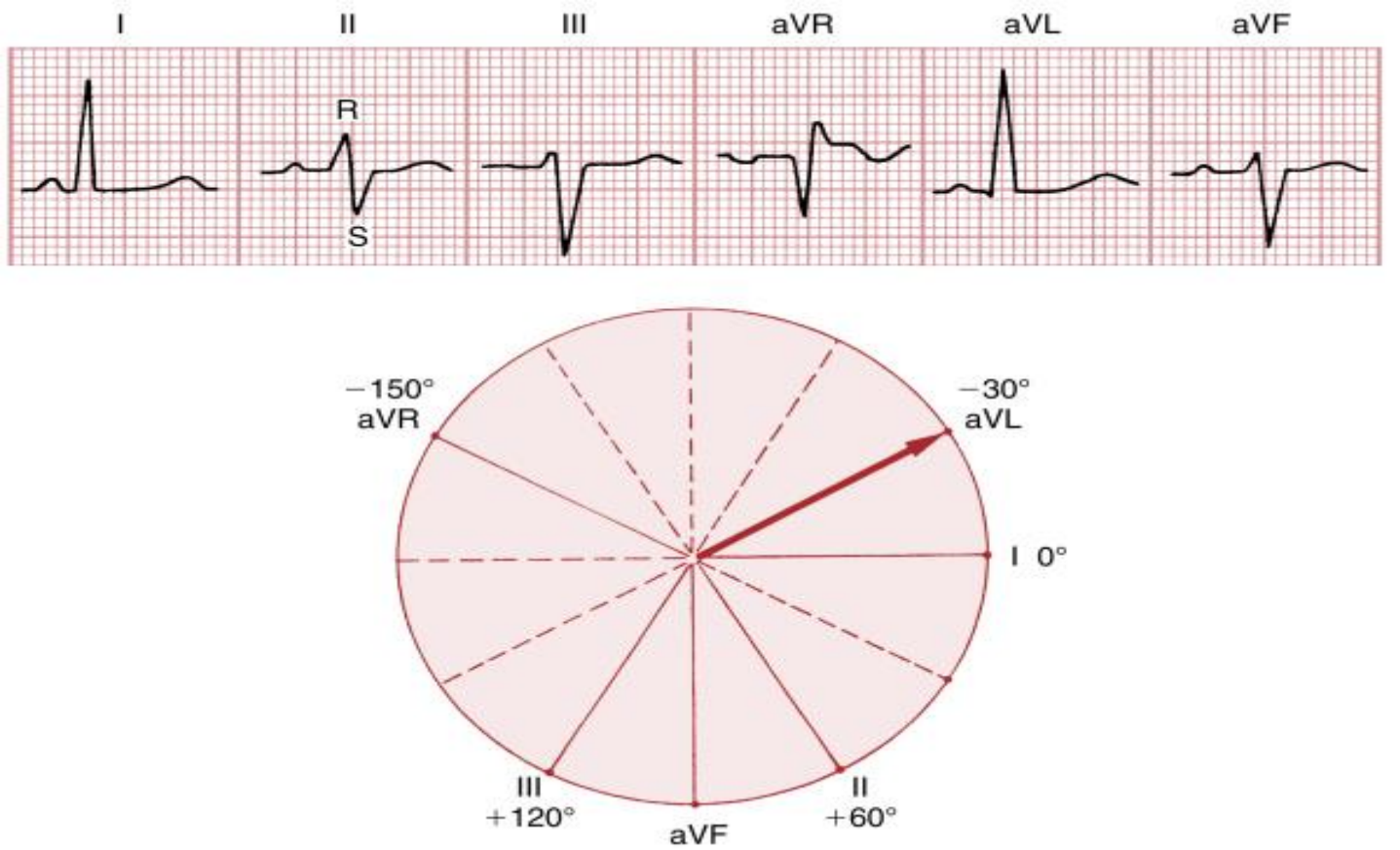
AXIS



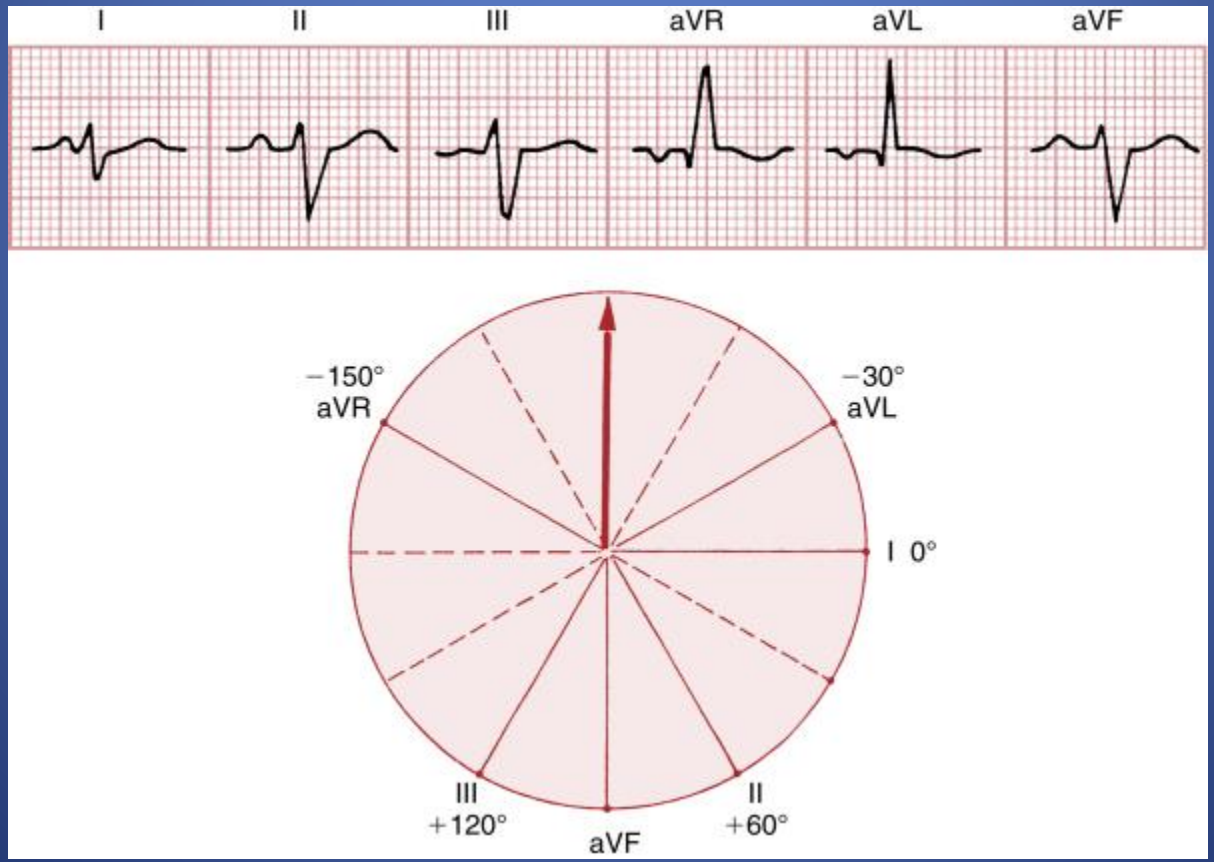
AXIS



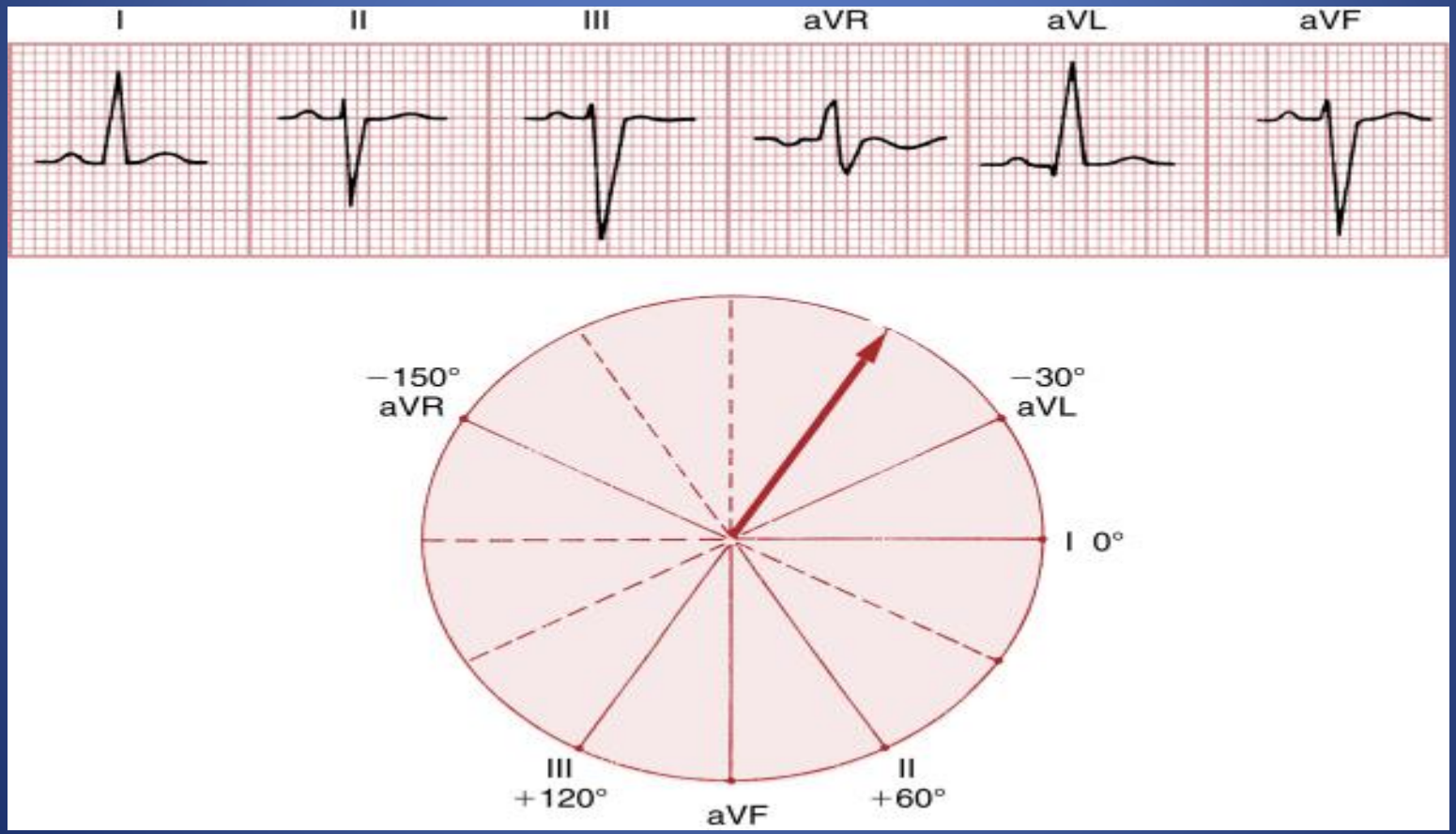
AXIS



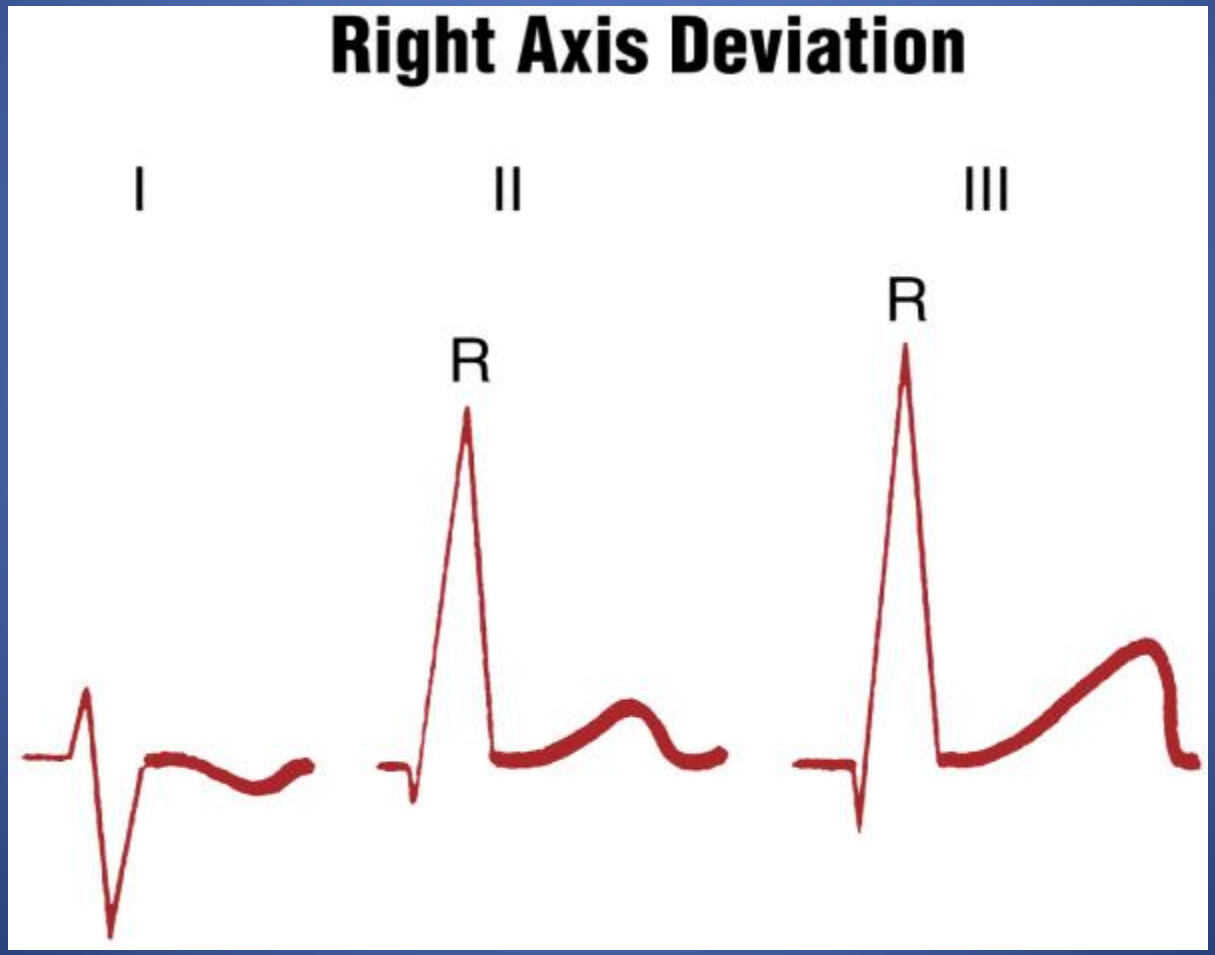
AXIS



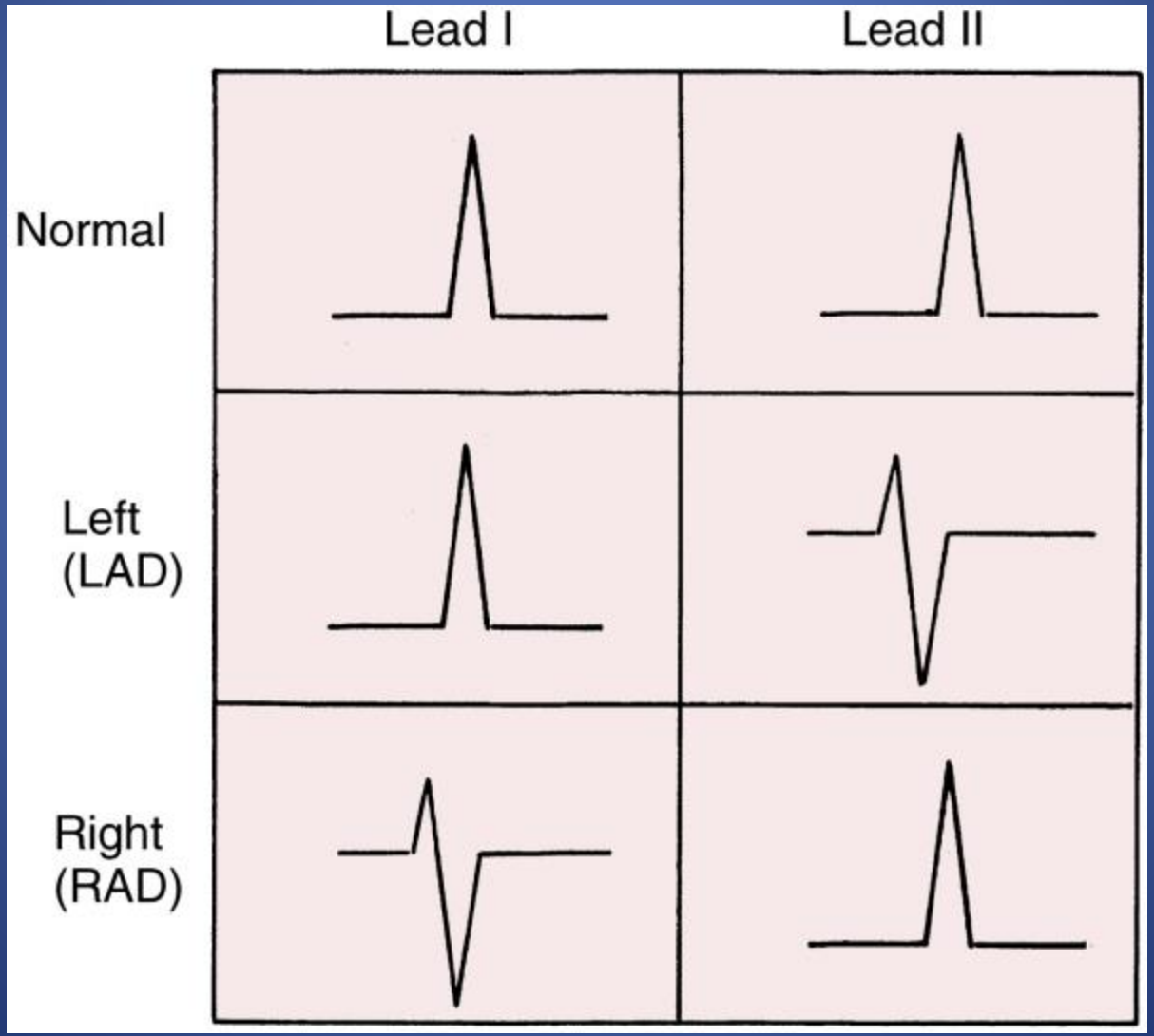
AXIS



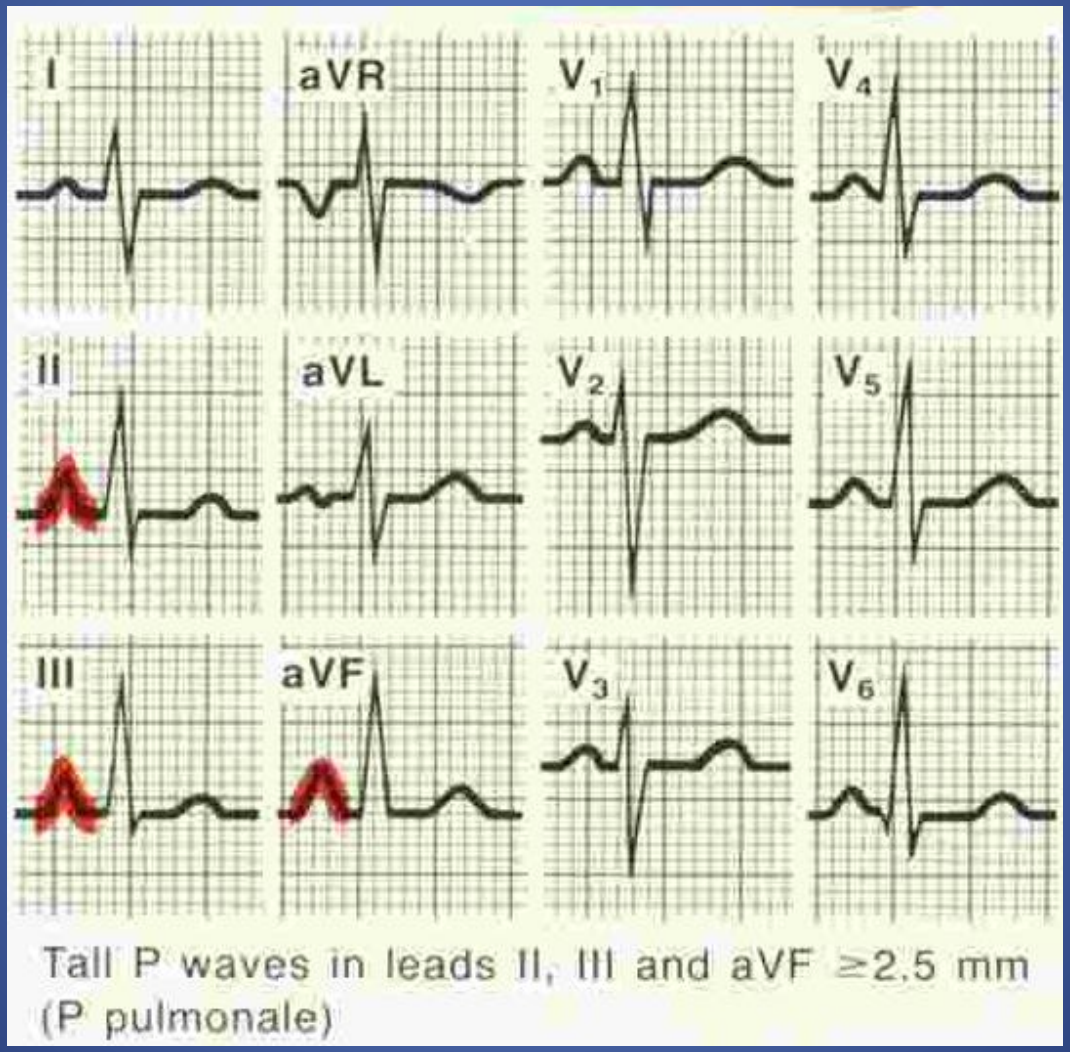
AXIS



AXIS

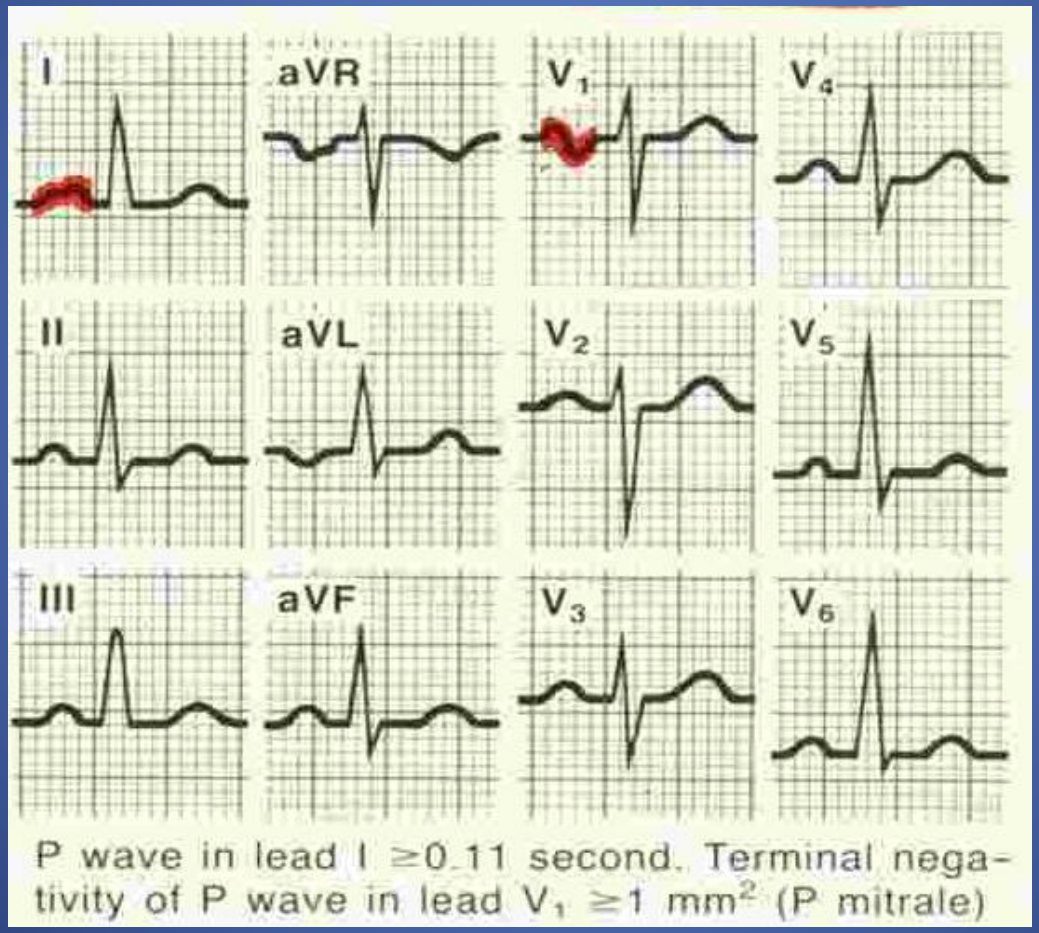


Right Atrial Enlargement



Tall P waves in leads II, III and aVF ≥2.5 mm
(P pulmonale)

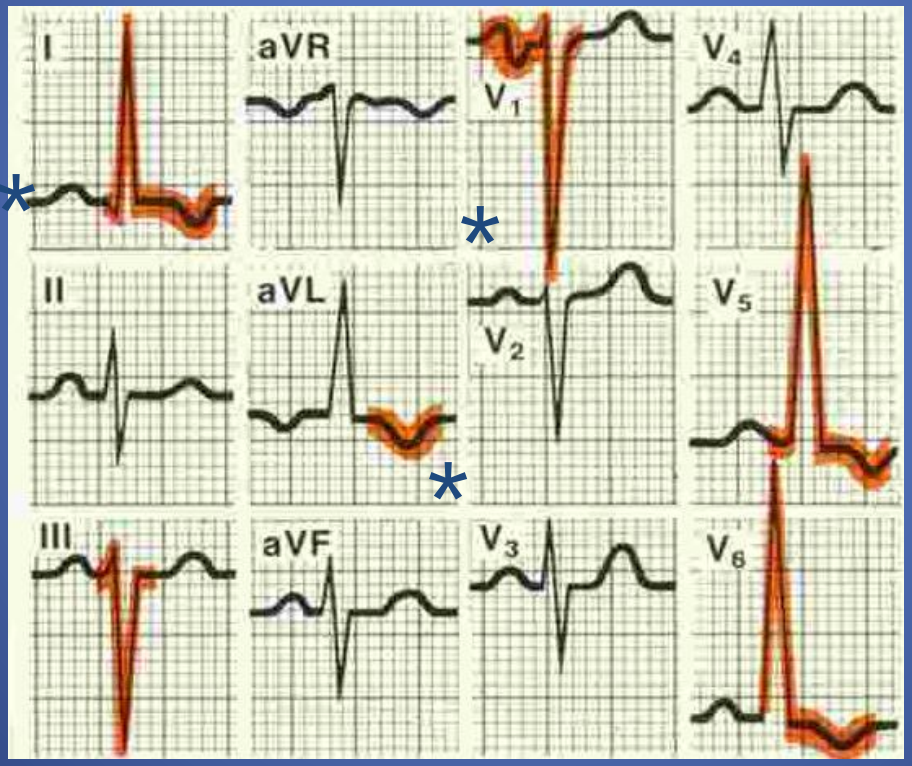
Left Atrial Enlargement



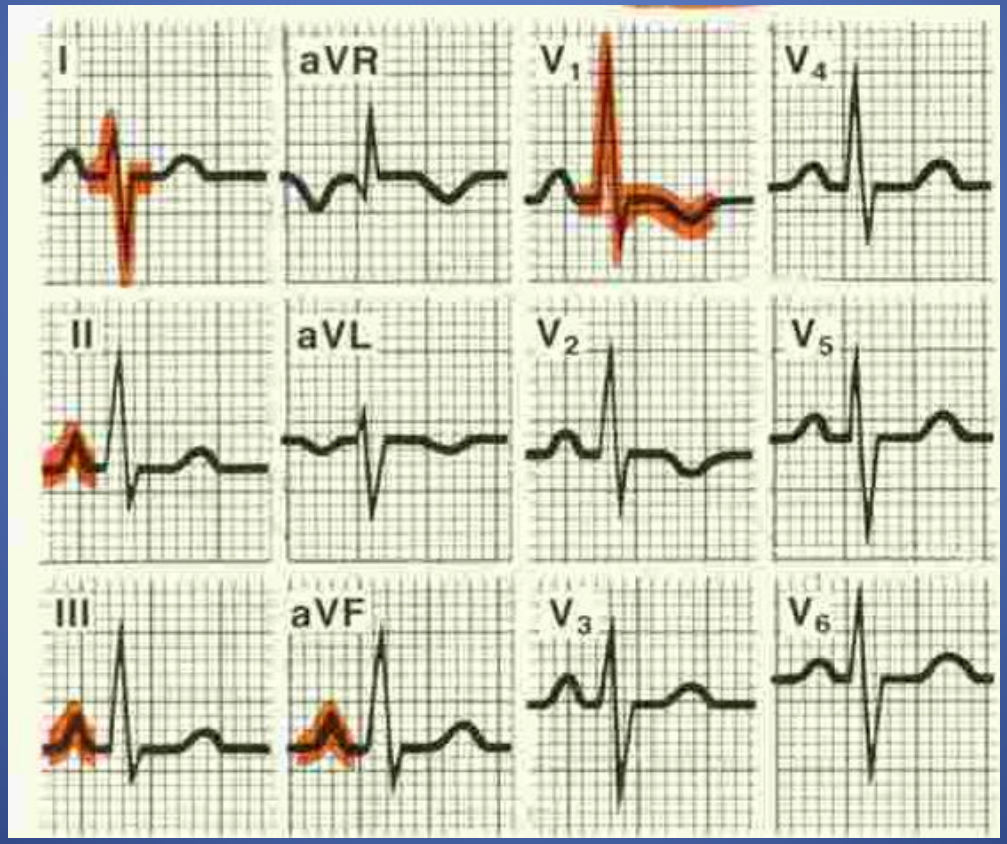
P wave in lead I ≥0.11 second. Terminal negativity of P wave in lead V_1 ≥1 mm^2 (P mitrale)

Left Ventricular Hypertrophy

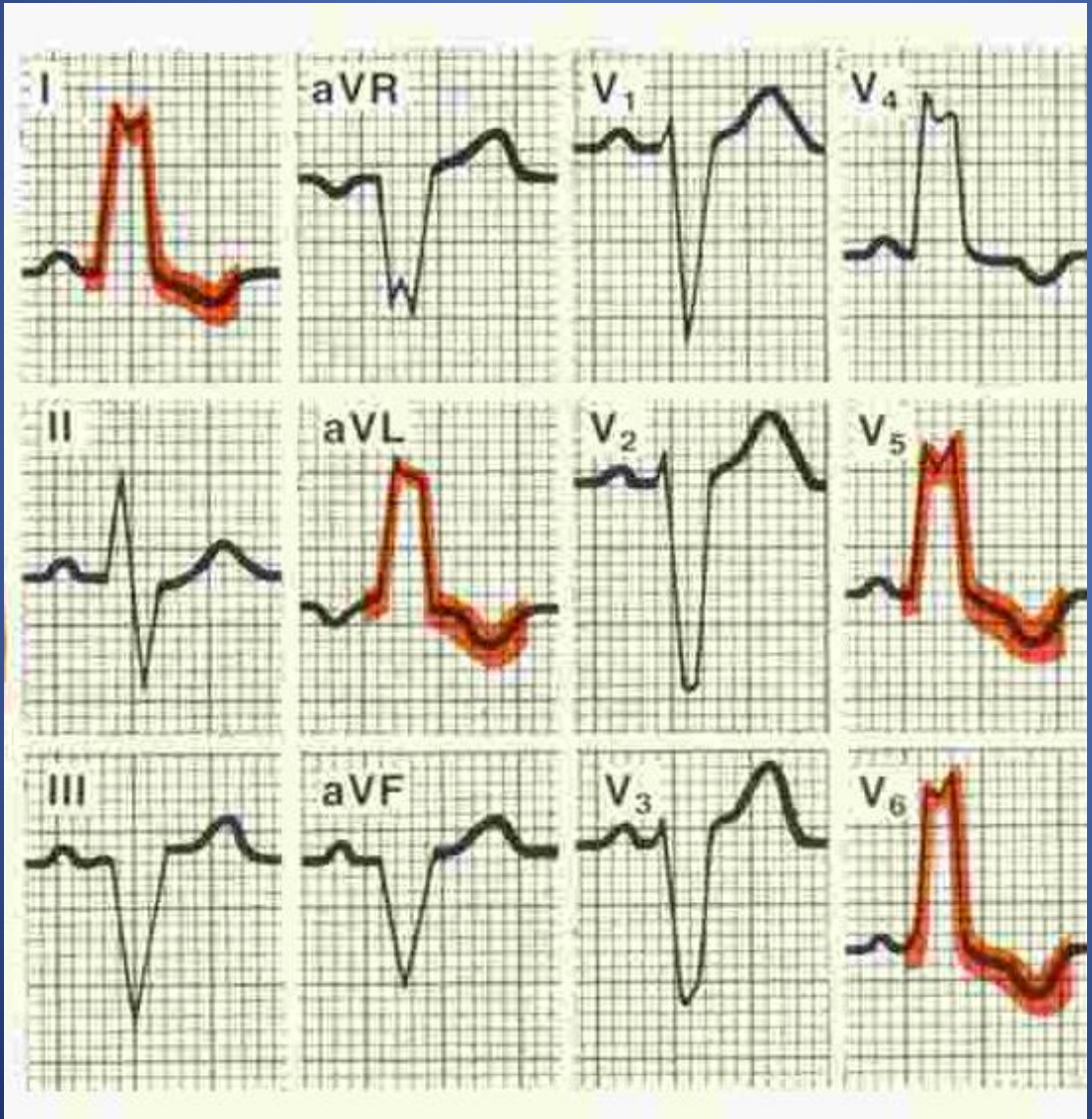
*



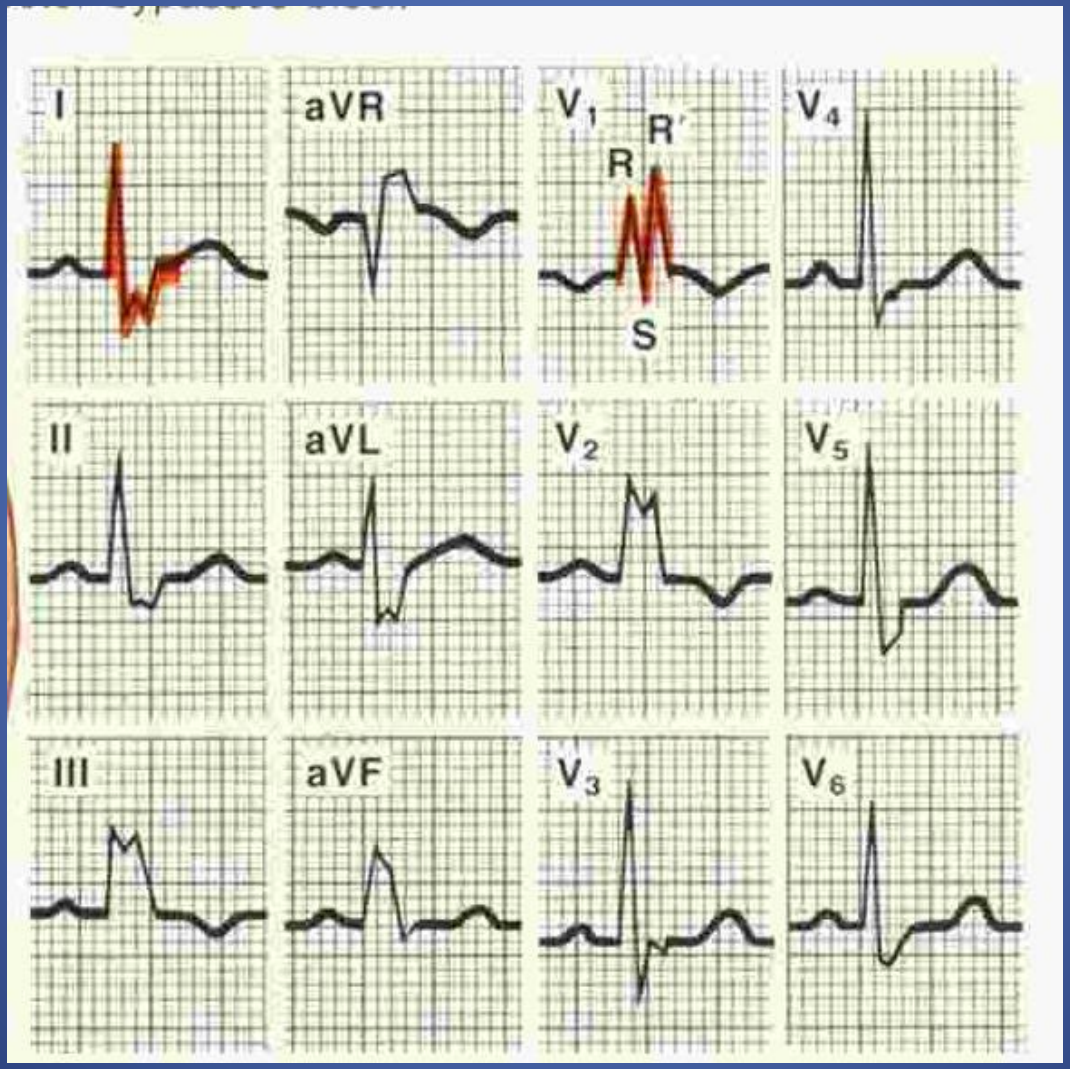
Right Ventricular Hypertrophy

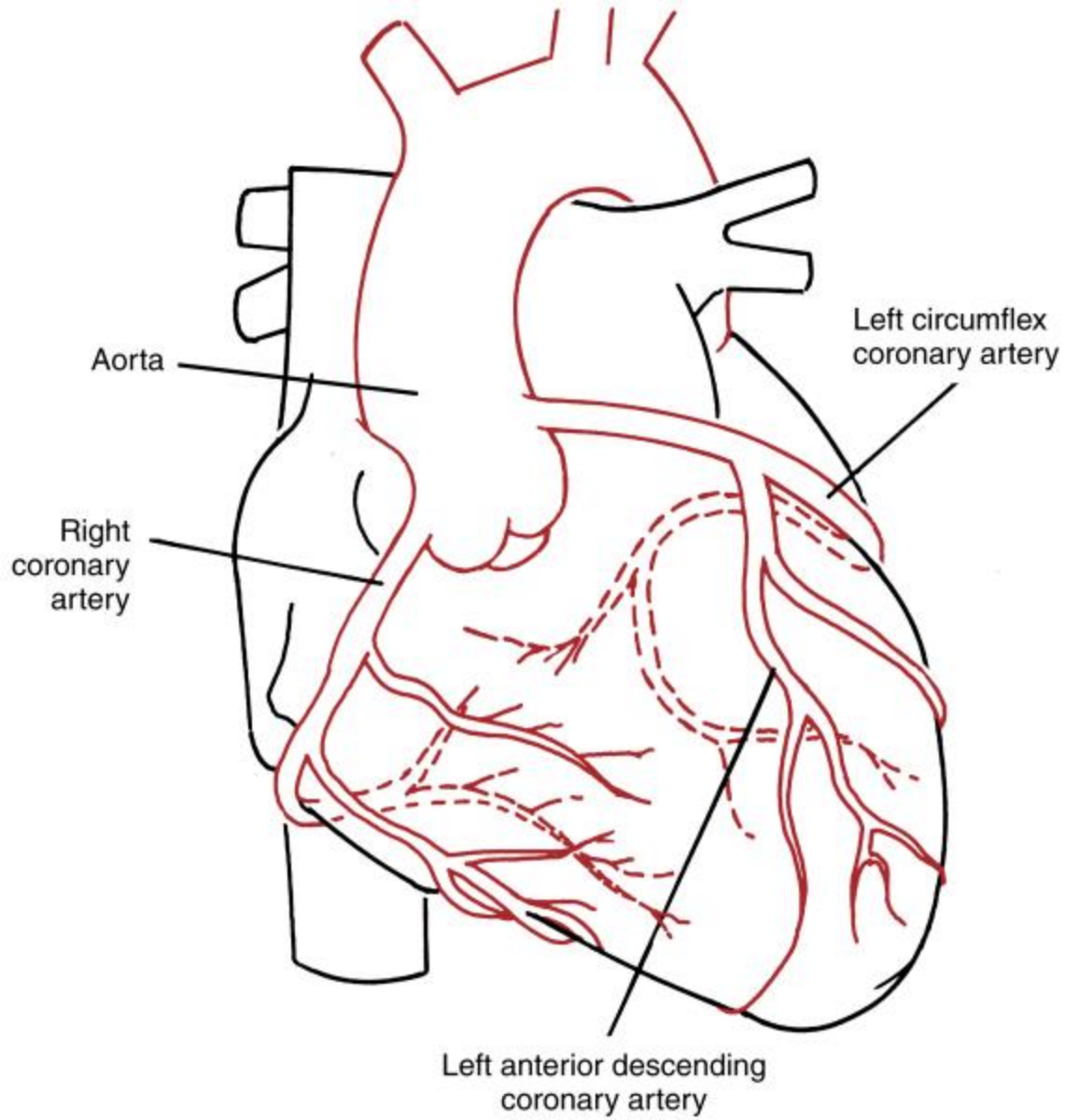


LBBB



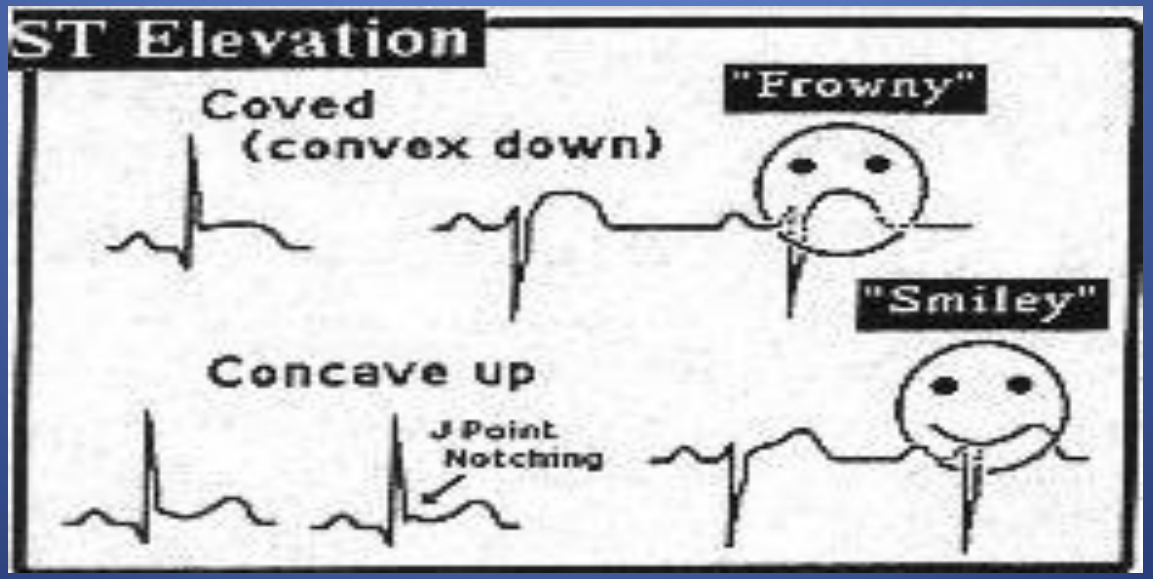
RBBB




Aorta
Left circumflex coronary artery
Right coronary artery
Left anterior descending coronary artery

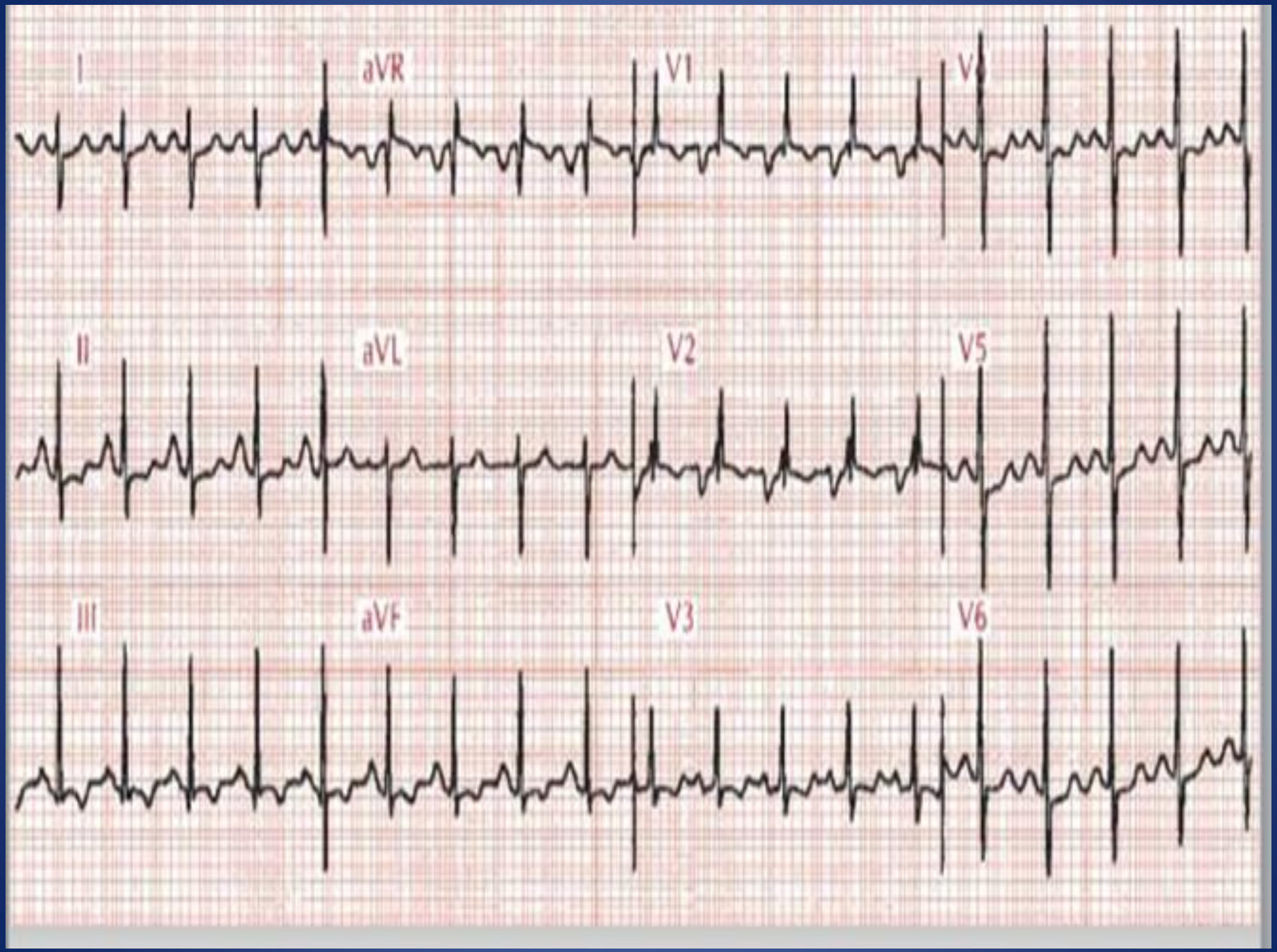
Morphology of STE

- Concave shape STE – non AMI causes
- AMI causes – usually demonstrate convex/straight STE

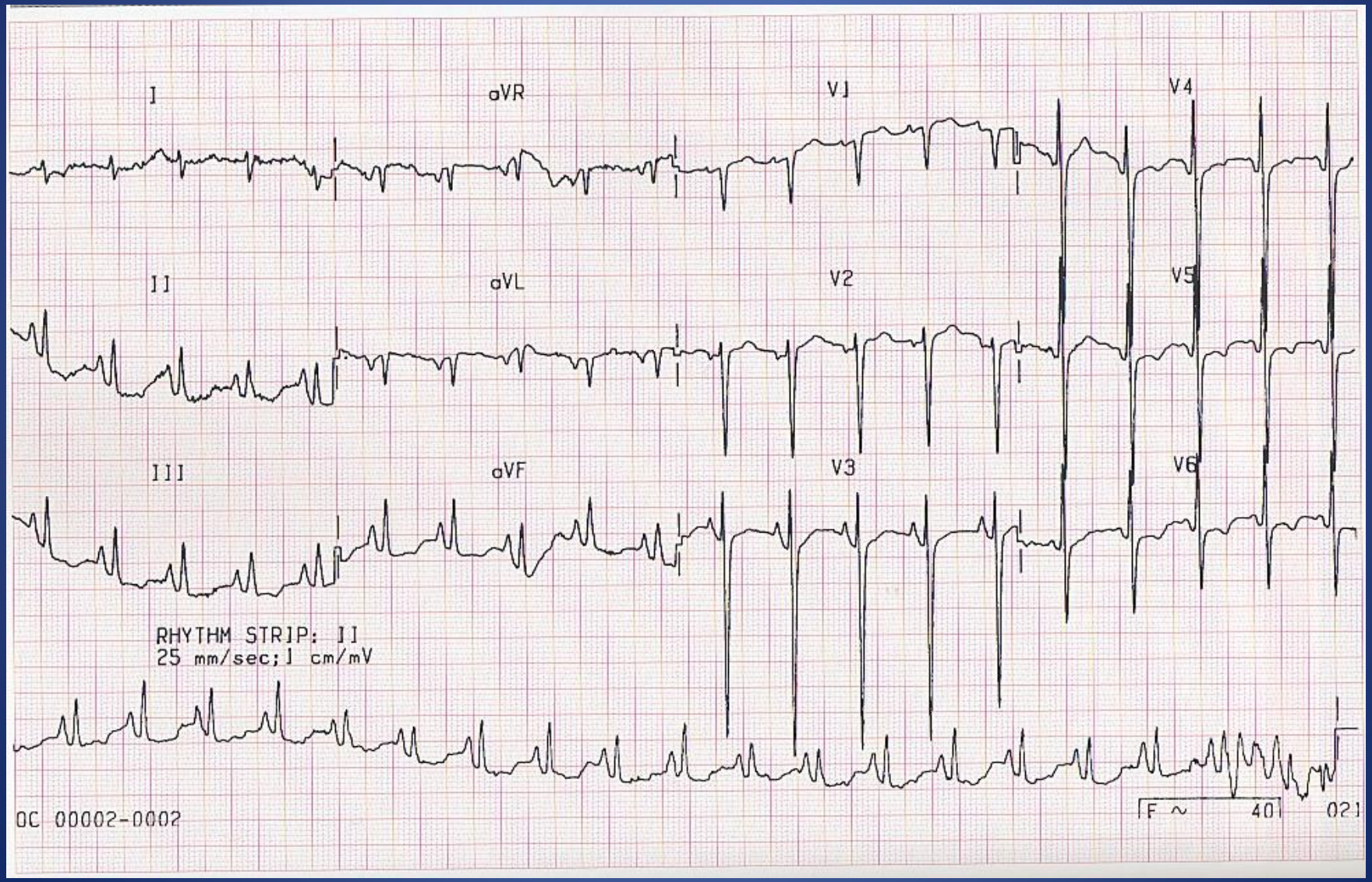


Distribution

SITE	FACING	RECIPROCAL
SEPTAL	V1, V2	NONE
ANTERIOR	V3, V4	NONE
ANTEROSEPTAL	V1, V2, V3, V4	NONE
LATERAL	I, aVL, V5, V6	II, III, aVF
ANTEROLATERAL	I, aVL, V3, V4, V5, V6	II, III, aVF
INFERIOR	II, III, aVF	I, aVL
POSTERIOR	NONE	V1, V2, V3, V4


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

Realty check



Realty check