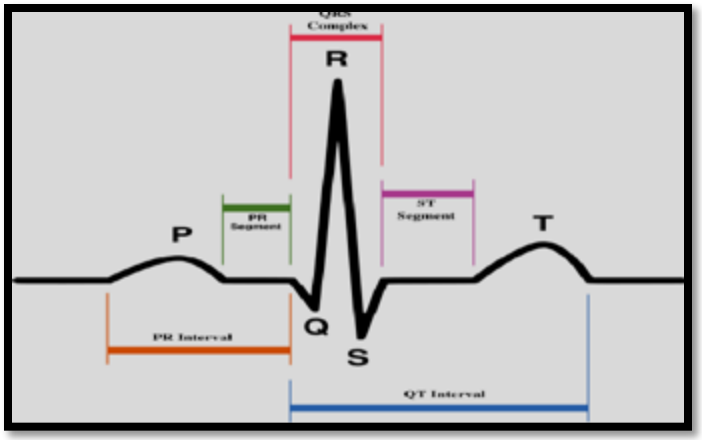
ELECTROCARDIOGRAM (ECG)



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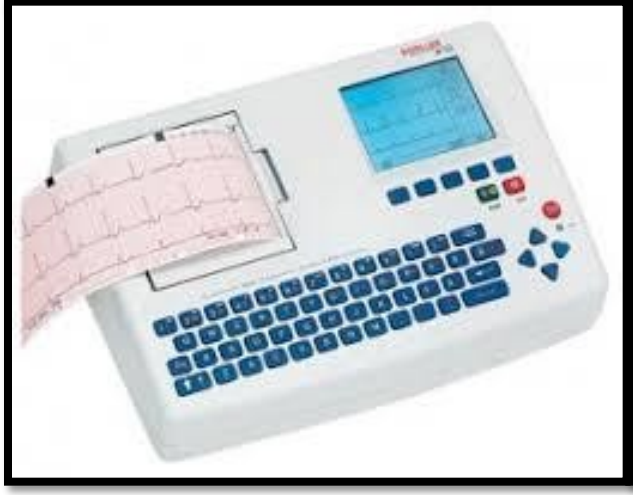
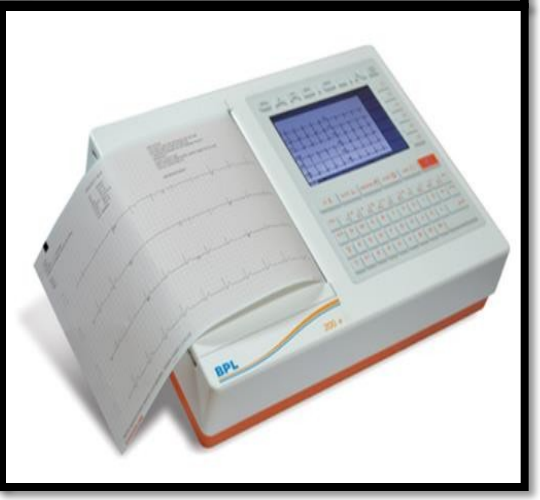
OBJECTIVES

At the end of this lecture you should be able

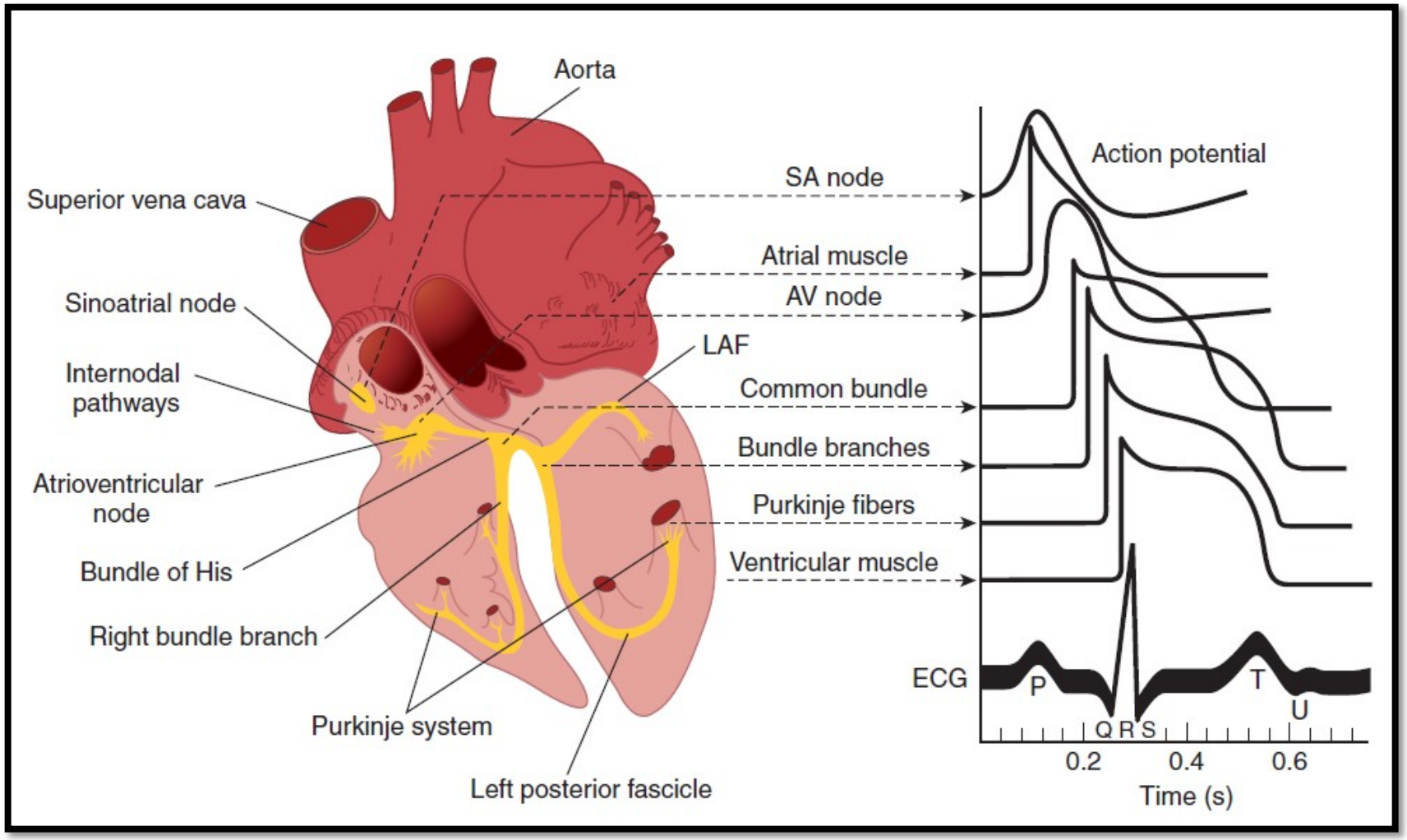
- Define ECG & list uses of ECG
- Understand basic ECG principles
- Describe ECG leads and Einthoven's triangle
- Recognize ECG waves, Intervals and, segments and their physiological correlation with significance
- Determine rate and normal heart rhythm
- Have some idea about ECG abnormalities in common clinical conditions

Modern ECG Machines





ECG is the record of the algebraic sum of electrical activity i.e. action potentials generated by the heart during cardiac cycle



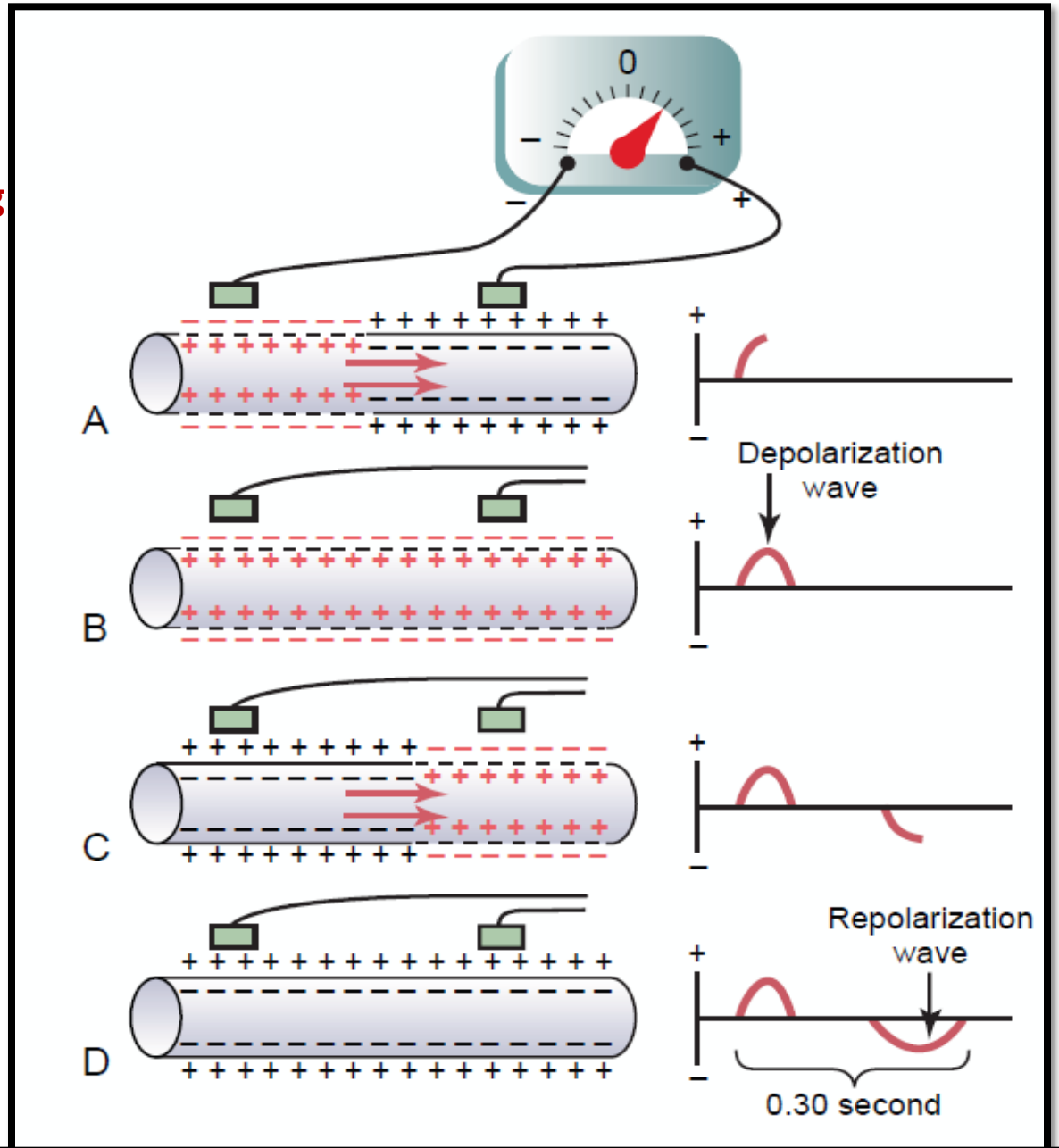
The action potentials and ECG are plotted on the same time axis

ECG PRINCIPLE

When the depolarization wave spread through heart, electrical currents pass into the surrounding tissue (body fluids are good conductors) and can be recorded from surface electrodes

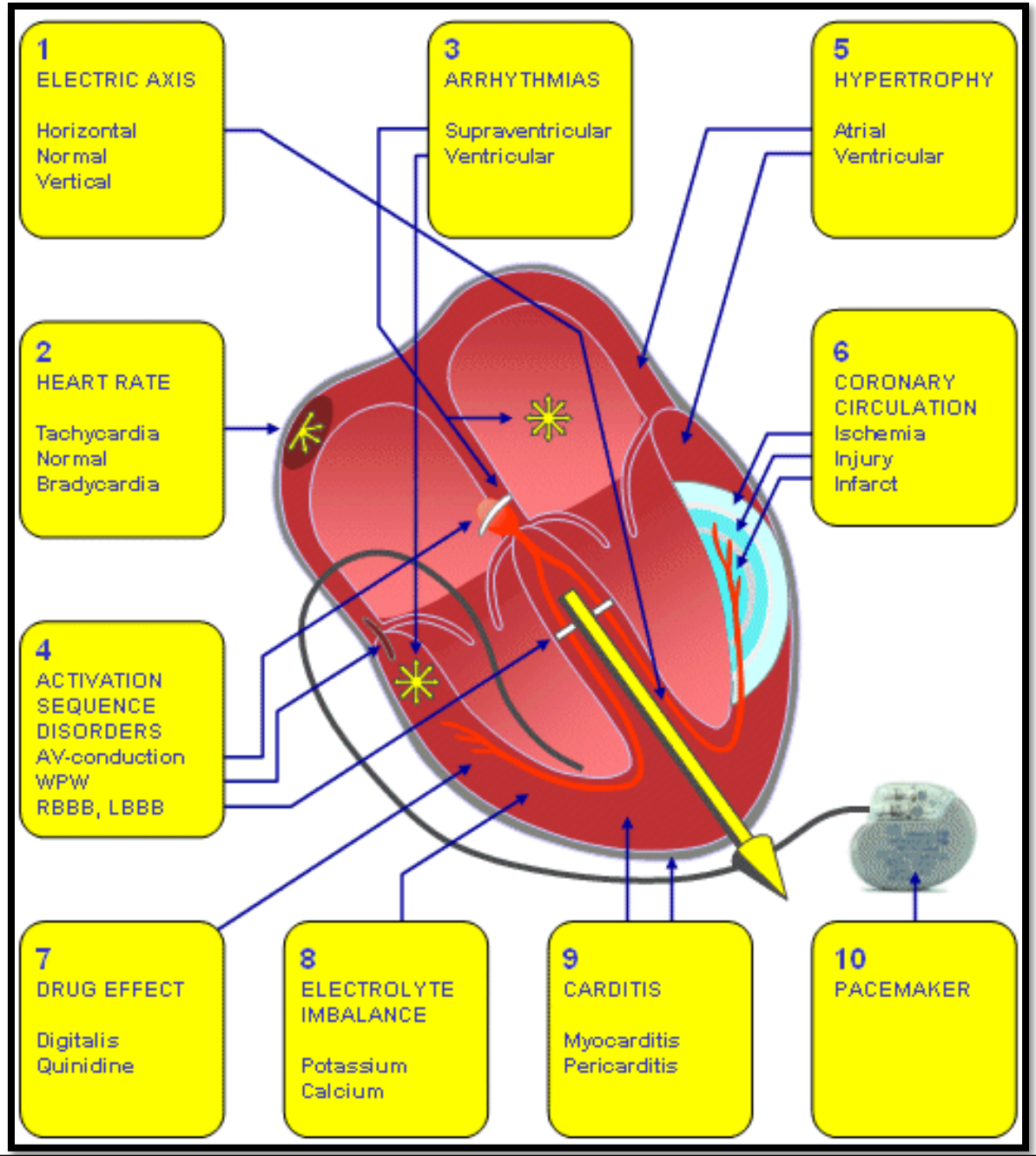
Recording the depolarization wave (*A* and *B*) and the repolarization wave (*C* and *D*) from a cardiac muscle fiber.

During depolarization, the normal negative potential inside the fiber reverses and becomes slightly positive inside and negative outside.

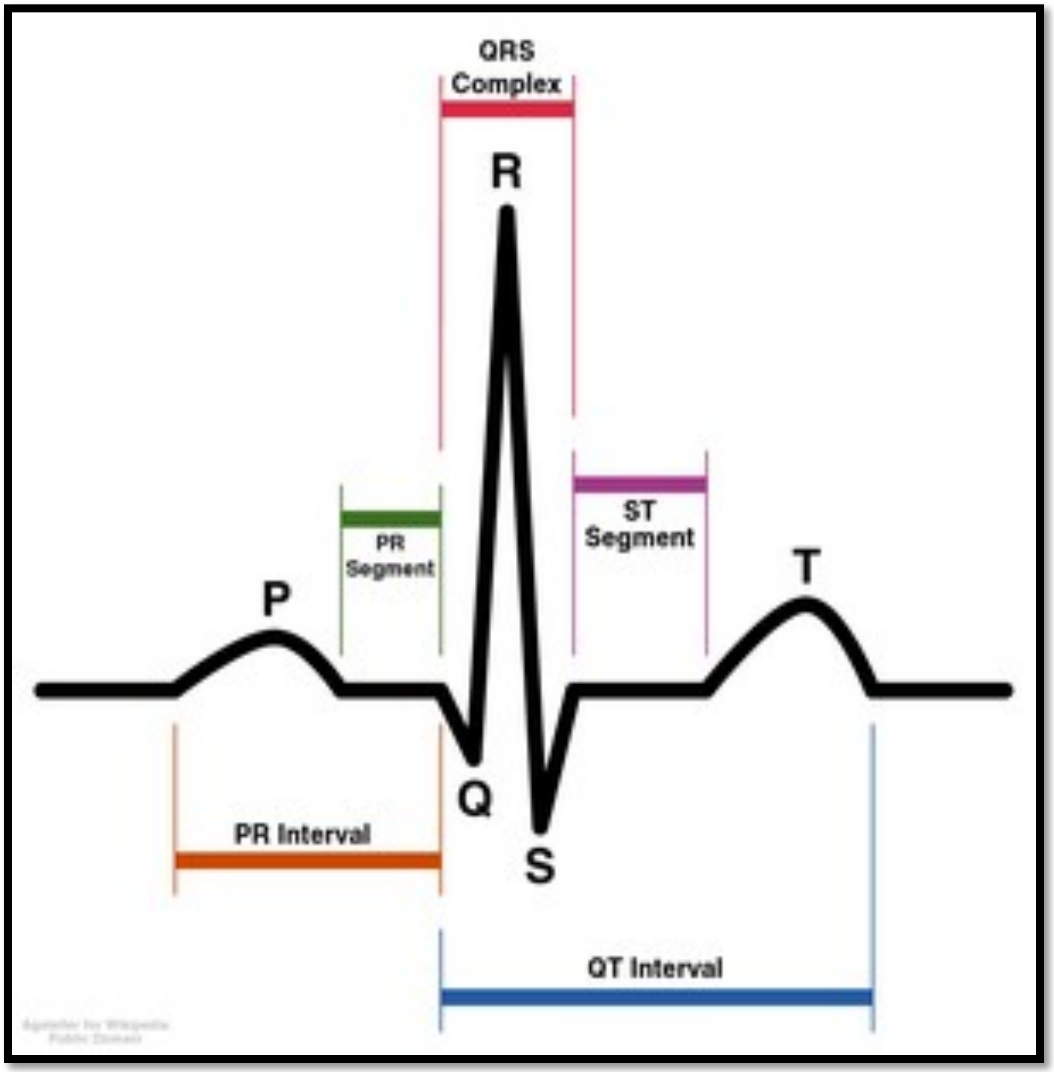


What types of information can we obtain from an ECG?

- Heart rate
- Heart Axis
- Heart Rhythm
- Myopathies
- Carditis
- Chamber Hypertrophy
- Conduction defects
- Myocardial Ischemia/MI
- Electrolyte disturbances
- Drug toxicity (eg; digoxin)



ECG Waveforms



3 waves:

- P- wave
- QRS complex
- T- wave

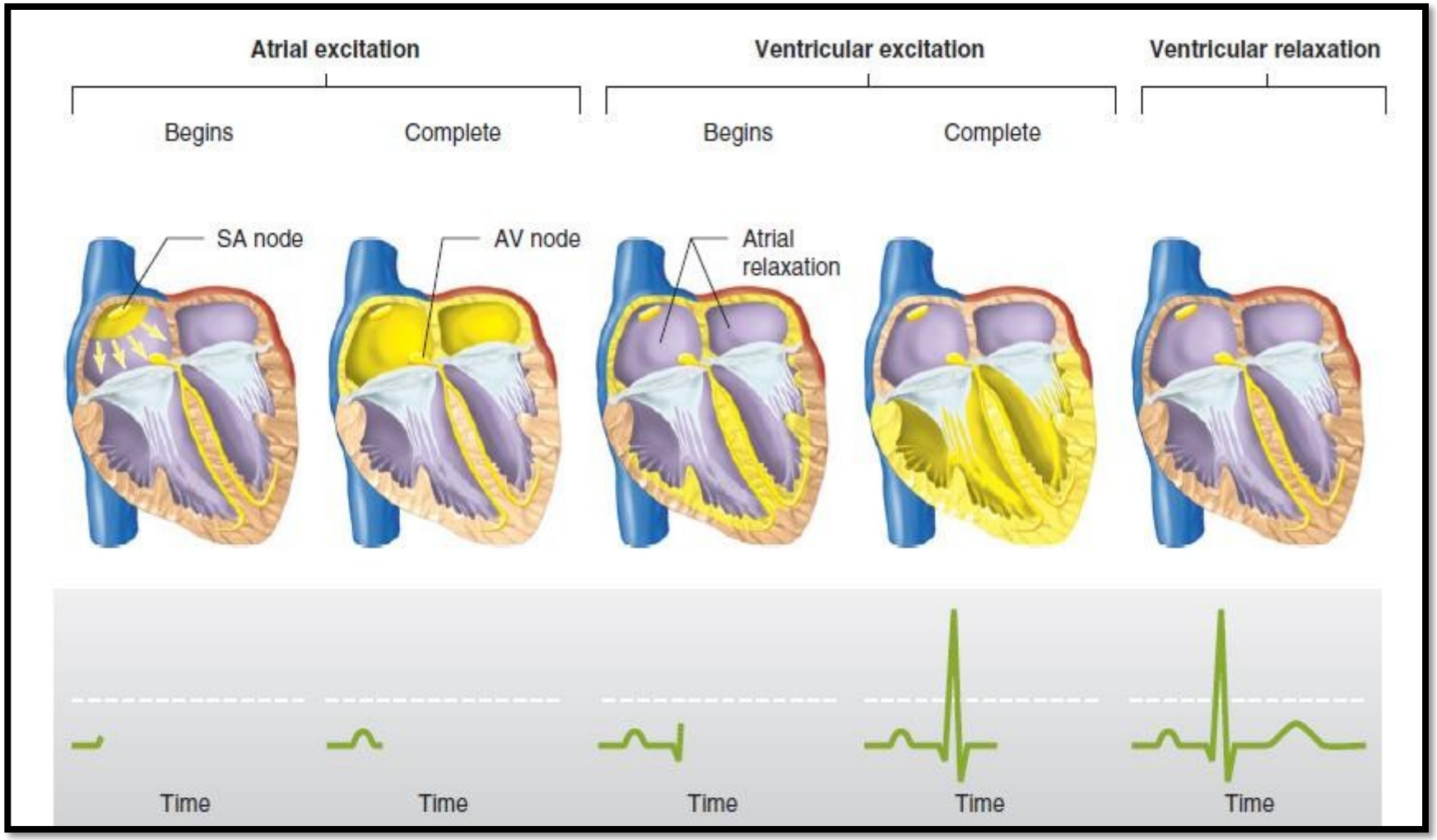
3 segments:

- ST segment
- TP segment
- PR segment

3 time intervals:

- P-R interval
- Q-T interval
- R-R interval

SEQUENCE OF CARDIAC EXCITATION

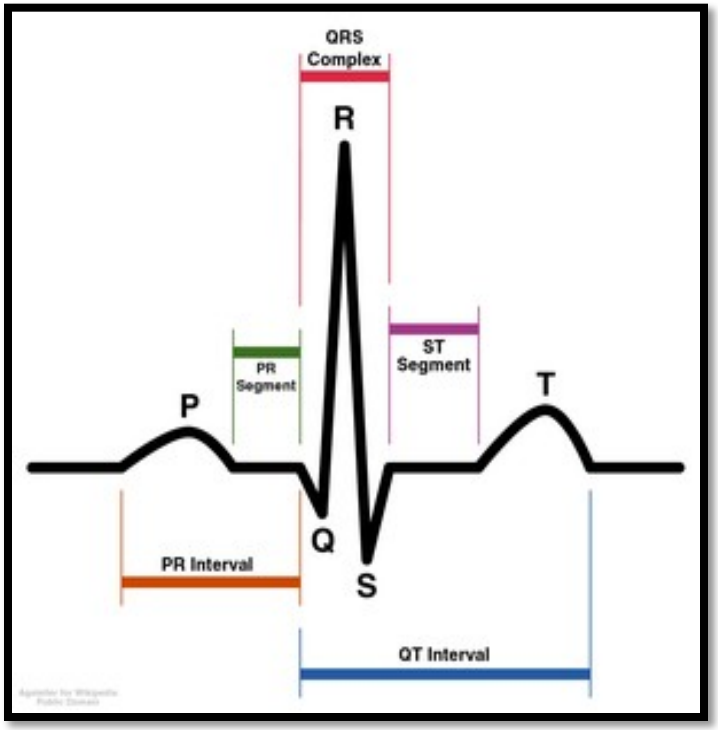


Anatomical position of electrical activity with Corresponding ECG waveforms

ECG Waveforms

P- wave

- Due to atrial depolarization
- P-wave is recorded before onset of atrial systole
- Atrial repolarization occurs at the same time with ventricular depolarization. But, since ventricular depolarization wave is giant, it masks the atrial repolarization wave



QRS complex

- Due to ventricular depolarization
- Q-wave due to depolarization of interventricular septum
- R-wave due to depolarization of ventricles
- S-wave due to depolarization of base of the heart
- QRS complex is recorded before the onset of ventricular systole

T- wave

- Due to ventricular repolarization
- T-wave is recorded before the onset of ventricular diastole

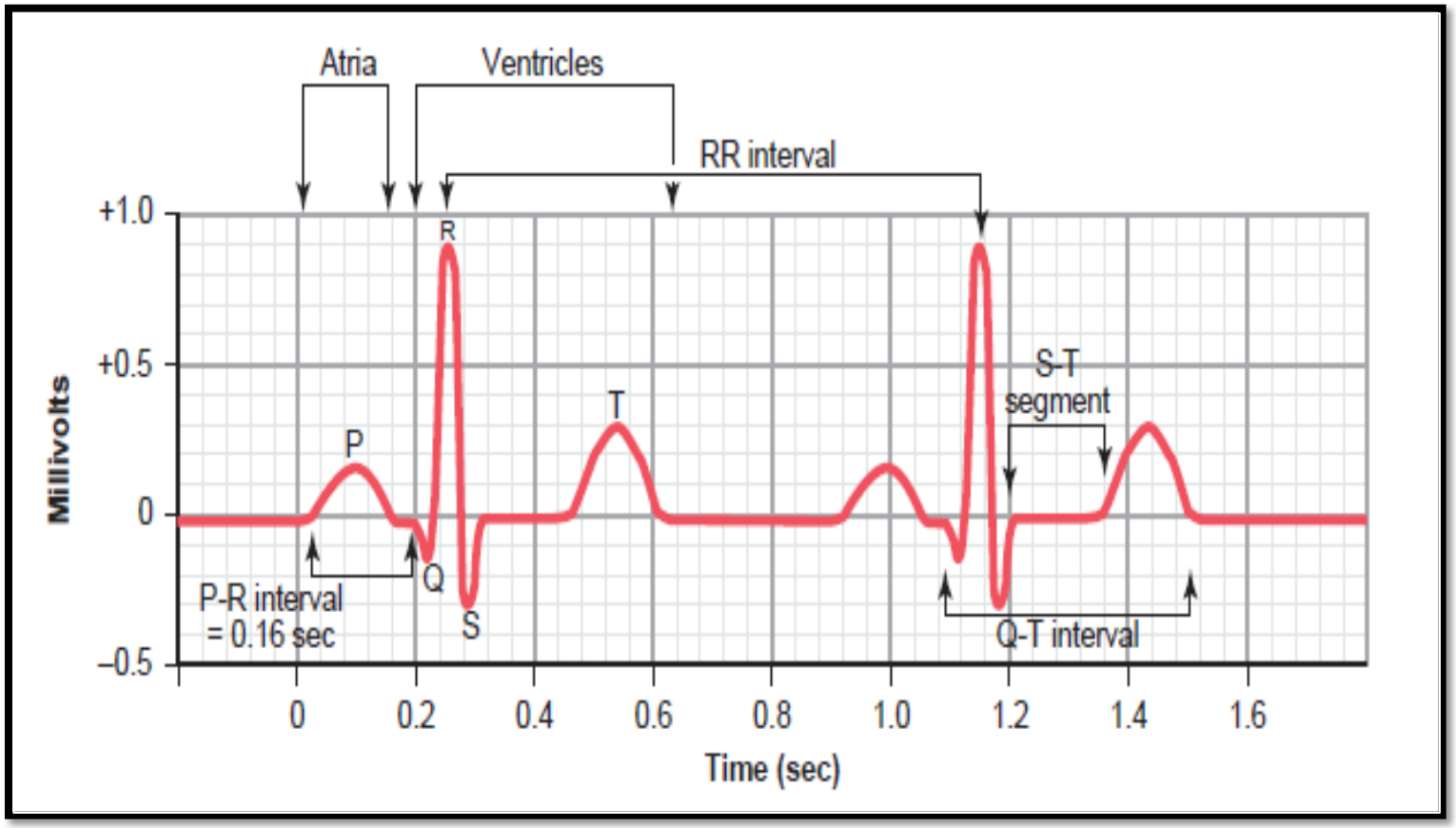

Atria
Ventricles
RR interval
+1.0
+0.5
0
–0.5
Millivolts
R
P
T
S-T
segment
Q
S
P-R interval
= 0.16 sec
Q-T interval
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
Time (sec)

TABLE 29–2 ECG intervals.

Intervals	Normal Durations		Events in the Heart during Interval
	Average	Range	
PR interval[a]	0.18[b]	0.12–0.20	Atrioventricular conduction
QRS duration	0.08	to 0.10	Ventricular depolarization
QT interval	0.40[c]	to 0.43	Ventricular action potential
ST interval (QT minus QRS)	0.32	…	Plateau portion of the ventricular action potential

[a]Measured from the beginning of the P wave to the beginning of the QRS complex.

[b]Shortens as heart rate increases from average of 0.18 s at a rate of 70 beats/min to 0.14 s at a rate of 130 beats/min.

[c]Can be lower (0.35) depending on the heart rate

Causes of ECG Waves

ECG Wave	Cause	Represent
P- wave	**Atrial depolarization**	Time of electrical impulse from SA node to spread through atrial muscle. Duration = 0.08 – 0.1 sec Precedes atrial contraction by ≈ 0.01 - 0.02 sec
QRS complex	**Ventricular depolarization**	Measured from beginning of Q wave till end of S wave. Consists of 3 waves: **Q wave: (-ve):** Produced by depolarization of interventricular septum. **R wave: (+ve):** Produced by depolarization of ventricular wall. **S wave: (-ve):** Produced by depolarization of the base of the heart. Duration ≤ 0.1 sec. Precedes ventricular contraction by ≈ 0.02 sec. Occurs after P-wave by ≈ 0.12-0.2 sec = PR interval
T- wave	**Ventricular repolarization**	Occurs during latter part of systole, before the onset of diastole. Ventricular repolarization progresses from apex to the base of the heart. Duration = 0.27 sec.

Atrial repolarization occurs at the same time with ventricular depolarization. But, since ventricular depolarization wave is giant, it masks the atrial repolarization wave

DEPOLARIZATION OF THE ATRIA—THE P WAVE

The area in the atria that also becomes repolarized first is the sinus nodal region, the area that had originally become depolarized First . Therefore, the atrial repolarization vector is backward to the vector of depolarization

In a normal ECG, the atrial T wave appears at about the same time that the QRS complex of the ventricles appears. Therefore, it is almost always totally obscured by the large ventricular QRS complex

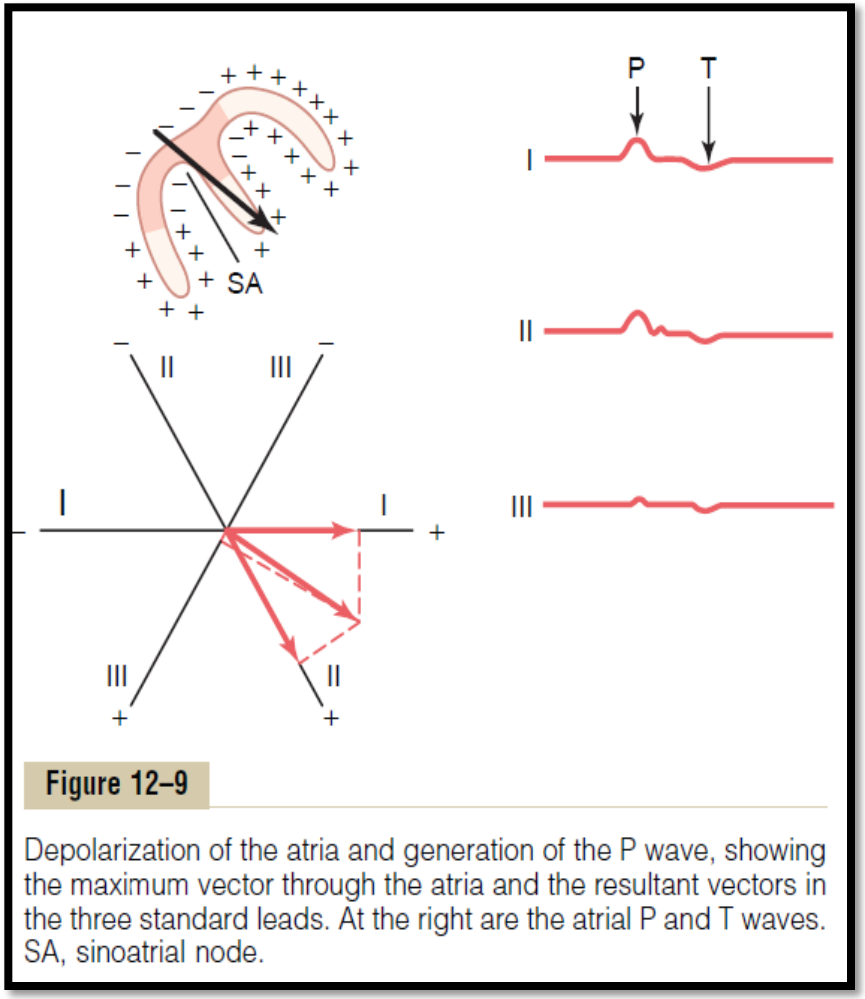


Figure 12–9

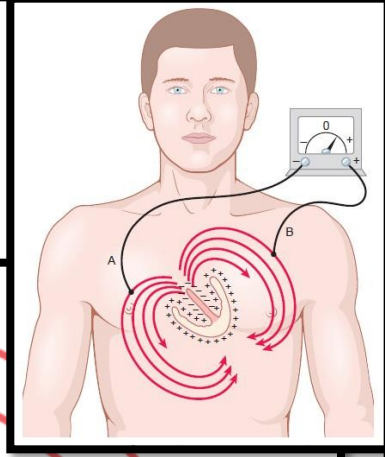
Depolarization of the atria and generation of the P wave, showing the maximum vector through the atria and the resultant vectors in the three standard leads. At the right are the atrial P and T waves. SA, sinoatrial node.

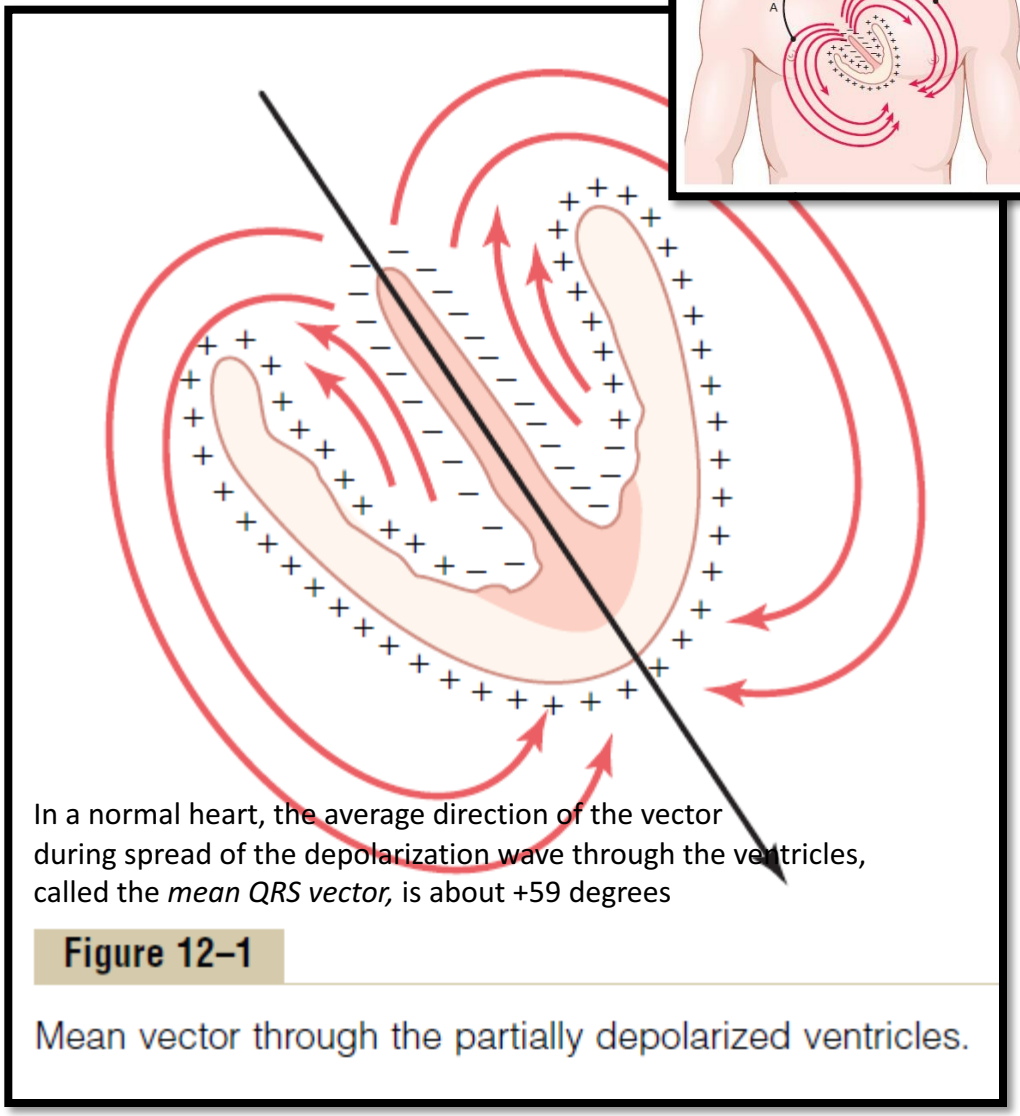
CARDIAC VECTORS

Electrical forces can be represented in the form of vectors

A vector is an arrow that points in the direction of the electrical potential generated by the current flow, with the arrowhead in the positive direction.

The length of the arrow is proportional to the voltage of the potential.





In a normal heart, the average direction of the vector during spread of the depolarization wave through the ventricles, called the *mean QRS vector,* is about +59 degrees

Figure 12–1

Mean vector through the partially depolarized ventricles.

VECTORS THAT OCCUR AT SUCCESSIVE INTERVALS DURING DEPOLARIZATION OF THE VENTRICLES—THE QRS COMPLEX

- When the cardiac impulse enters the ventricles through the atrioventricular bundle, the first part of the ventricles to become depolarized is the left endocardial surface of the septum.

- It spreads through the ventricular muscle to the outside of the heart

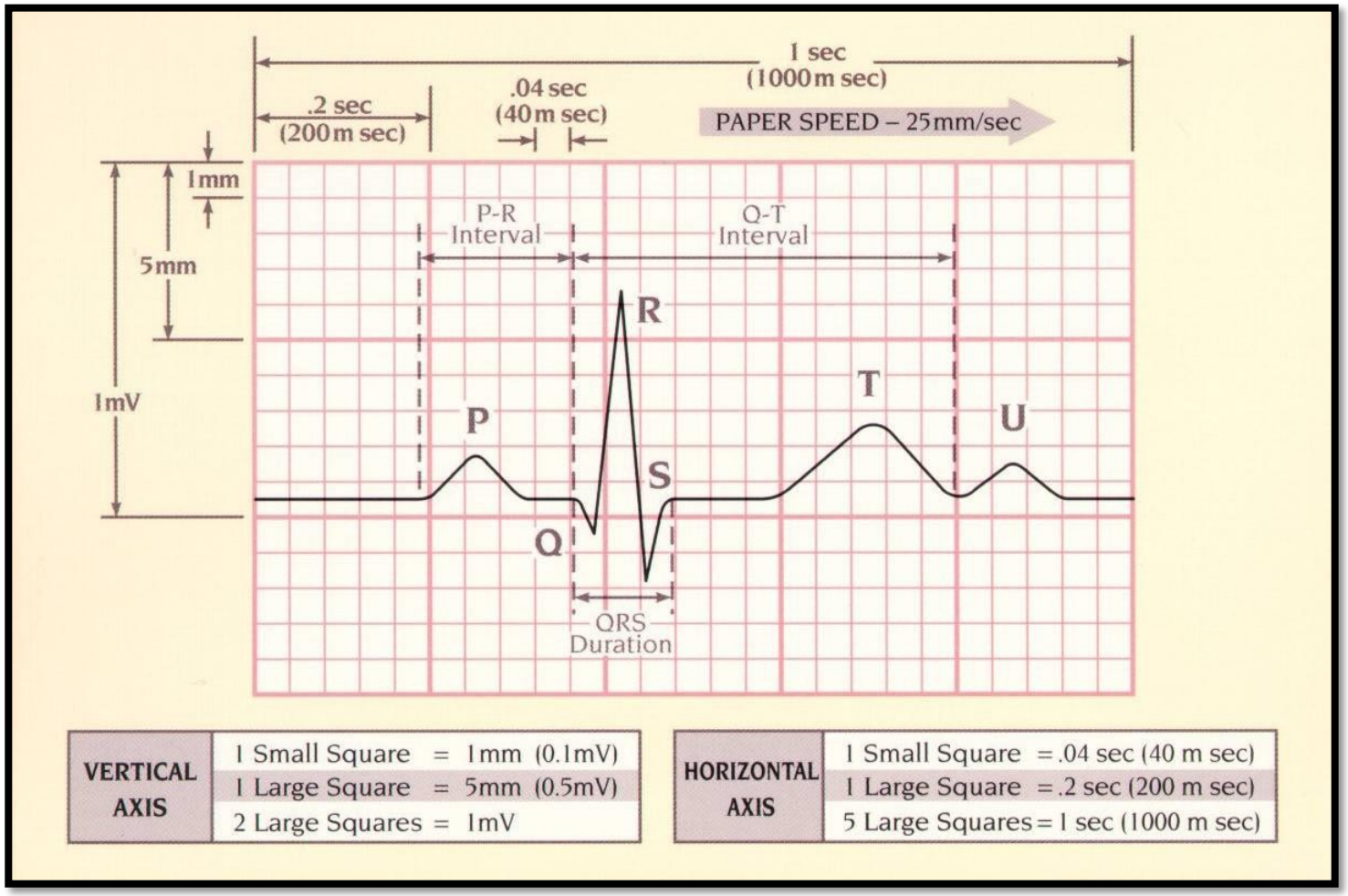
- Q wave is caused by initial depolarization of the left side of the septum before the right side, which creates a weak vector from left to right for a fraction of a second before the usual base-to-apex vector occurs.

ELECTROCARDIOGRAM DURING VENT REPOLARIZATION THE T WAVE

Because the septum and endocardial areas of the ventricular muscle depolarize first, it seems logical that these areas should repolarize first as well, but actually it is NOT so!!!!!!!!

- **The greatest portion of ventricular muscle mass to repolarize first is the entire outer surface of the ventricles, especially near the apex of the heart because the septum and other endocardial areas have a longer period of contraction than do most of the external surfaces of the heart so endocardial areas, conversely, normally repolarize last.**
- **Therefore, the positive end of the overall ventricular vector during repolarization is toward the apex of the heart. As a result, the normal T wave in all three bipolar limb leads is positive, which is also the polarity of most of the normal QRS complex.**

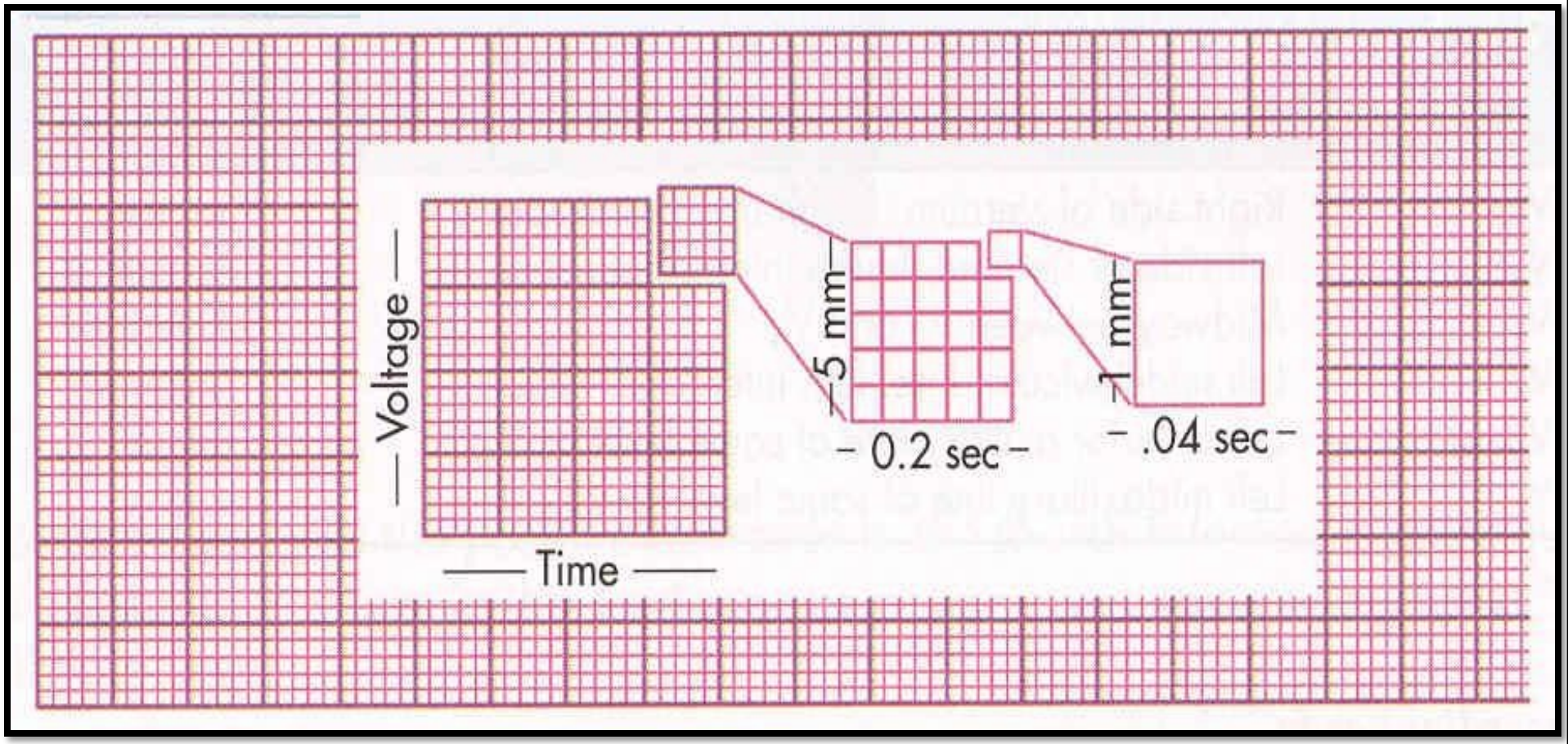
The ECG Paper



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)

The ECG Paper



ECG Leads

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

1. **Two exploring (Active) electrodes attached to the surface of body (bipolar leads)**

2. **One point on the body (Exploring) and a virtual reference point (Indifferent) electrode with zero electrical potential (unipolar leads)**

Summary of ECG Leads

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

ECG Leads

The standard ECG has 12 leads

3 Standard Limb Leads (Bipolar)

3 Augmented Limb Leads (Unipolar)

6 Precordial (chest) Leads (Unipolar)

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

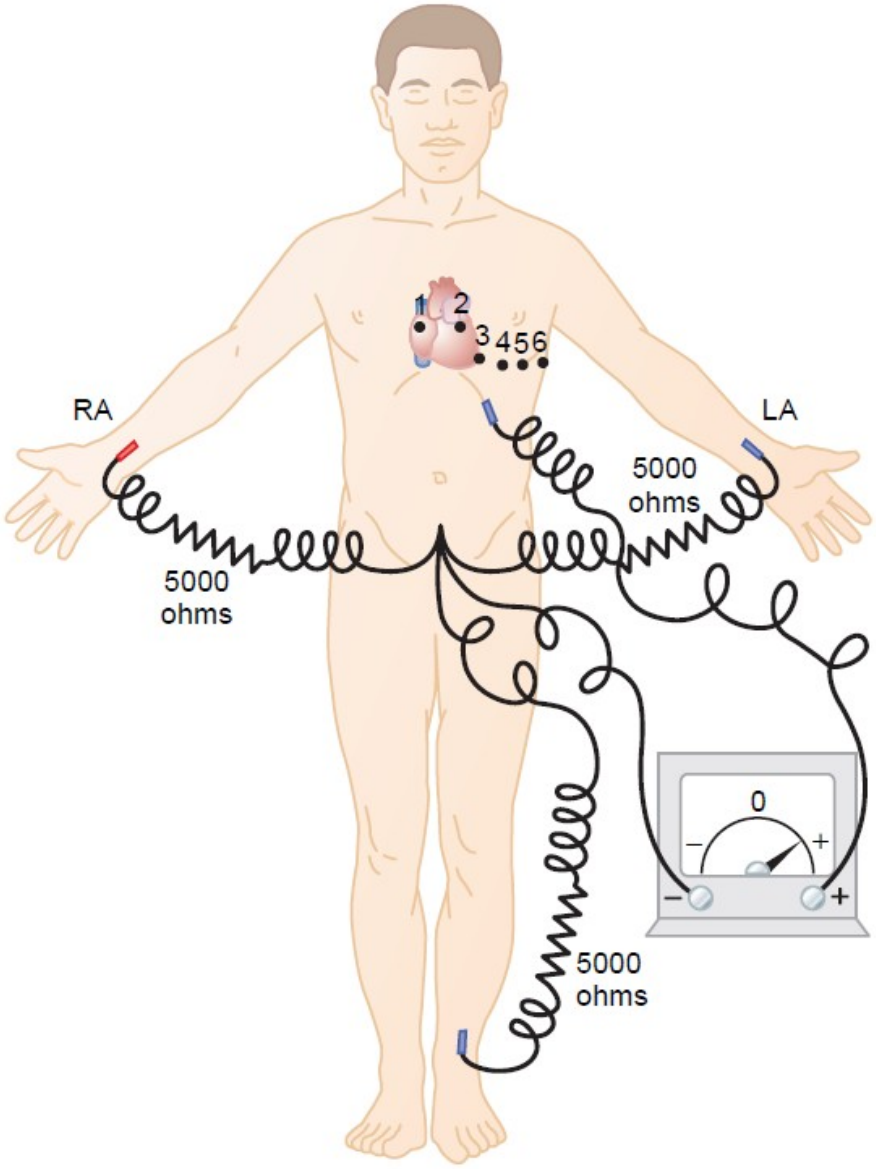


Figure 11–8

Connections of the body with the electrocardiograph for recording *chest leads*. LA, left arm; RA, right arm.

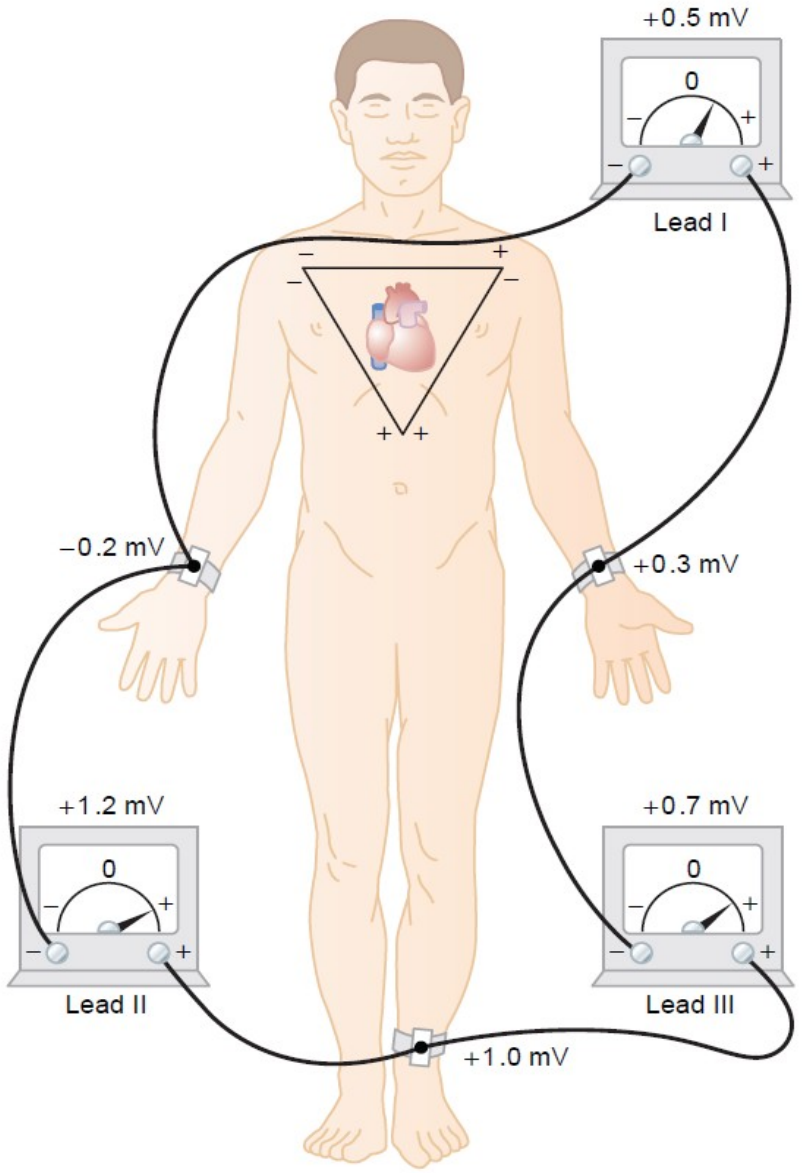
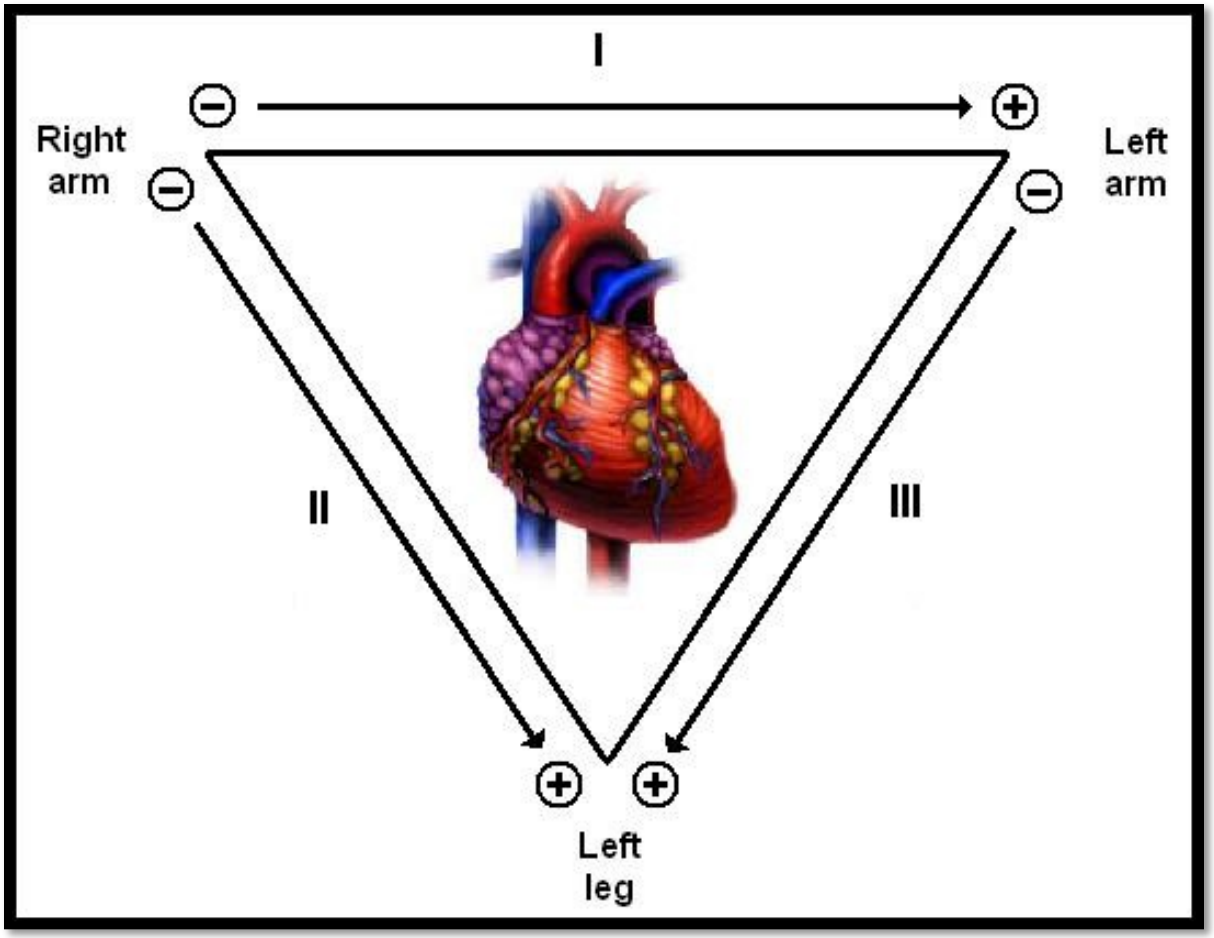


Figure 11–6

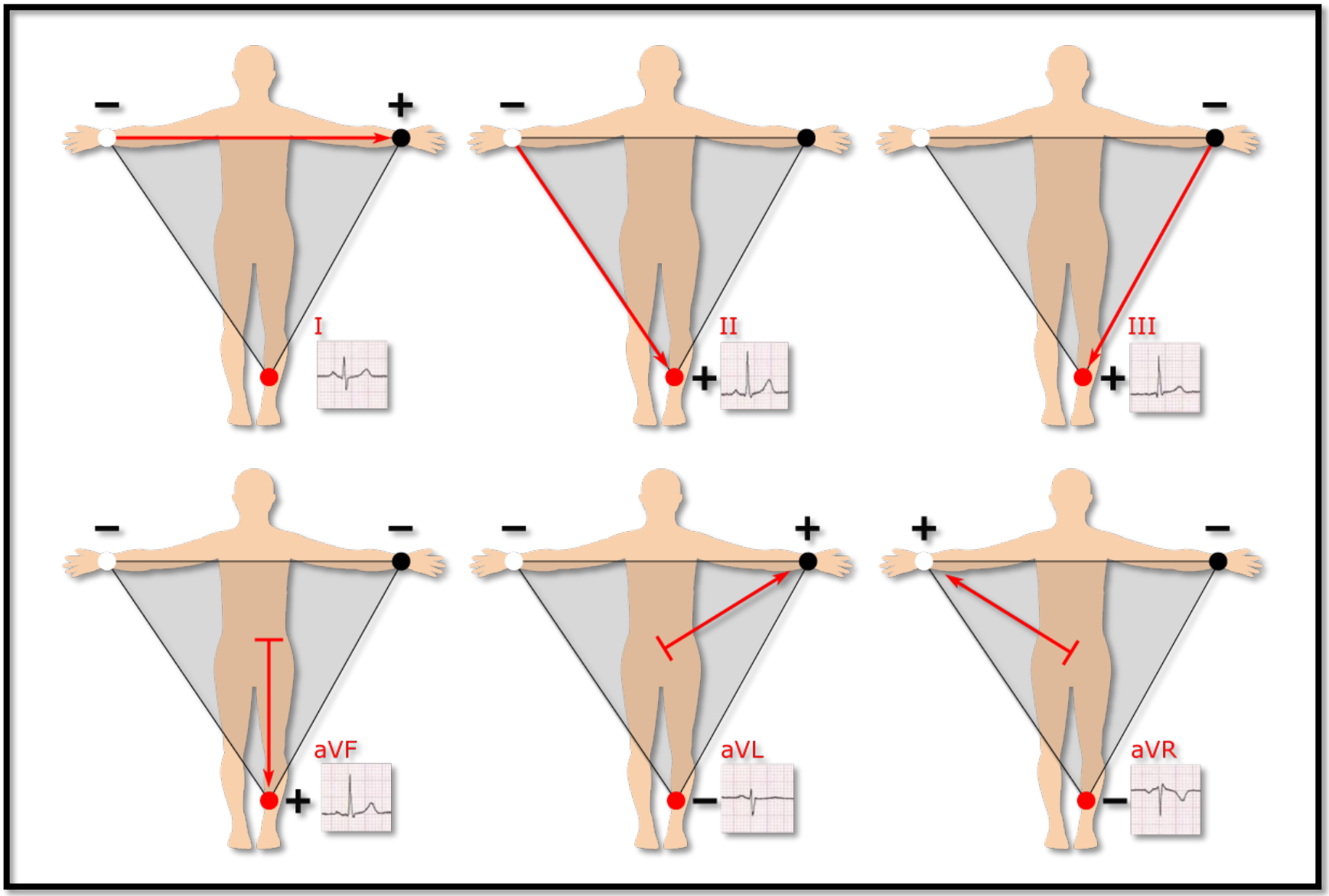
Conventional arrangement of electrodes for recording the standard electrocardiographic leads. Einthoven's triangle is superimposed on the chest.

Standard Bipolar Limb Leads

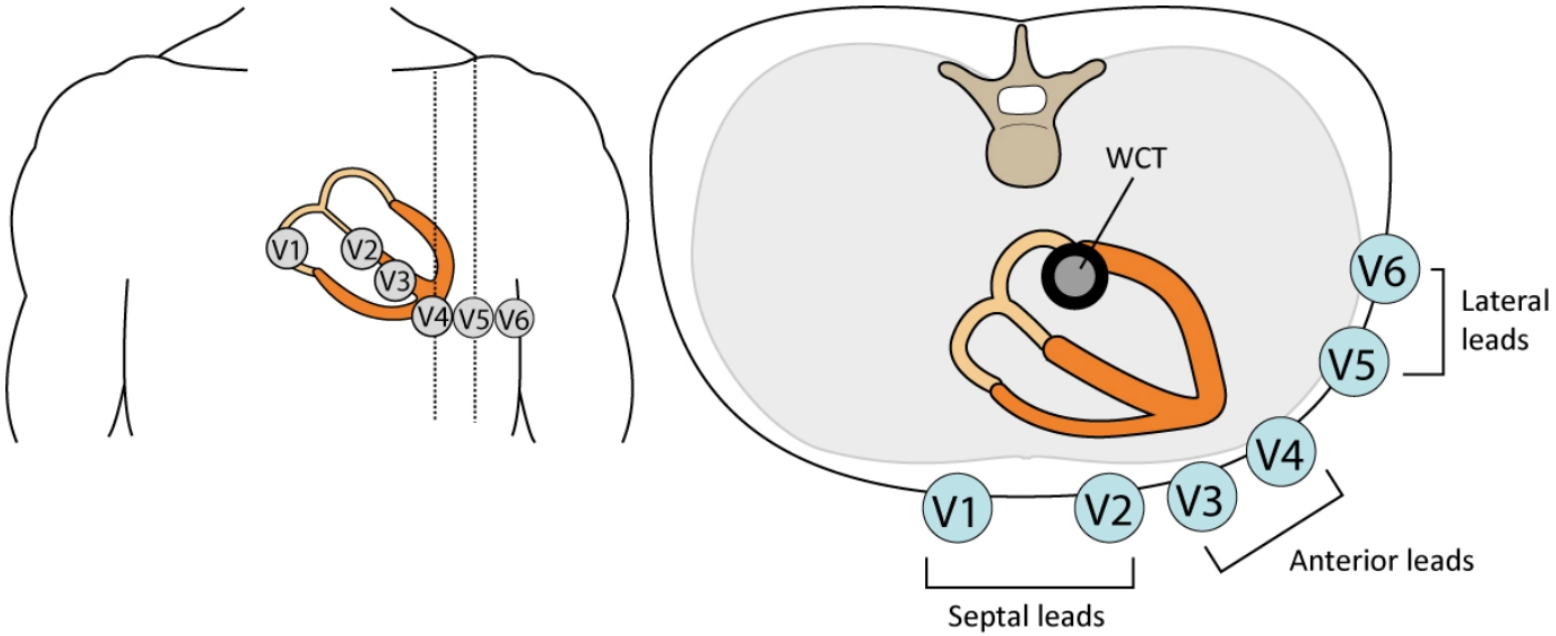


Einthoven's Law. Einthoven's law states that if the ECGs are recorded simultaneously with the three limb leads, the sum of the potentials recorded in leads I and III will equal the potential in lead II.

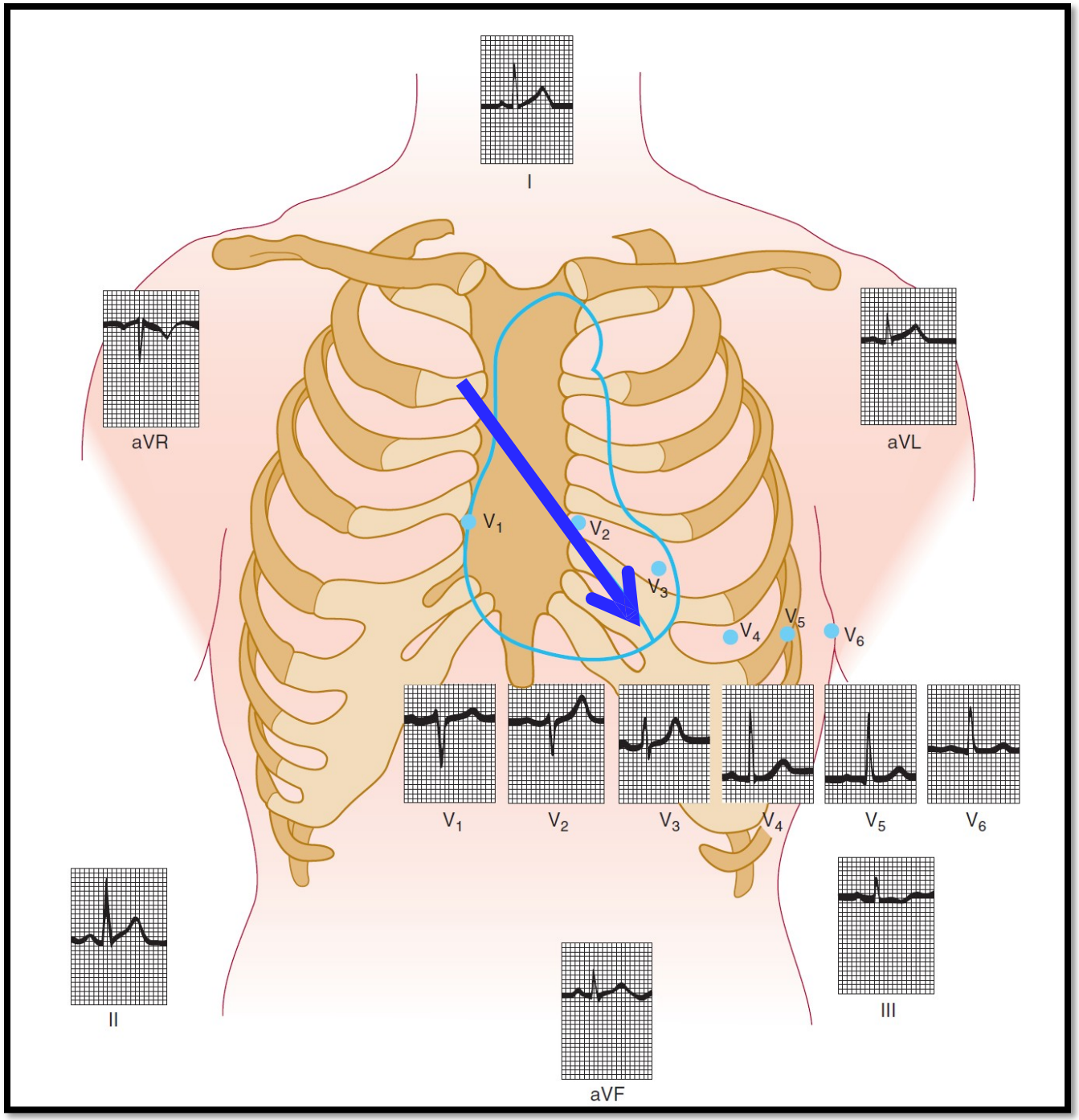
Lead I + Lead III= Lead II


I
II
III
aVF
aVL
aVR

Chest leads (precordial leads)



Figur 19. The chest (precordial) leads. WCT = Wilson's central terminal.


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

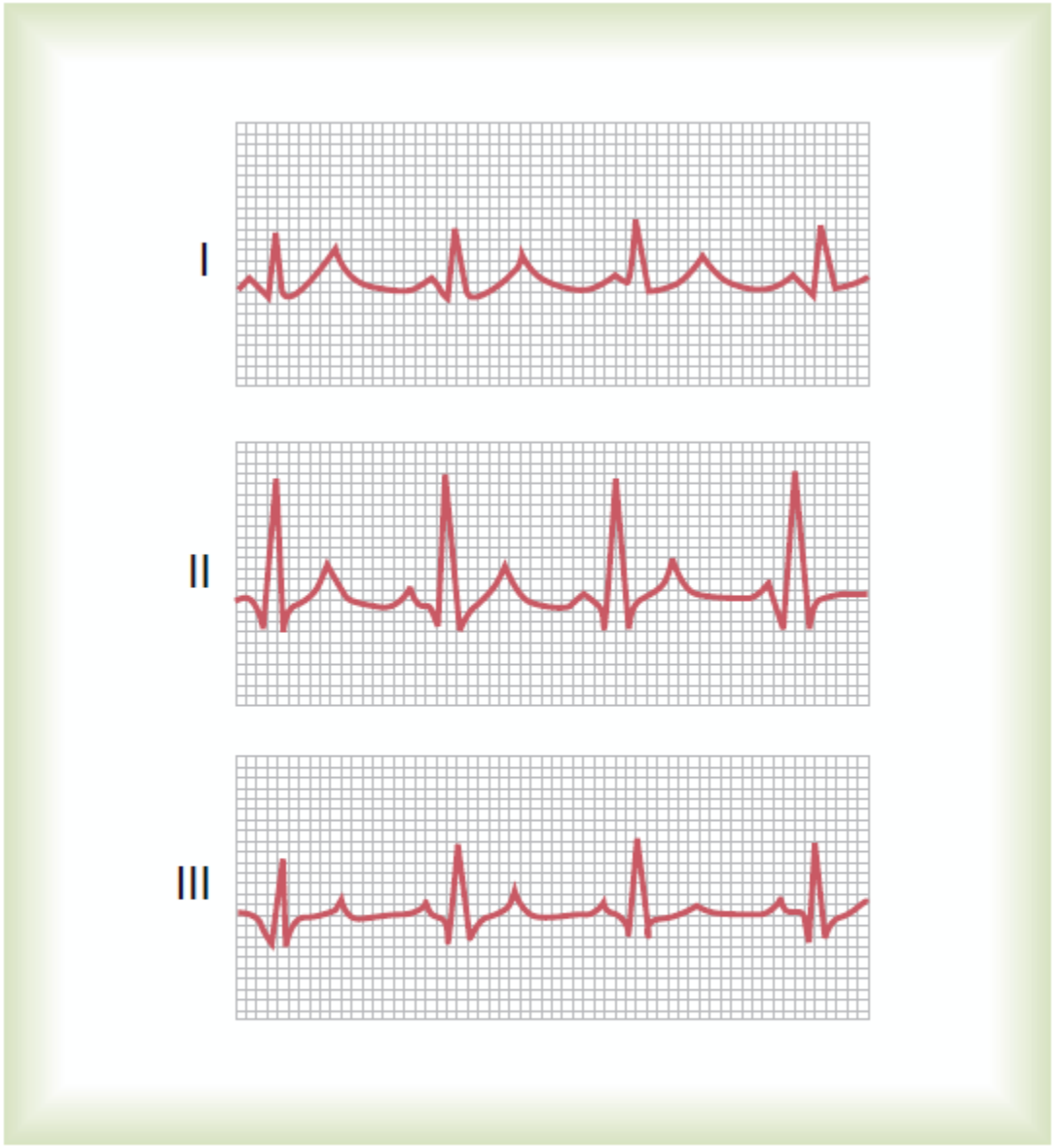


Figure 11–7

Normal electrocardiograms recorded from the three *standard* electrocardiographic leads.

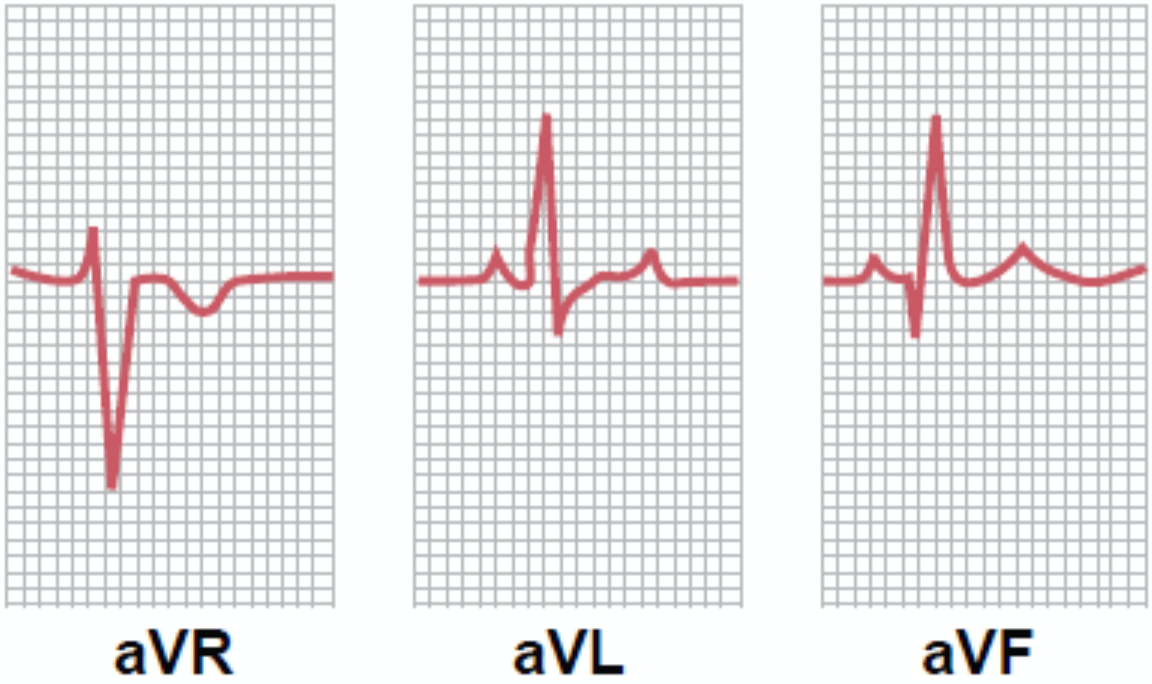


Figure 11–10

Normal electrocardiograms recorded from the three *augmented unipolar limb leads.*

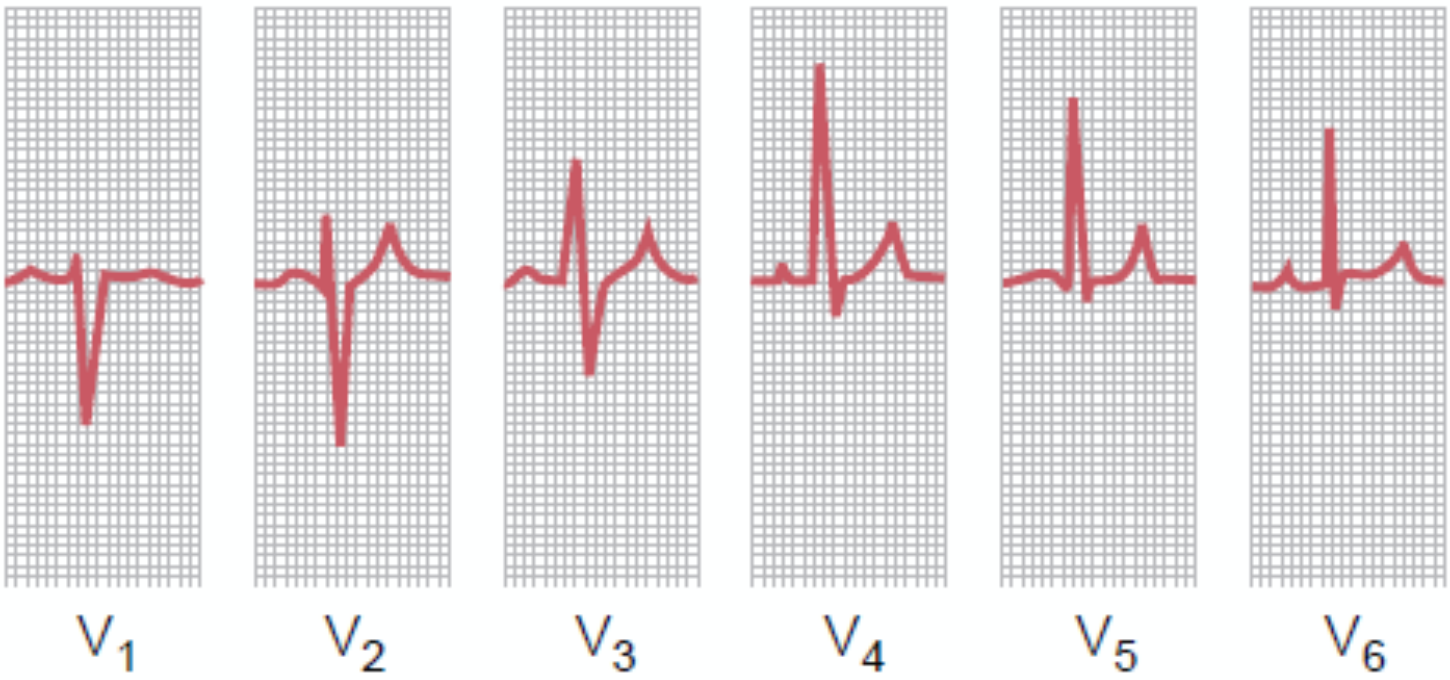


Figure 11–9

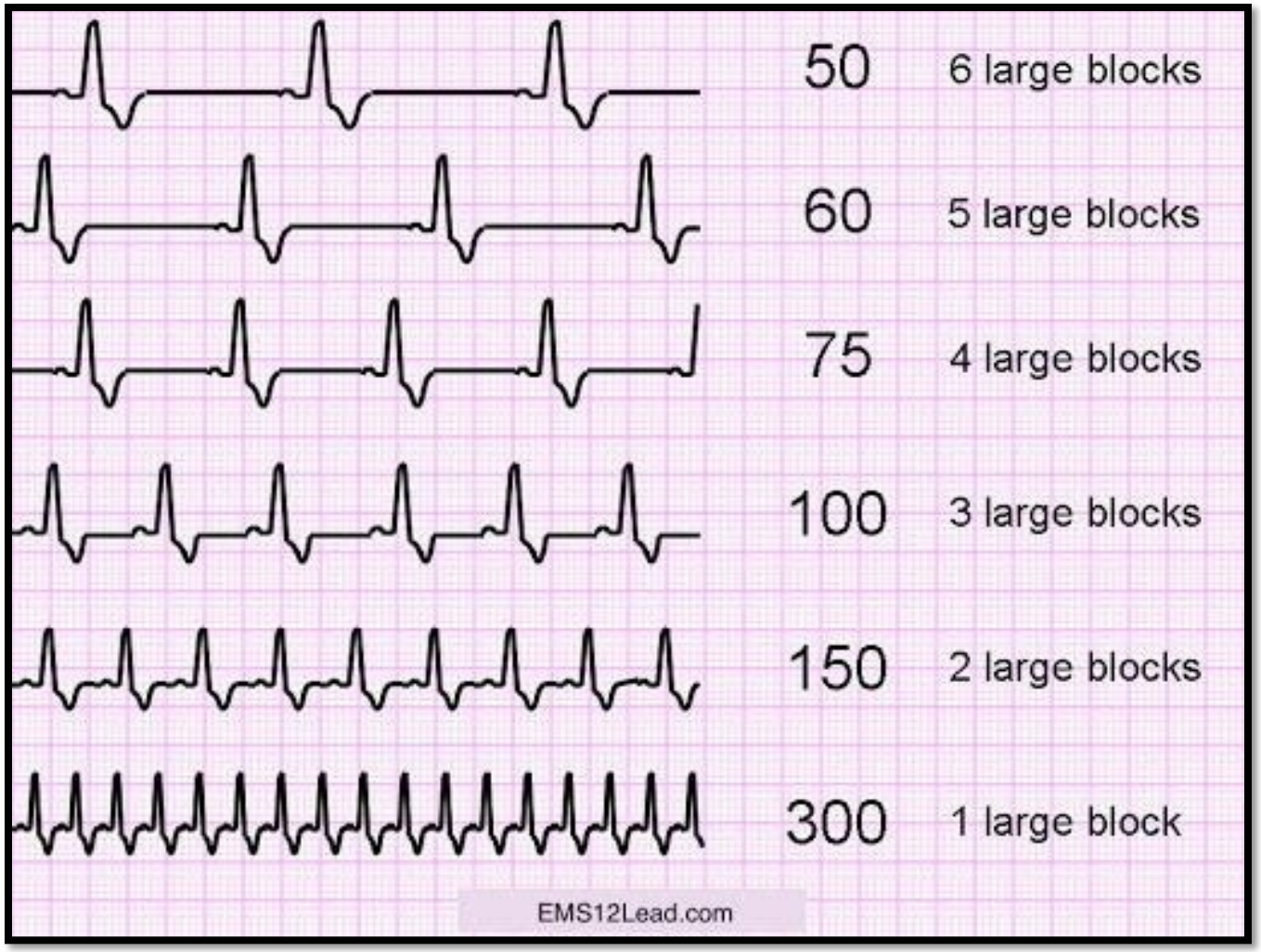
Normal electrocardiograms recorded from the six standard chest leads.

U-WAVE

The U wave is a wave on an electrocardiogram that is not always seen. It is typically small, and, by definition, follows the T wave. U waves are thought to represent repolarization of the papillary muscles or Purkinje fibers

Normal U waves are small, round and symmetrical and positive in lead II. It is the same direction as T wave in that lead.

How to calculate HR from ECG



Heart Rate = 300/Large squares between R-R

OR

1500/Small squares between R-R


THANKS