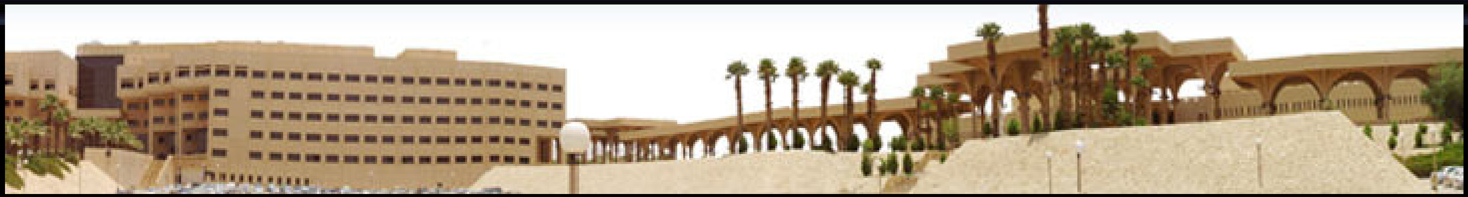
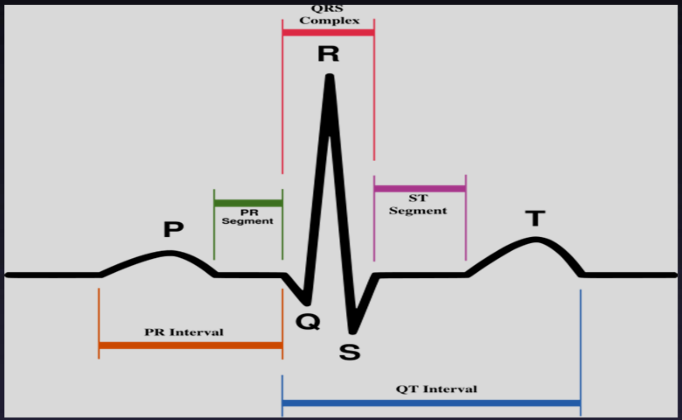


ELECTROCARDIOGRAM (ECG)



Prof. Shahid Habib
King Saud University

OBJECTIVES

At the end of this lecture you should be able to

- Enumerate uses of ECG
- Explain basic ECG principles
- Describe ECG leads and their application
- Recognize ECG waves, Intervals and, segments
- Determine rate and normal heart rhythm
- Have some idea about ECG abnormalities in common clinical conditions

DEFINITION

"ECG is a graphical representation of the sum of all the electrical activities of the heart usually recorded from the body surface".

ECG can help the doctor see if you have heart muscle damage or electrical problems in the heart.

HISTORY

- 1842- Italian scientist Carlo Matteucci realizes that electricity is associated with the heart beat
- 1872- French scientist Gabriel Lippmann , invented the capillary electrometer which can measure electricity by utilizing mercury
- 1876- Irish scientist Marey analyzes the electric pattern of frog’s heart

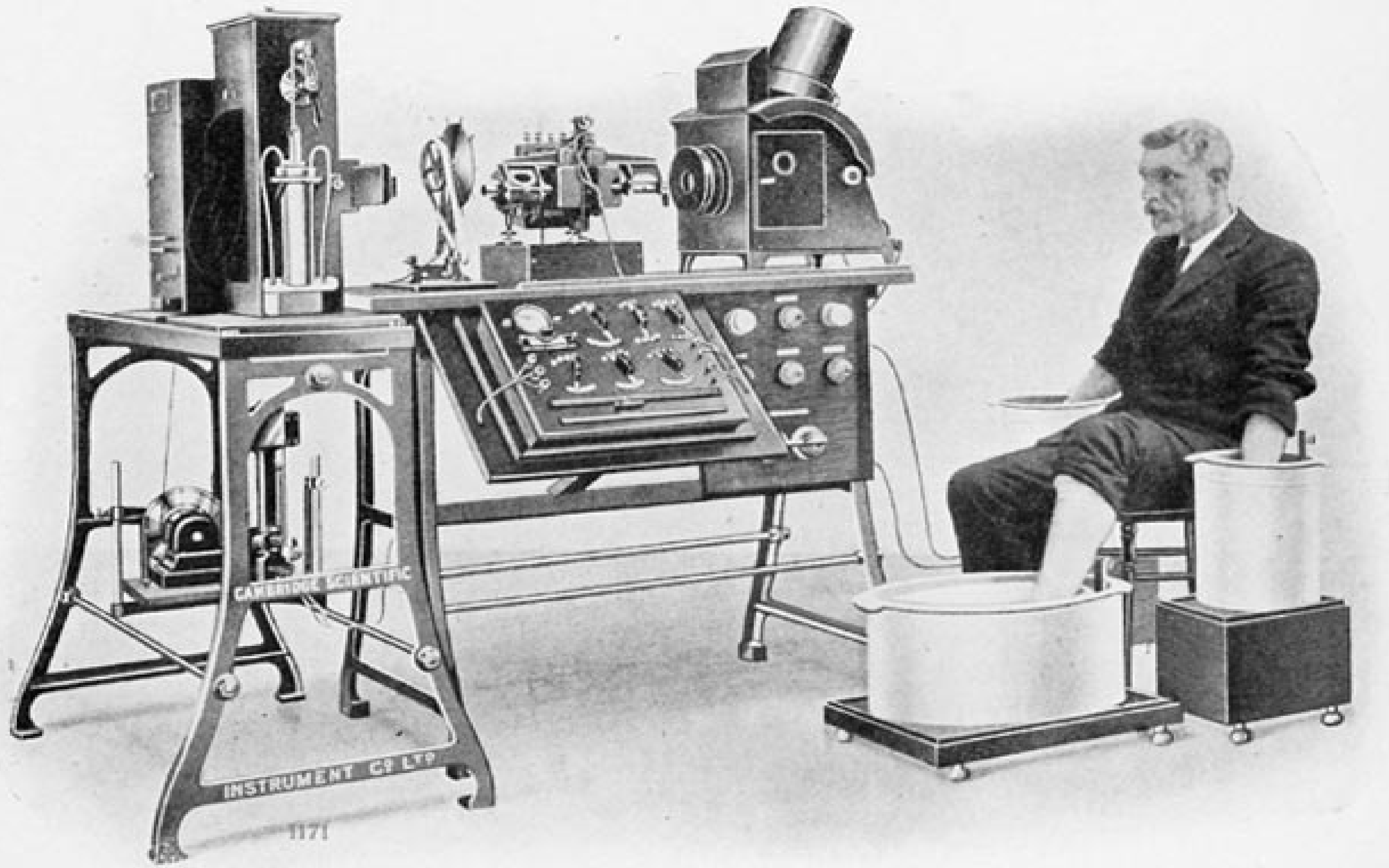
CONTD…

- 1895 - William Einthoven , credited for the invention of EKG

- 1906 - using the string electrometer EKG,

  William Einthoven diagnoses some heart problems

- 1924 - the noble prize for physiology or medicine is given to William Einthoven for his work on EKG

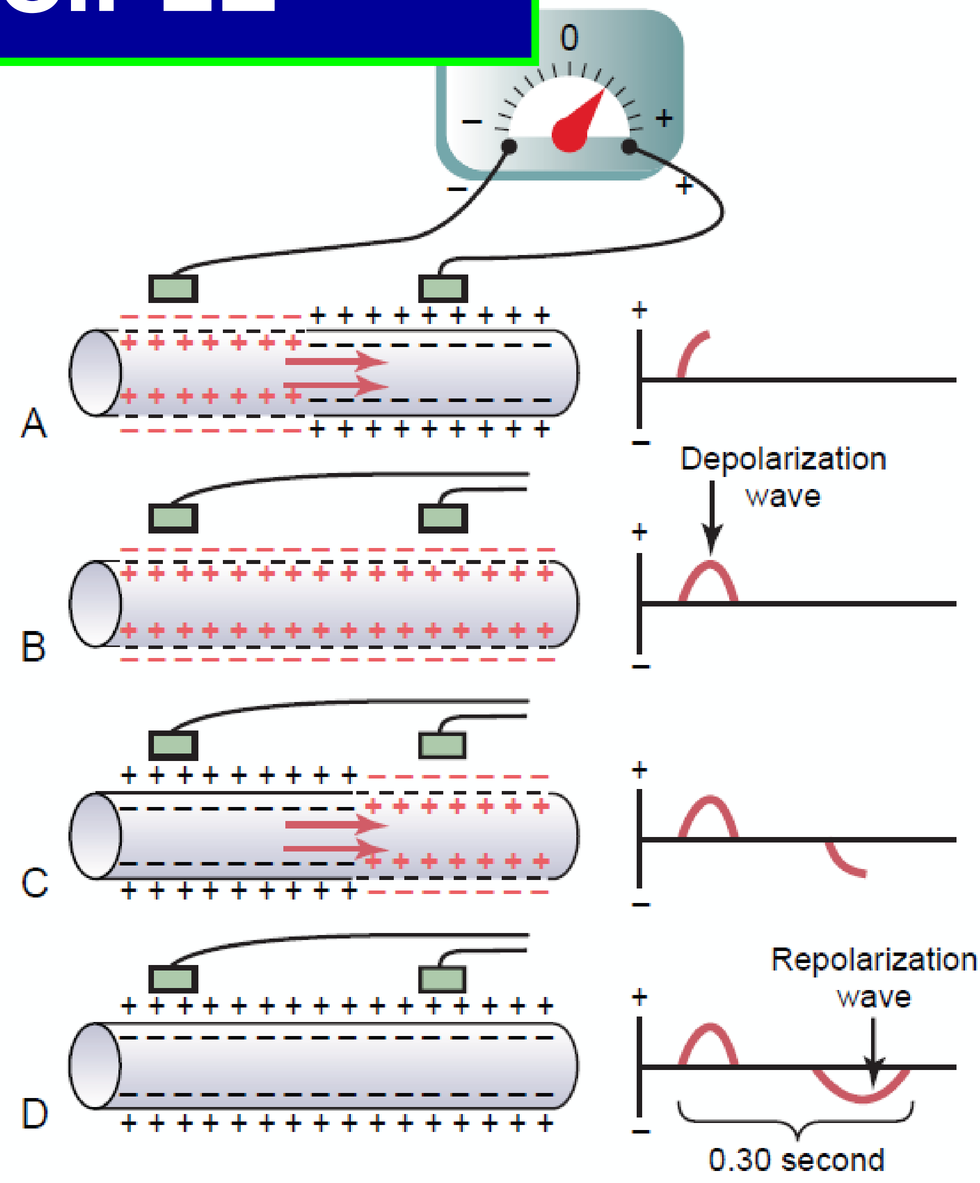


Photograph of a Complete Electrocardiograph, Showing the Manner in which the Electrodes are Attached to the Patient, In this Case the Hands and One Foot Being Immersed in Jars of Salt Solution

What types of information can we obtain from an ECG?

- Heart rate
- Heart Rhythem
- Myopathies
- Helps in diagnosis of chest pain
- Proper use of thrombolysis in treatment of MI depend upon it
- Electrolyte disturbances (i.e. hyperkalemia, hypokalemia)
- Drug toxicity (i.e. digoxin and drugs which prolong the QT interval)

ECG PRINCIPLE



ECG PRINCIPLE

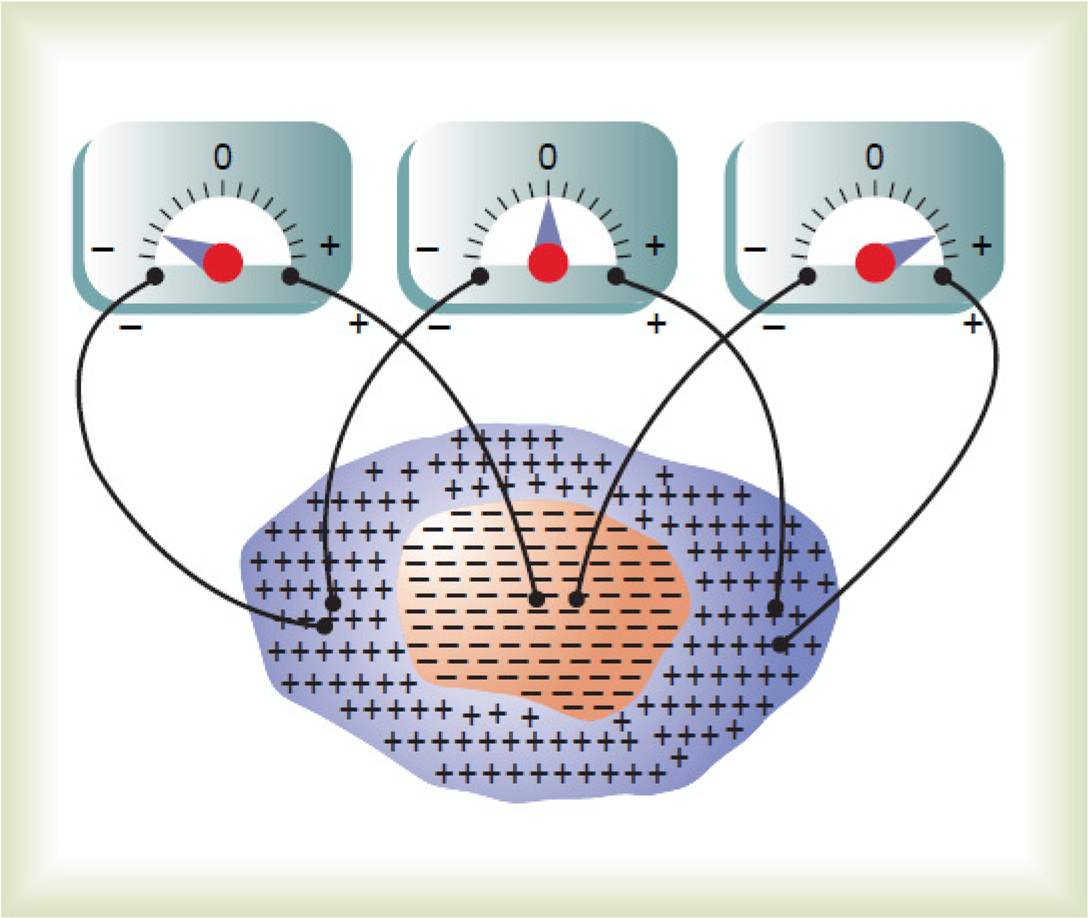


Figure 11–4

Instantaneous potentials develop on the surface of a cardiac muscle mass that has been depolarized in its center.

ECG Waveforms

P wave = atrial depolarisation.

PR Interval = impulse from atria to ventricles.

QRS complex = ventricular depolarisation.

ST segment = isoelectric - part of repolarisation.

T wave = usually same direction as QRS - ventricular repolarisation.

QT Interval = This interval spans the onset of depolarisation to the completion of repolarization of the ventricles.

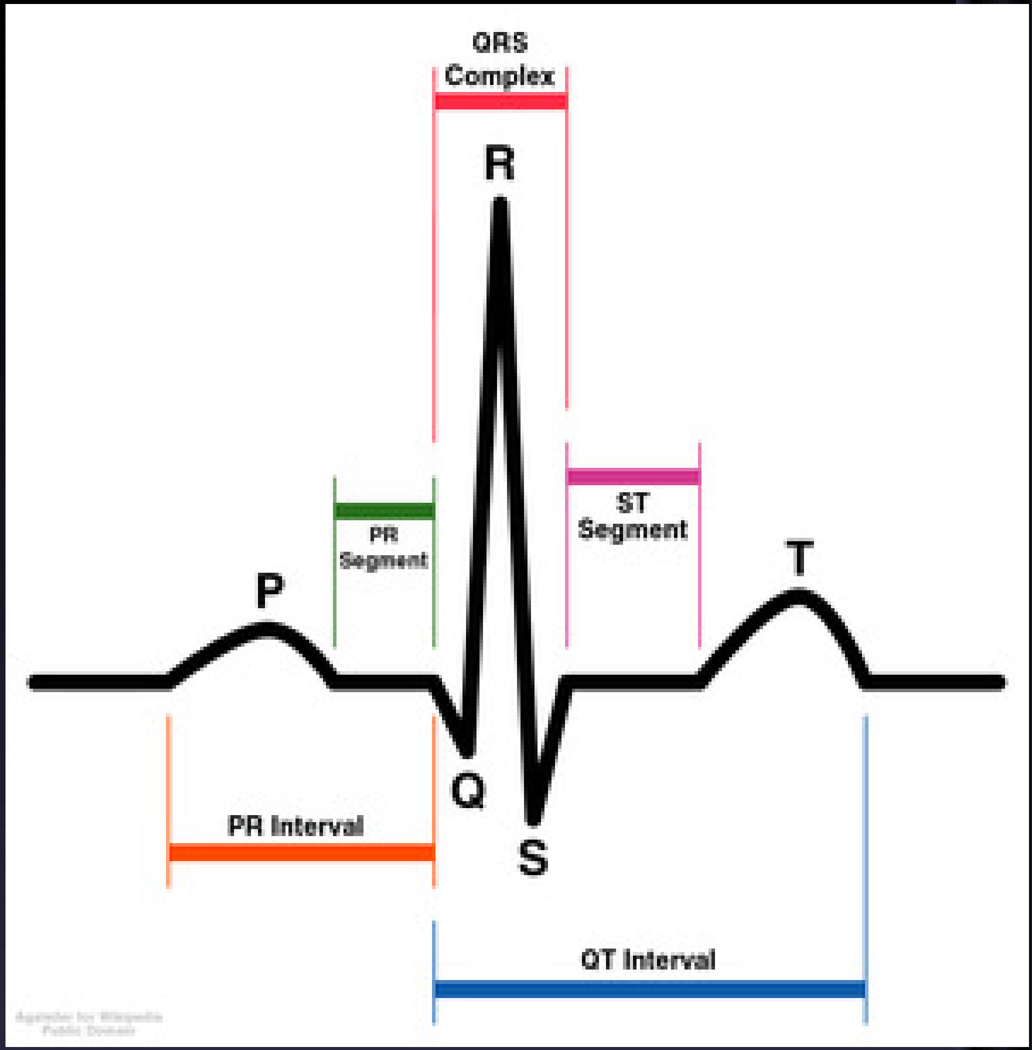


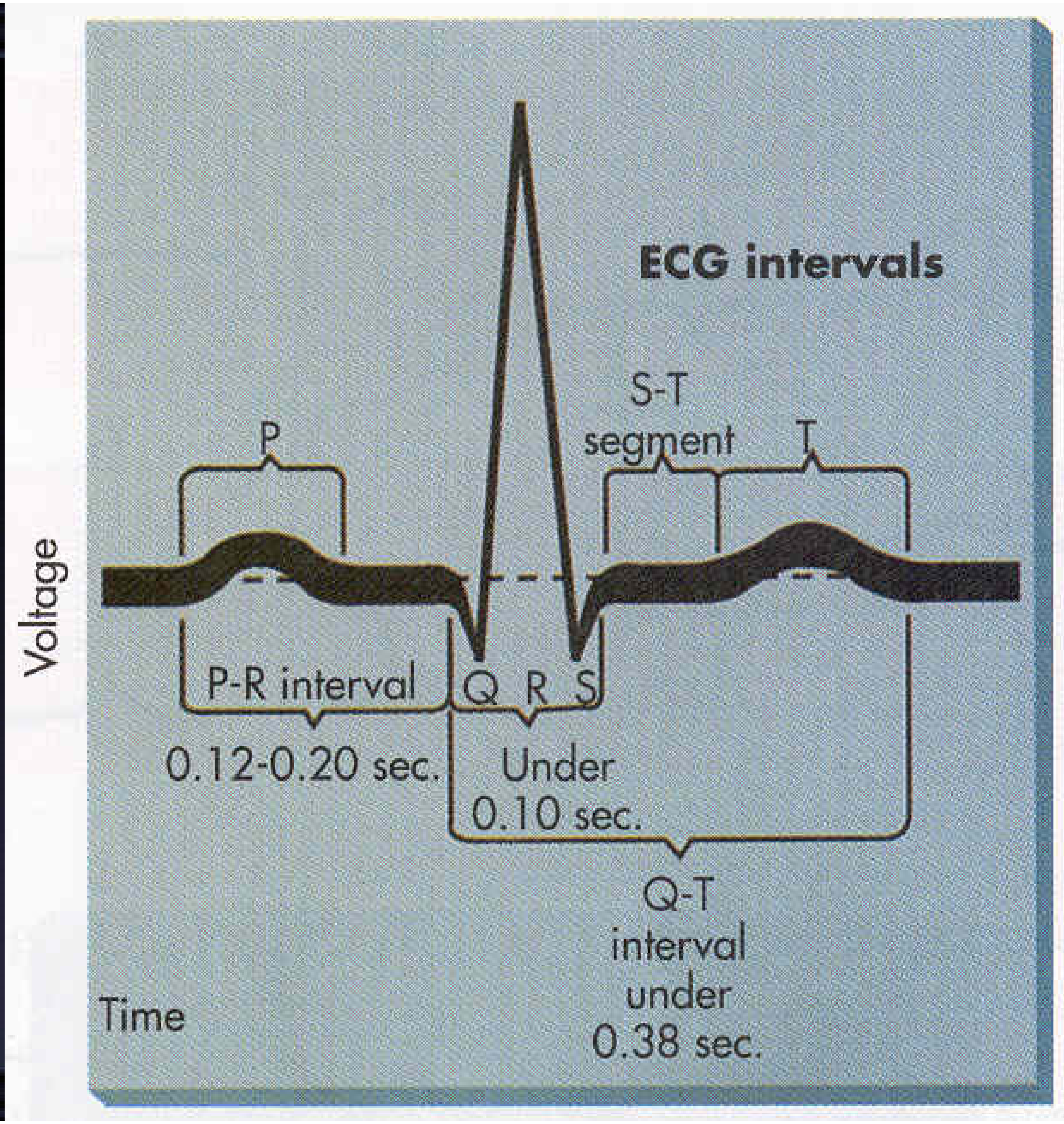
TABLE 29–2 ECG intervals.

Intervals	Normal Durations: Average	Normal Durations: Range	Events in the Heart during Interval
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.

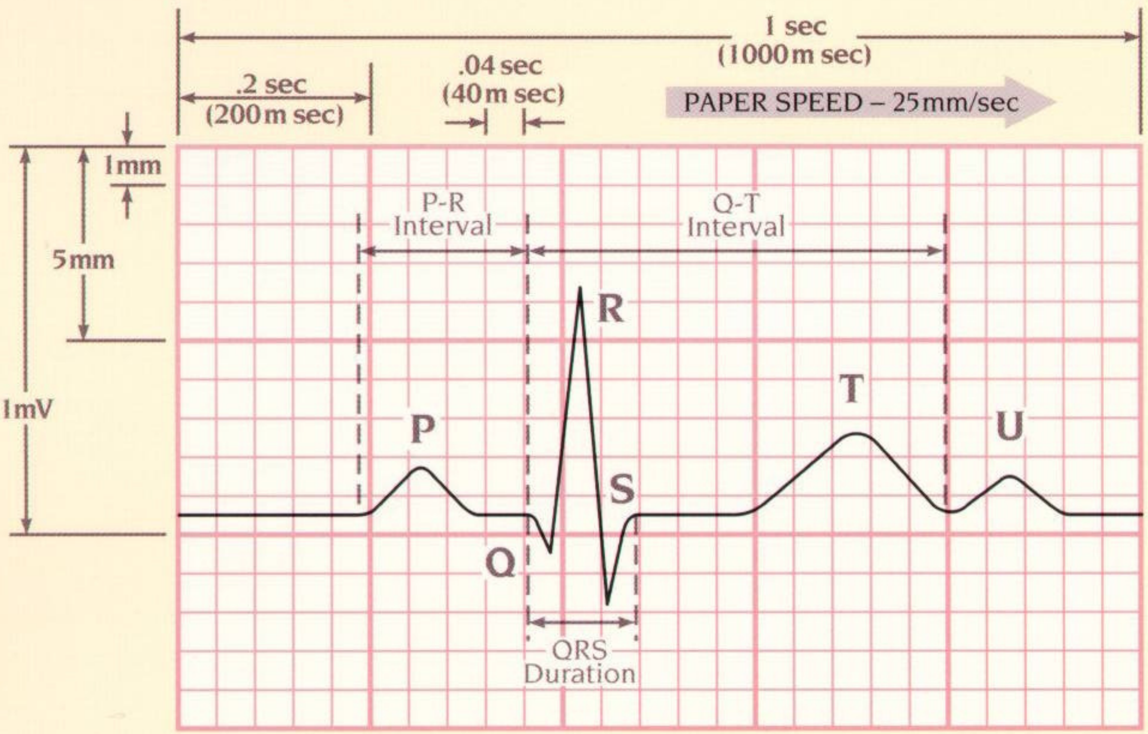
[b]Shortens as heart rate increases from average of 0.18 s at a rate of 70 beats/min to 0.14 s at a rate of 130 beats/min.

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



ECG intervals
P
S-T
segment
T
Voltage
P-R interval
Q R S
0.12-0.20 sec.
Under
0.10 sec.
Q-T
interval
under
0.38 sec.
Time

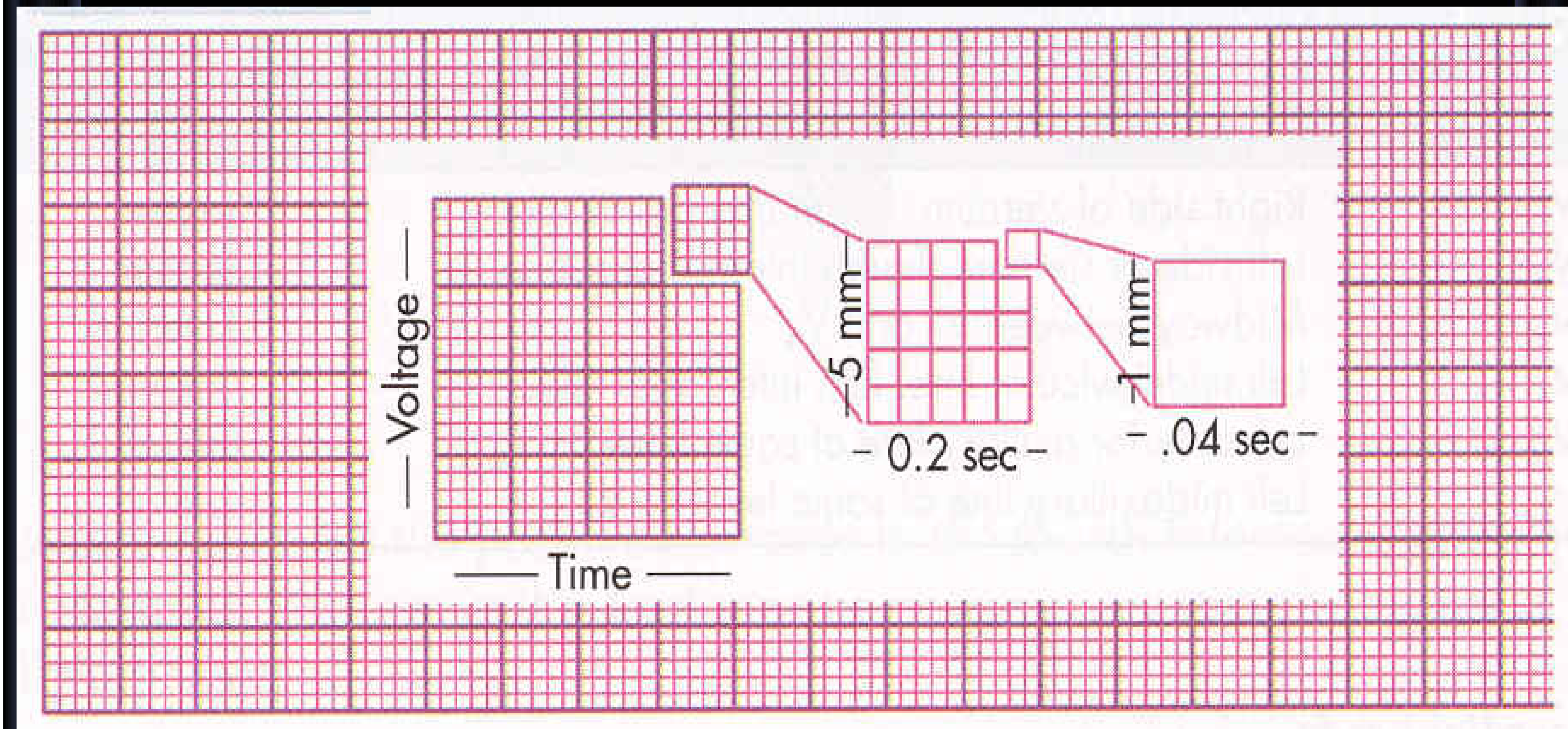
The ECG Paper



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.

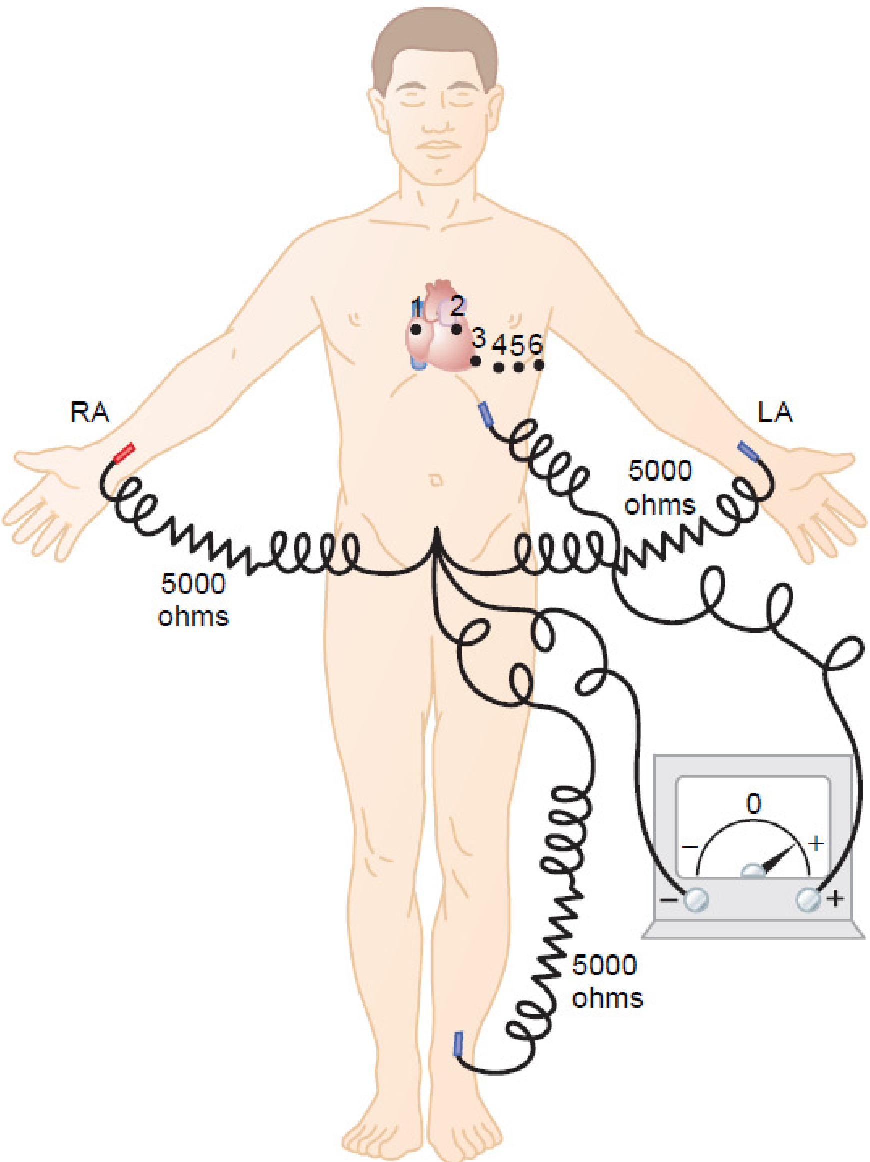


Figure 11–8

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

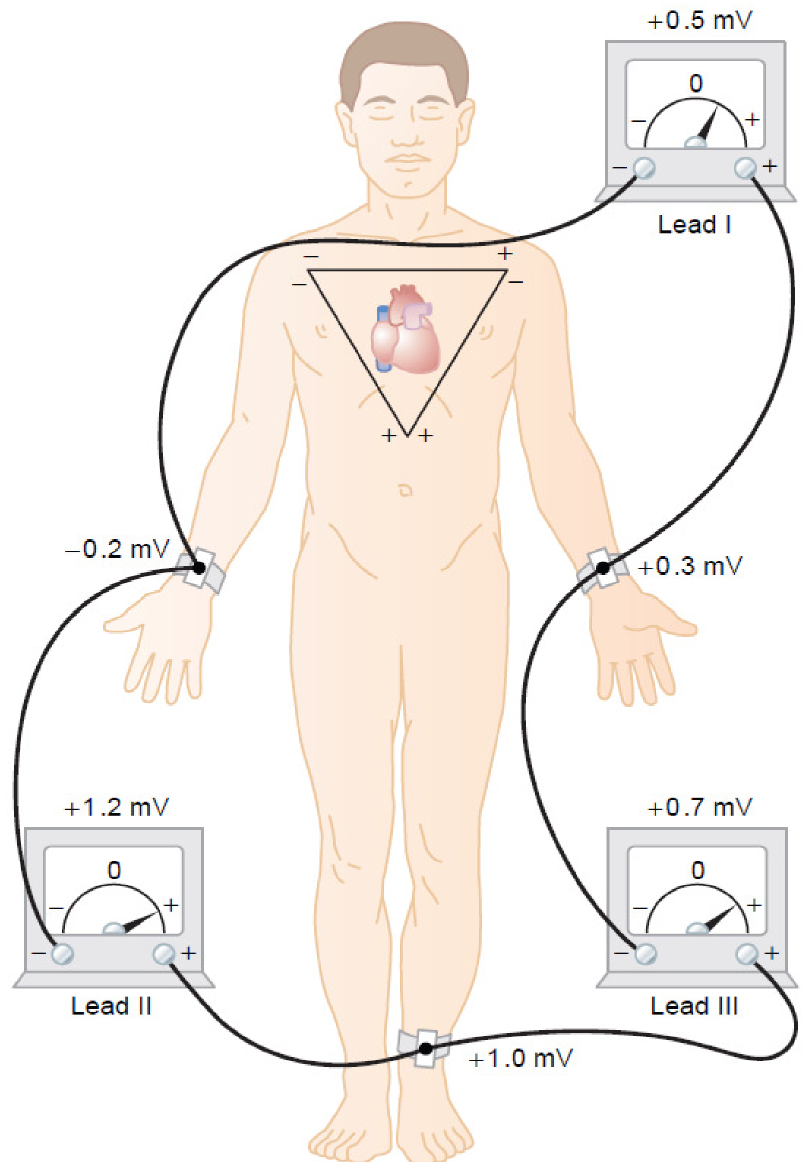
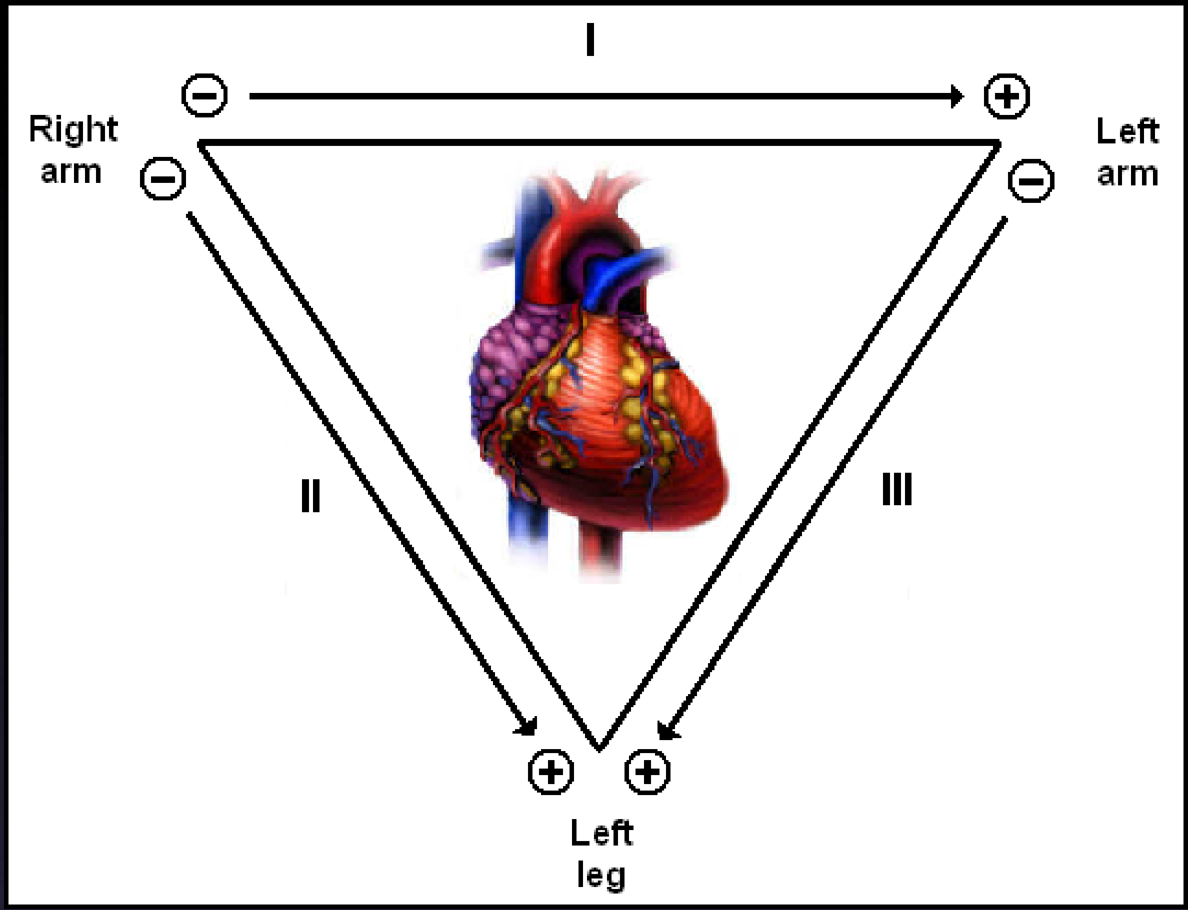


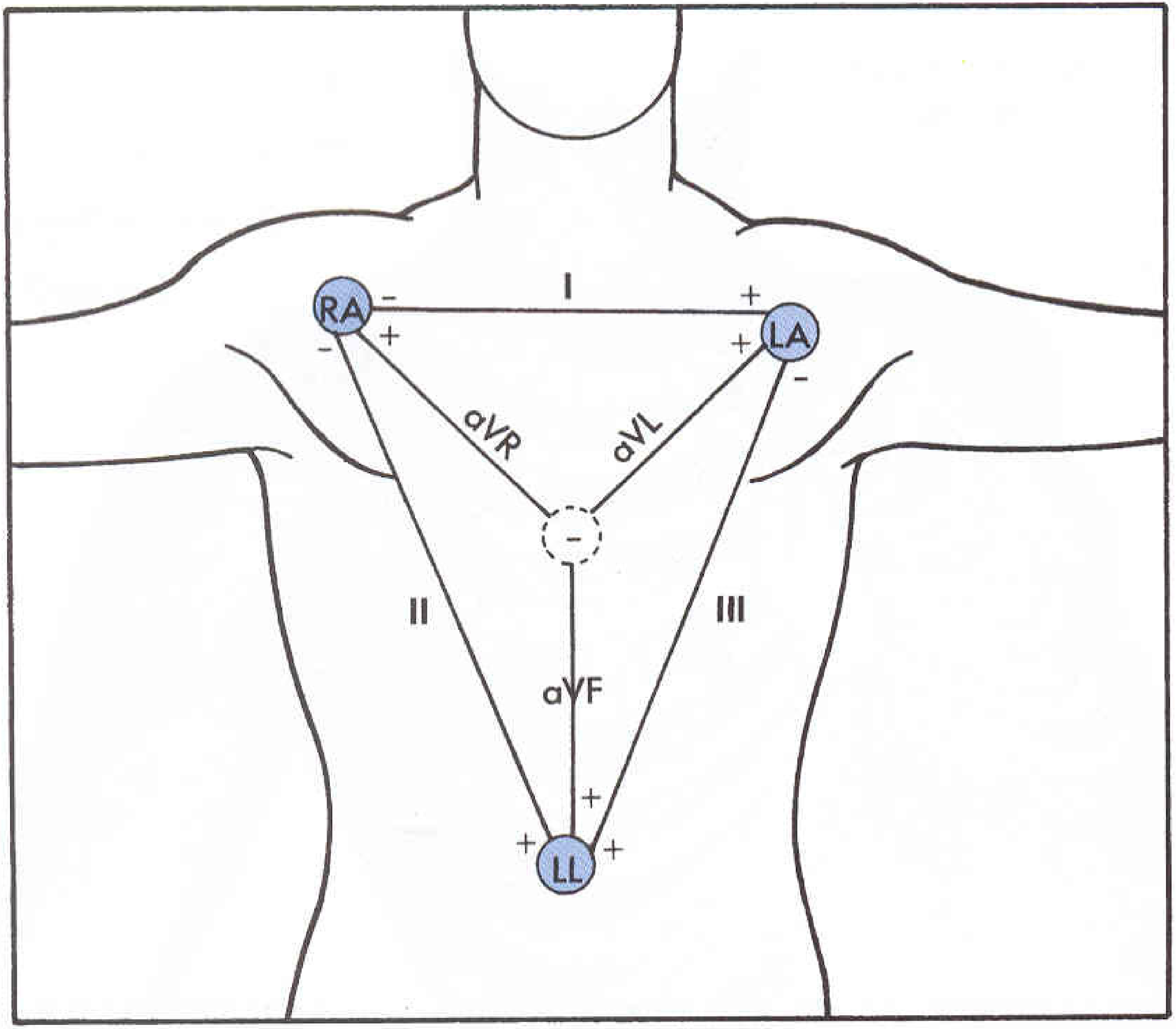
Figure 11–6

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

Standard Bipolar Limb Leads

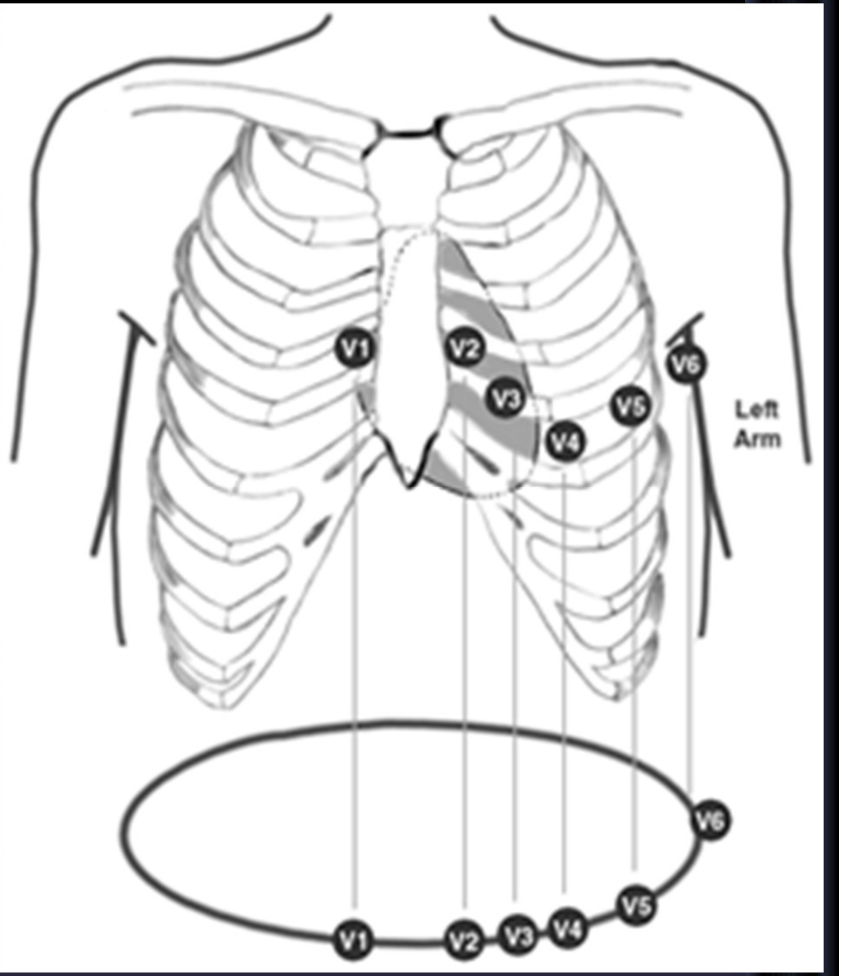


Einthoven's Law. Einthoven's law states that if the ECGs are recorded simultaneously with the three limb leads, the sum of the potentials recorded in leads I and III will equal the potential in lead II.


RA
LA
LL
I
II
III
aVR
aVL
aVF
+
−

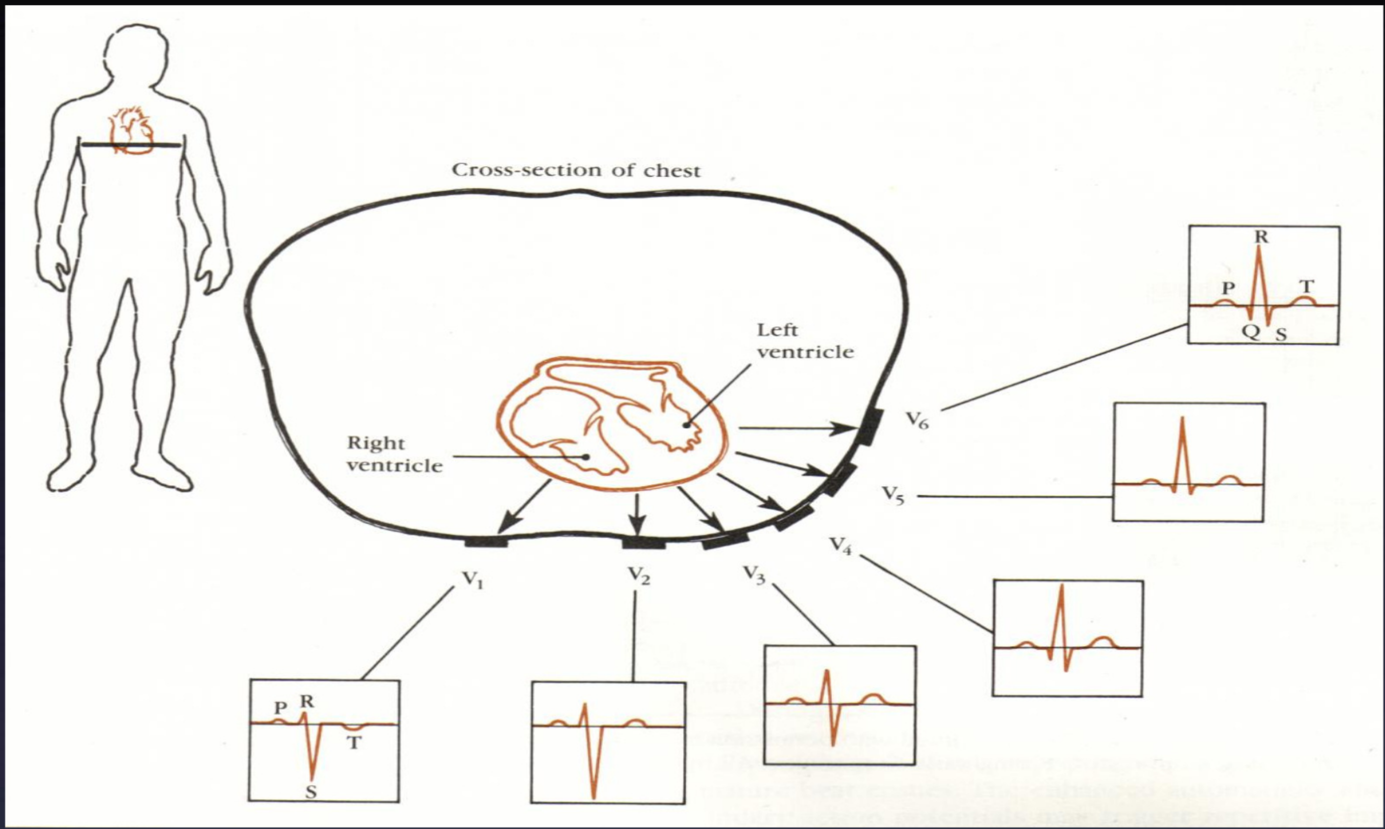
Lead Placement

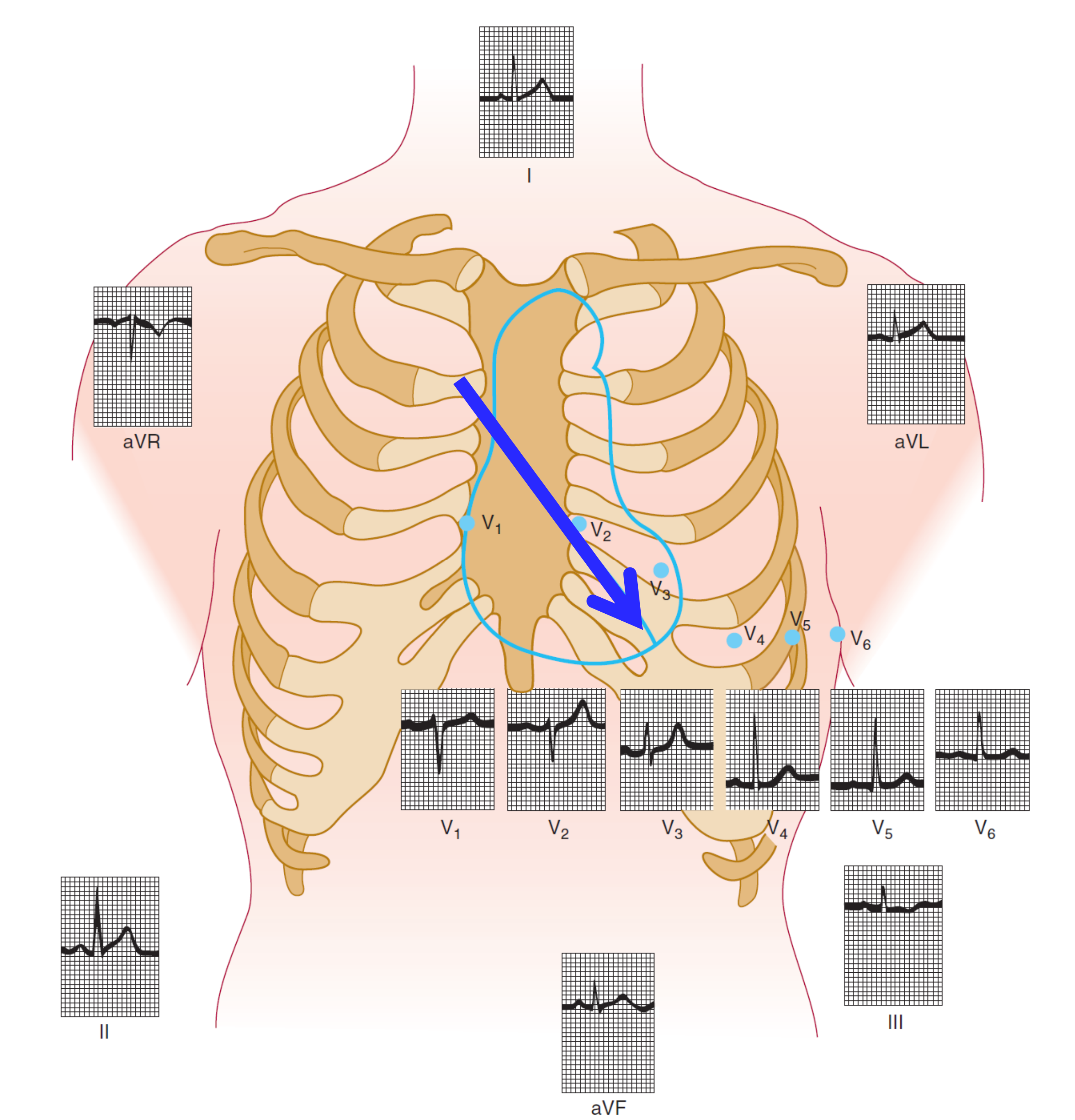
V1 = 4th ICS right sternum
V2 = 4th ICS left sternum
V3 = midway between V2 and V4
V4 = 5th ICS midclavicular
V5 = between V4 and V6 anterior auxiliary line
V6 = midauxillary line lateral to V4 and V5



Lead Placement

- **Electrical activity towards = ↑**
- **Electrical activity away = ↓**




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

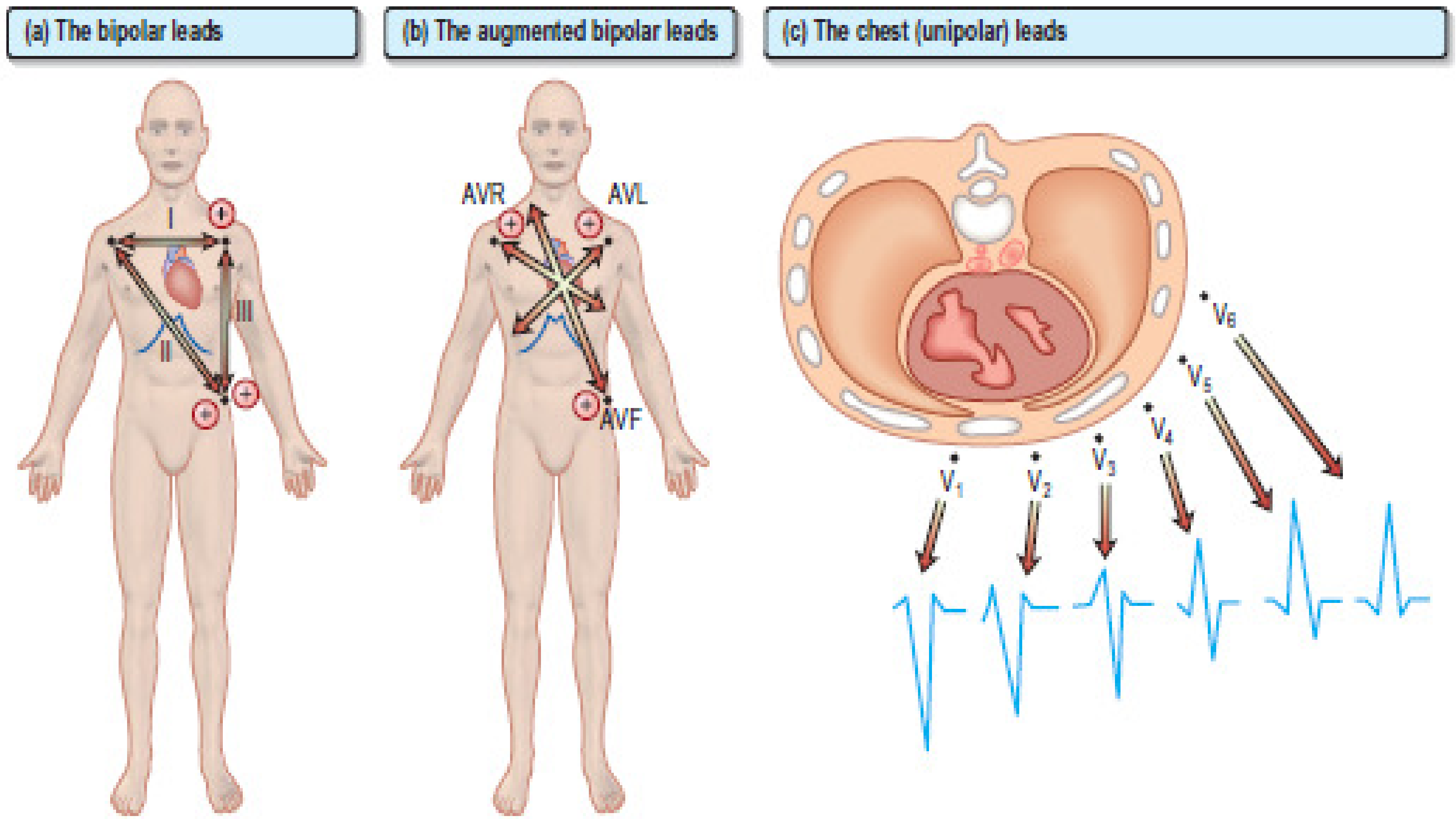
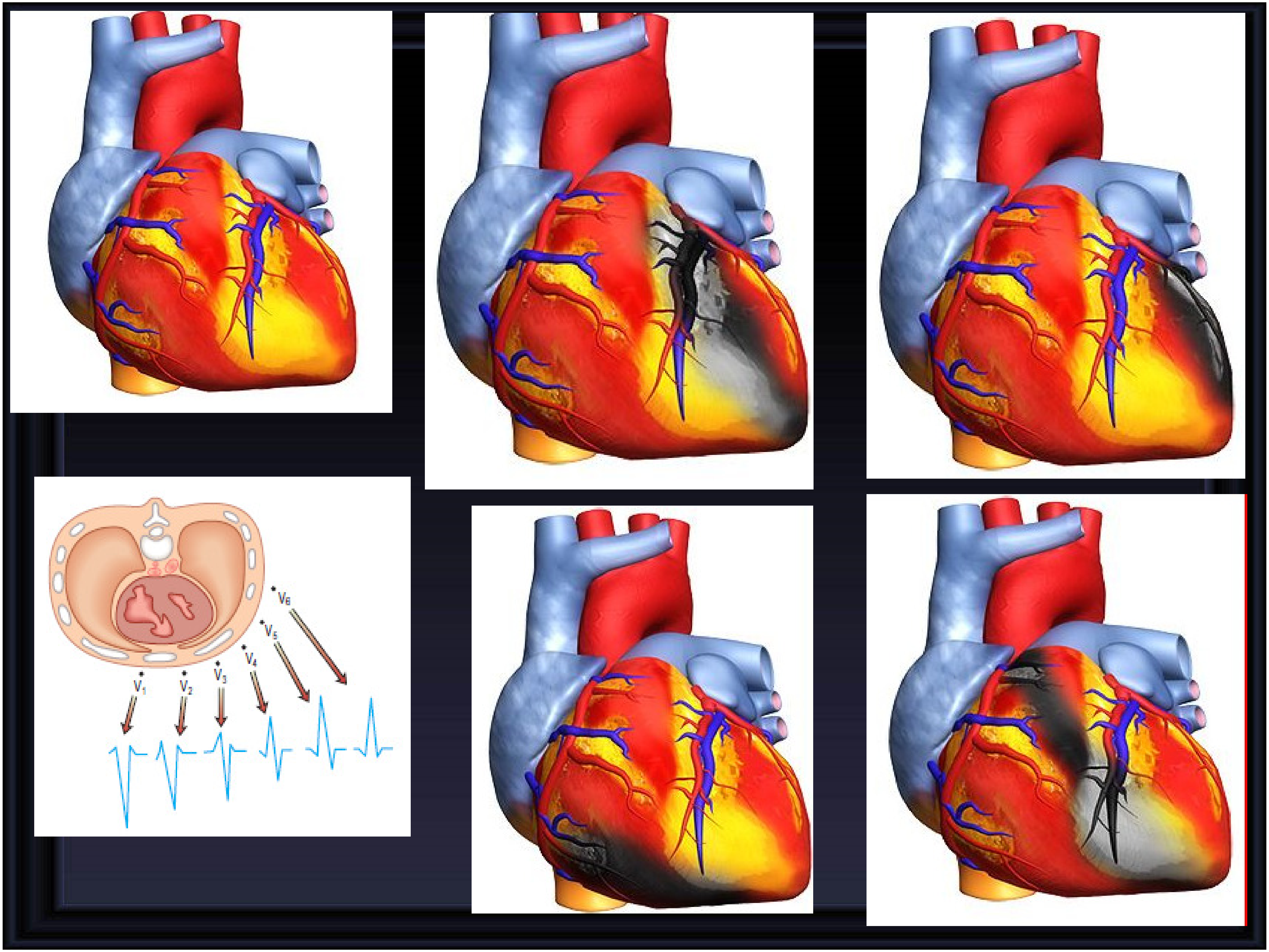


Fig. 13.17 **The connections or directions that comprise the 12-lead electrocardiogram.**

Two leads of the same anatomic group are "Anatomically Contiguous"

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

The criteria for a STEMI is ST segment elevation in two or more contiguous Leads



V_1
V_2
V_3
V_4
V_5
V_6

CARDIAC 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.

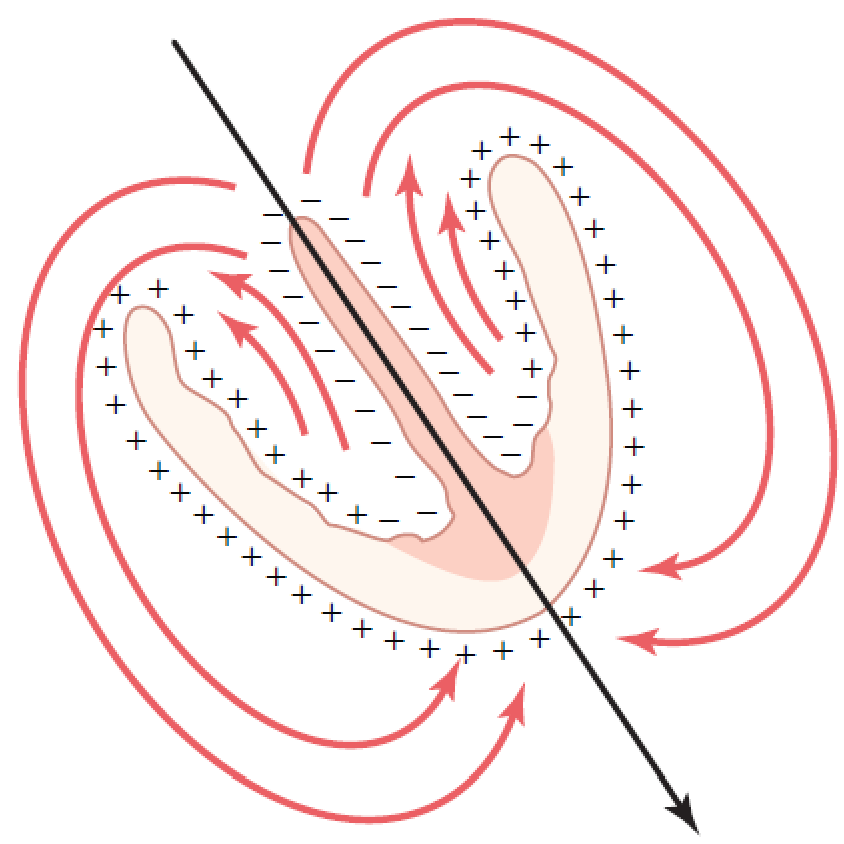


Figure 12–1

Mean vector through the partially depolarized ventricles.

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

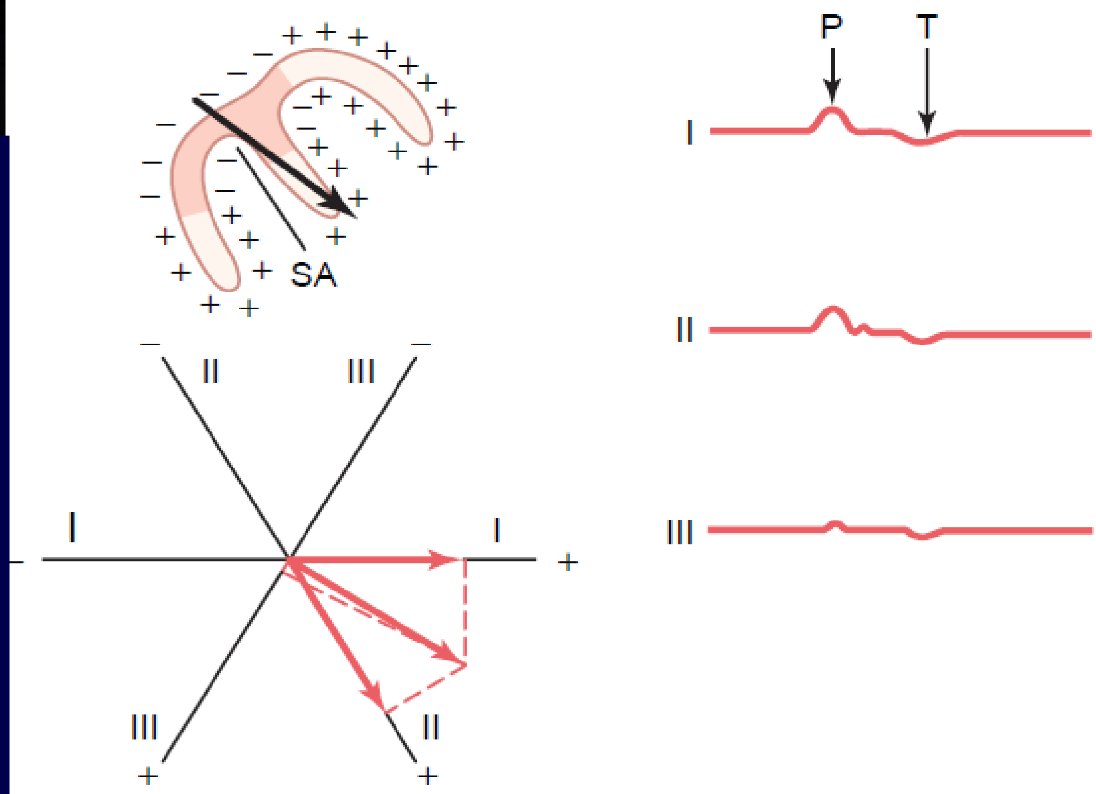


Figure 12–9

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.

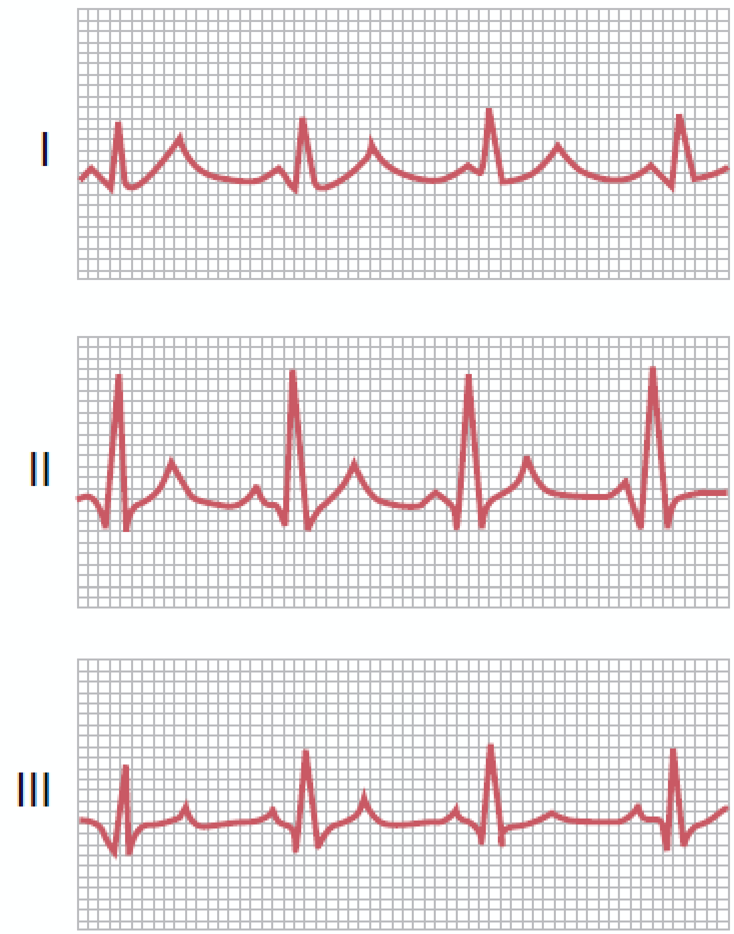


Figure 11–7

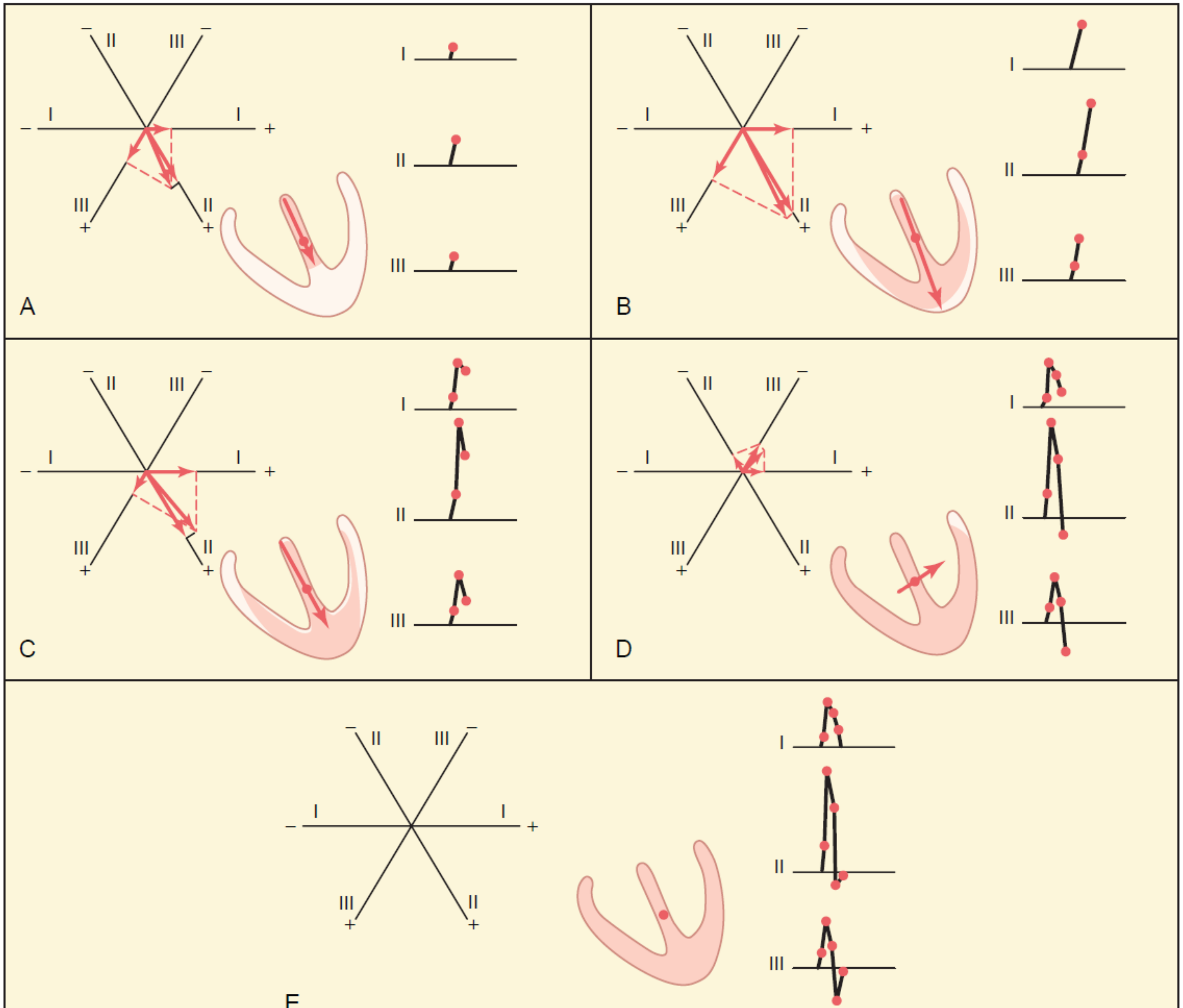
Normal electrocardiograms recorded from the three *standard* electrocardiographic leads.

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

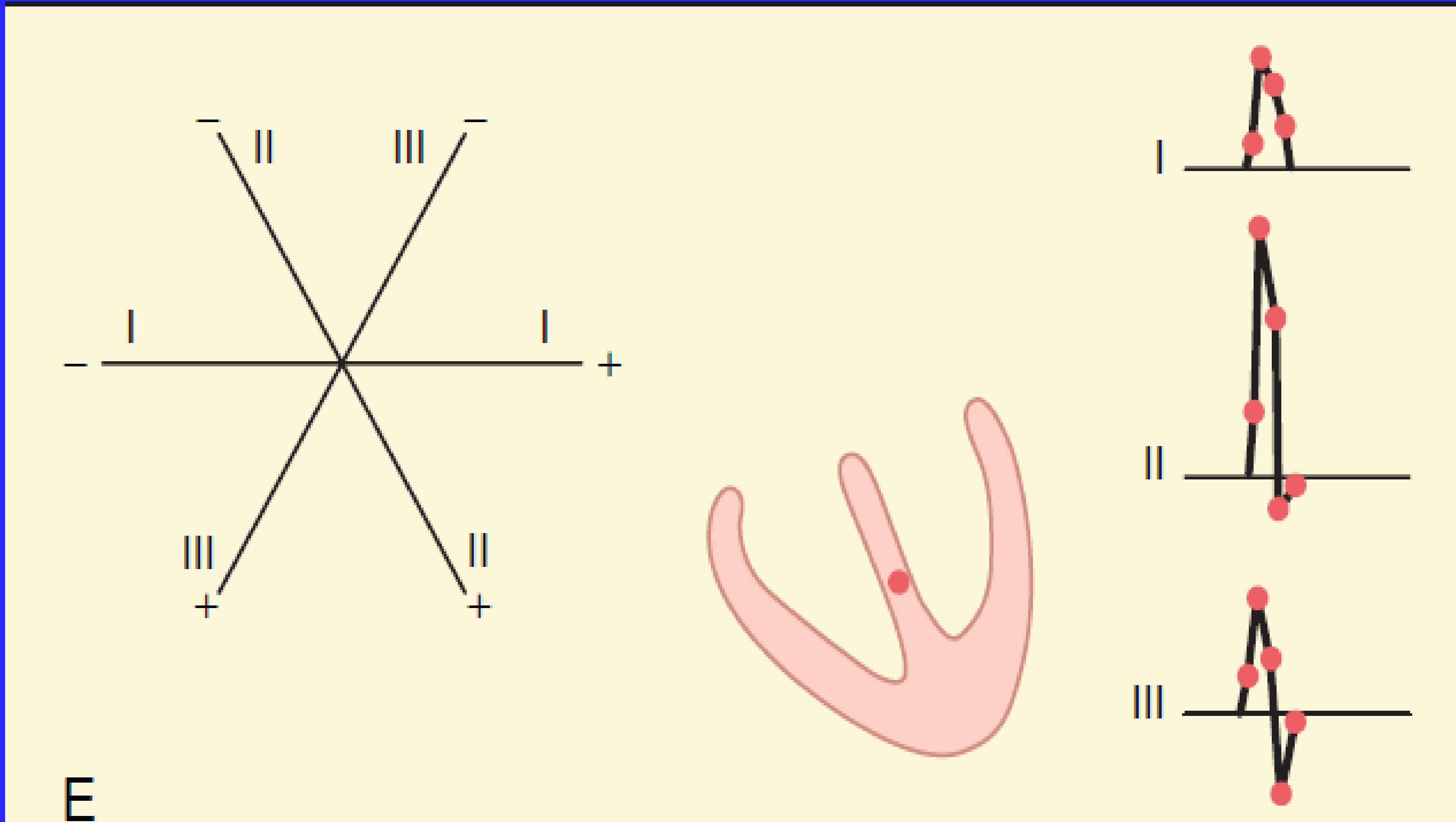
- **When the cardiac impulse enters the ventricles through the atrioventricular bundle, the first part of the ventricles to become depolarized is the left endocardial surface of the septum.**

- **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.**



Shaded areas of the ventricles are depolarized (−); nonshaded areas are still polarized (+). The ventricular vectors and QRS complexes 0.01 second after onset of ventricular depolarization (A)*;* 0.02 s (B)*;* 0.035 s (C)*;* 0.05 s (D)*;* and after depolarization of the ventricles is complete, 0.06 second after onset (E)*.*



Shaded areas of the ventricles are depolarized (–); nonshaded areas are still polarized (+). The ventricular vectors and QRS complexes 0.01 second after onset of ventricular depolarization (A); 0.02 s (B); 0.035 s (C); 0.05 s (D); and after depolarization of the ventricles is complete, 0.06 second after onset (E).

ELECTROCARDIOGRAM DURING REPOLARIZATION—THE T WAVE

- 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.

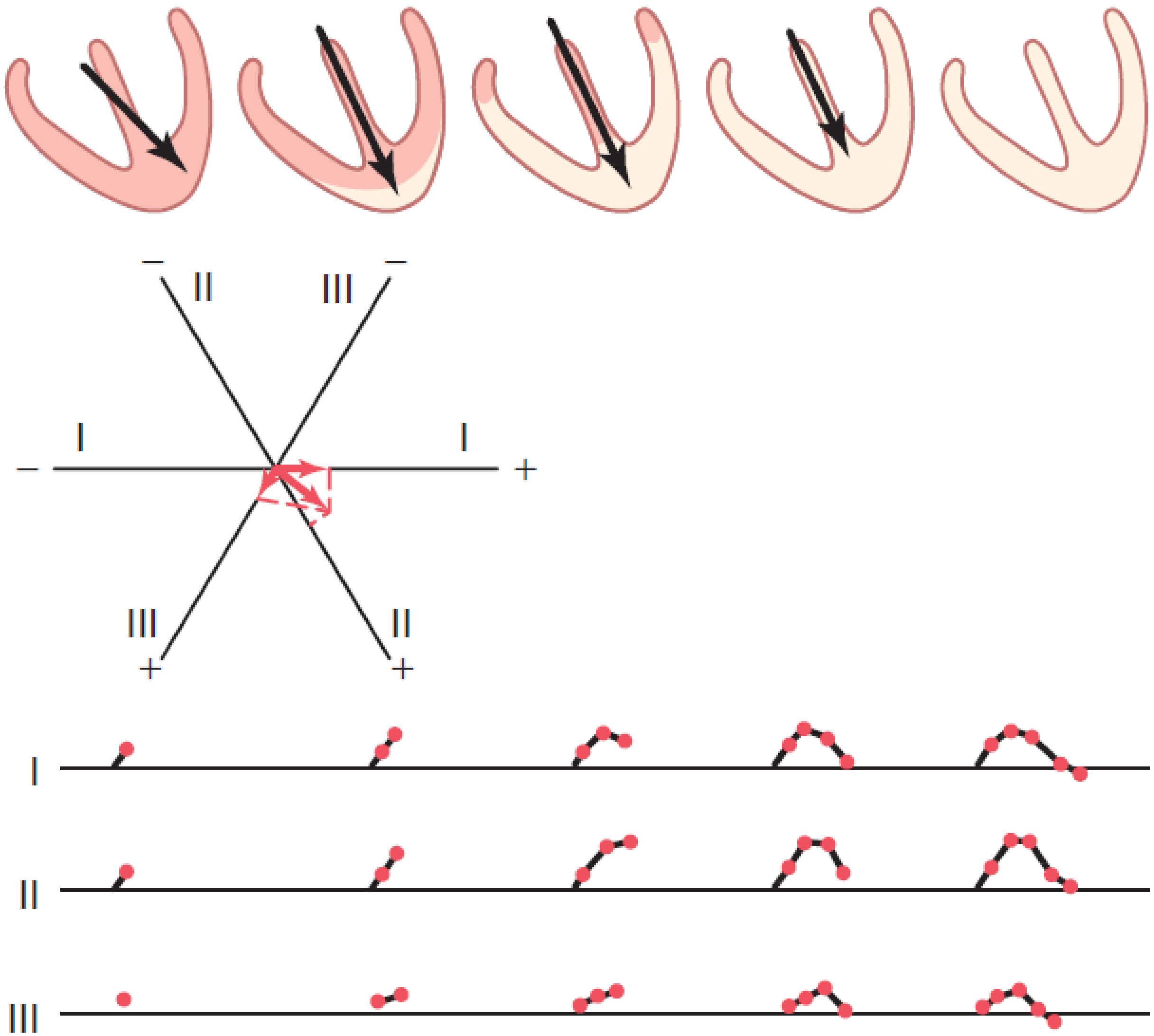


Figure 12-8. Generation of the T wave during repolarization of the ventricles, showing also vectorial analysis of the first stage of repolarization. The total time from the beginning of the T wave to its end is approximately 0.15 second.

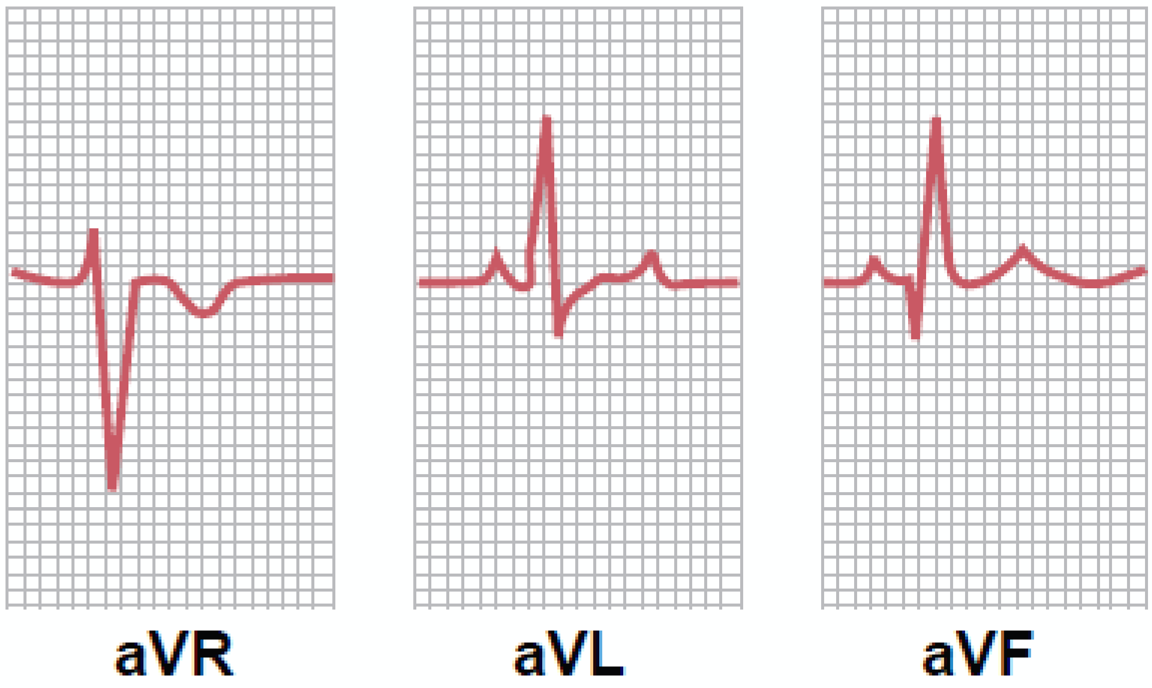


Figure 11–10

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

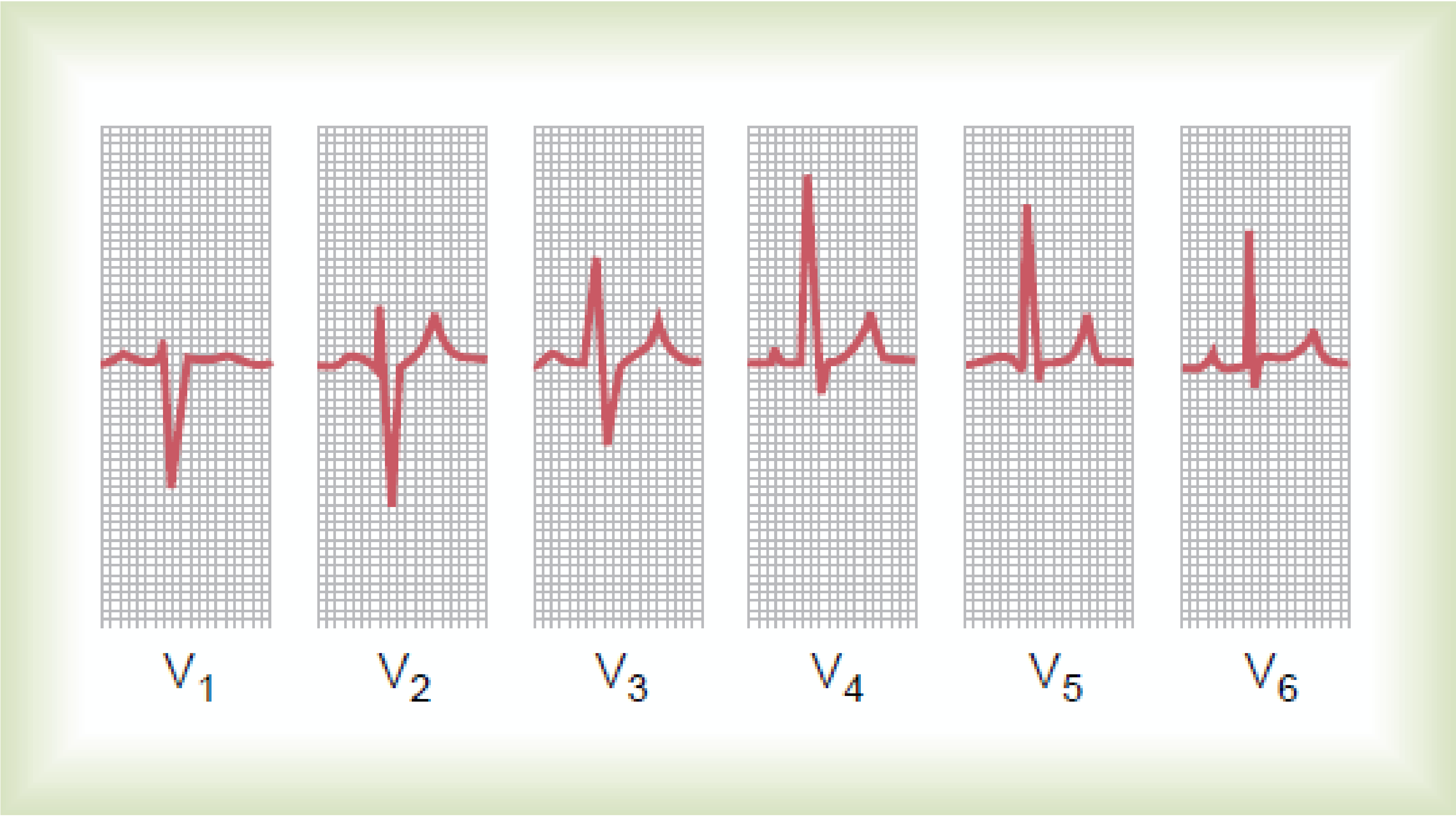
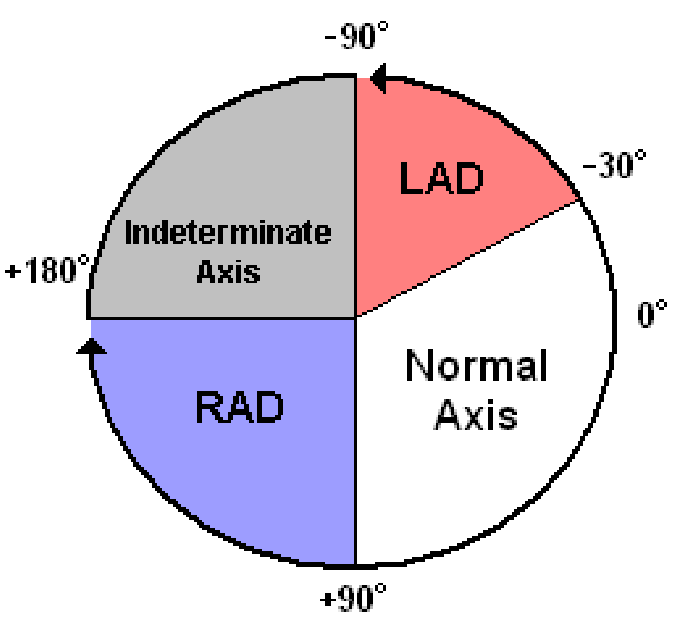


Figure 11–9

Normal electrocardiograms recorded from the six standard chest leads.

HEXA AXIAL REFERENCE SYSTEM

DIAGRAM



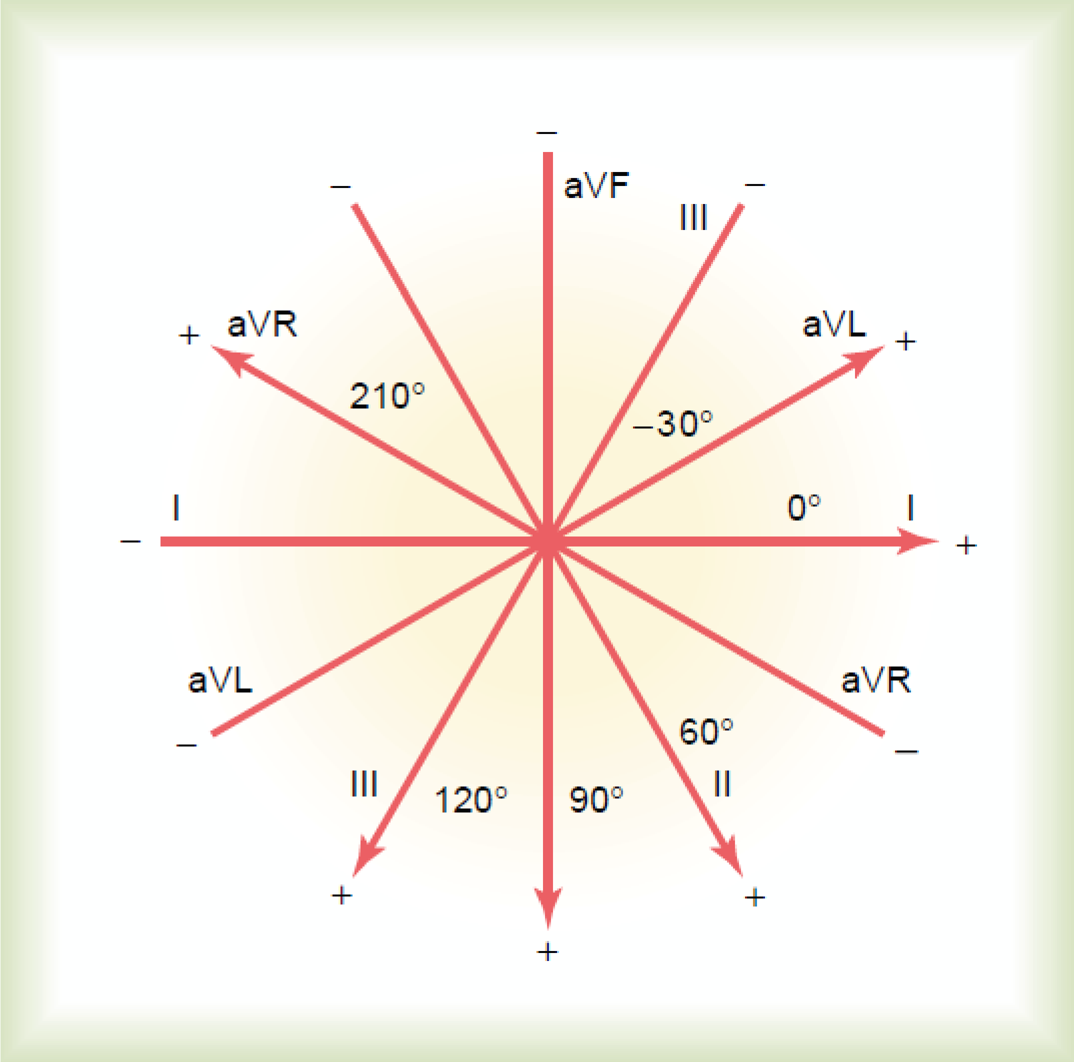
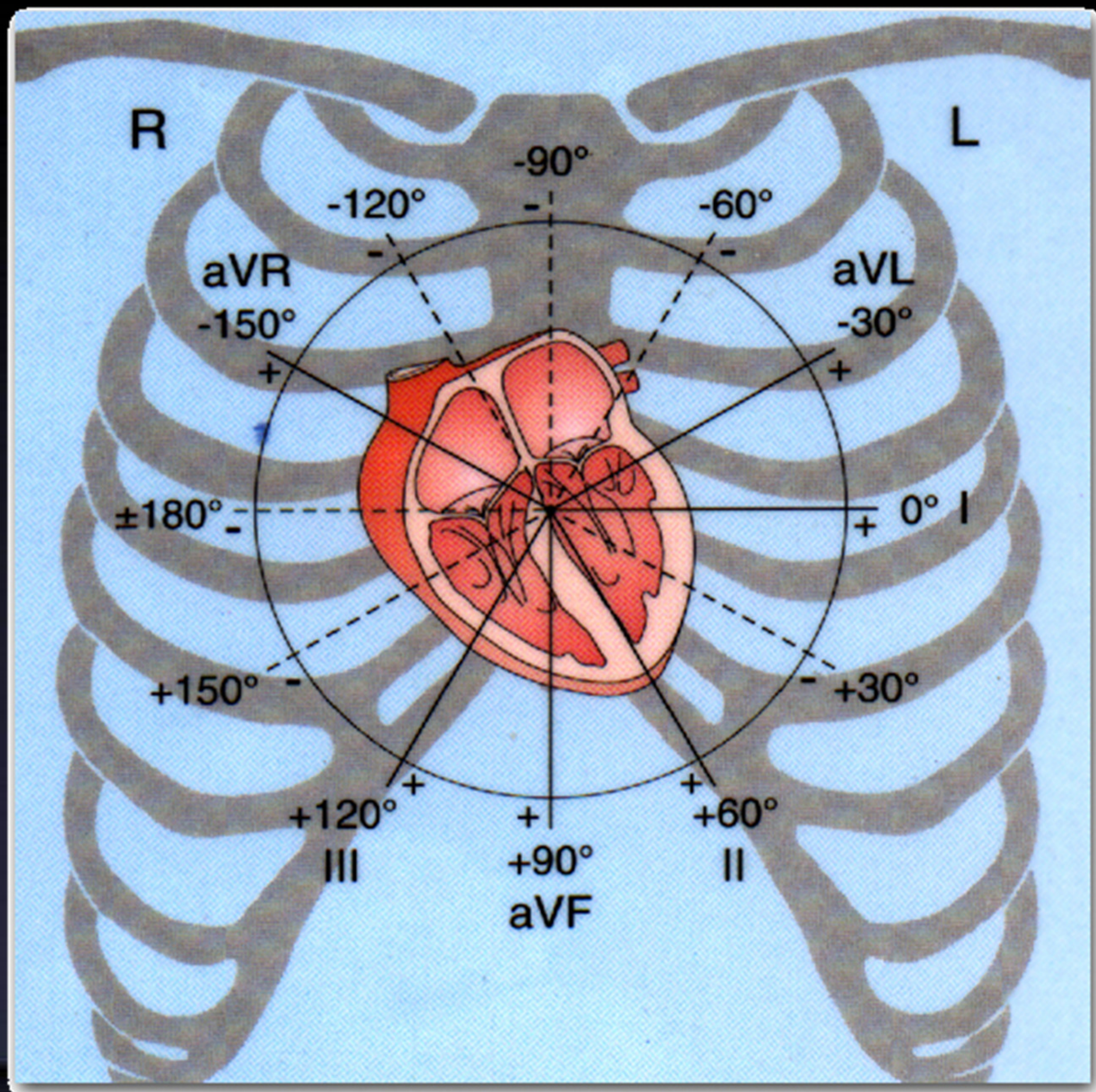


Figure 12–3

Axes of the three bipolar and three unipolar leads.

Lead Placement



Mean Cardiac Electrical Axis

When the vector in the heart is in a direction almost perpendicular to the axis of the lead, the voltage recorded in the ECG of this lead is very low.

Conversely, when the heart vector has almost exactly the same axis as the lead axis, essentially the entire voltage of the vector will be recorded.

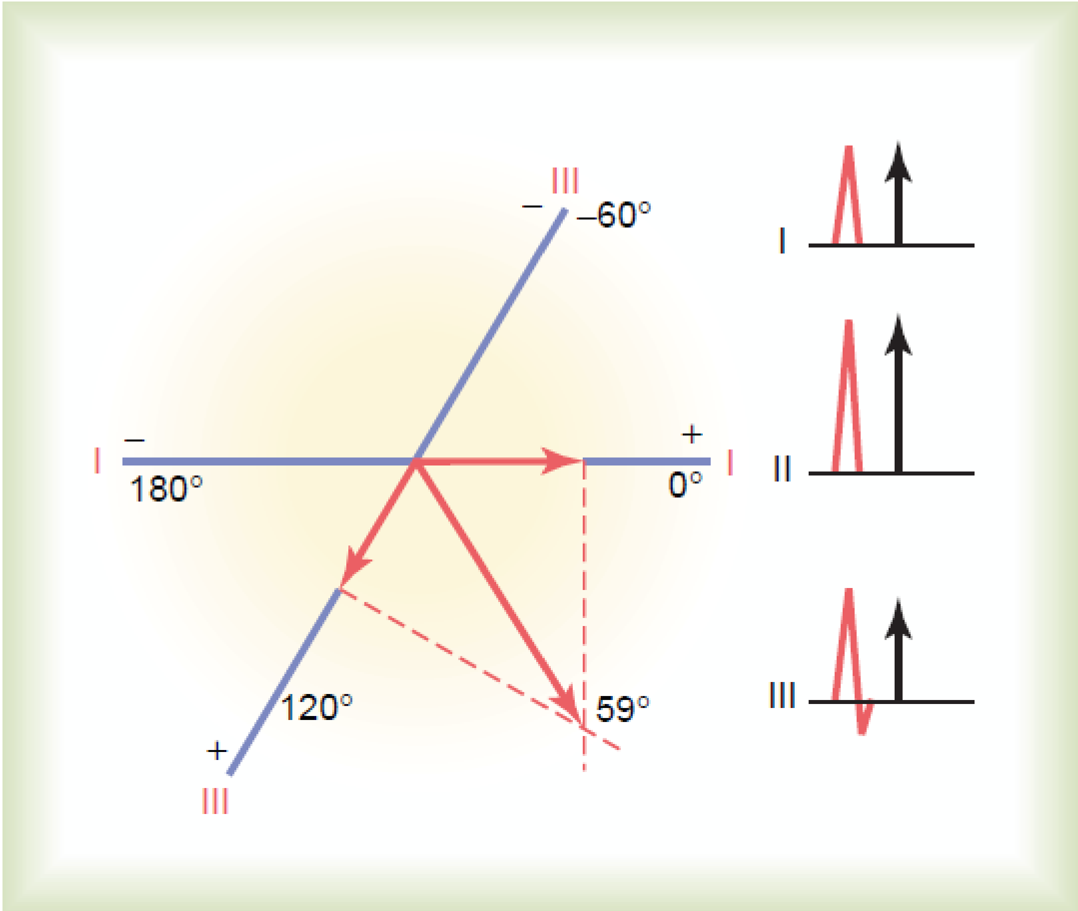


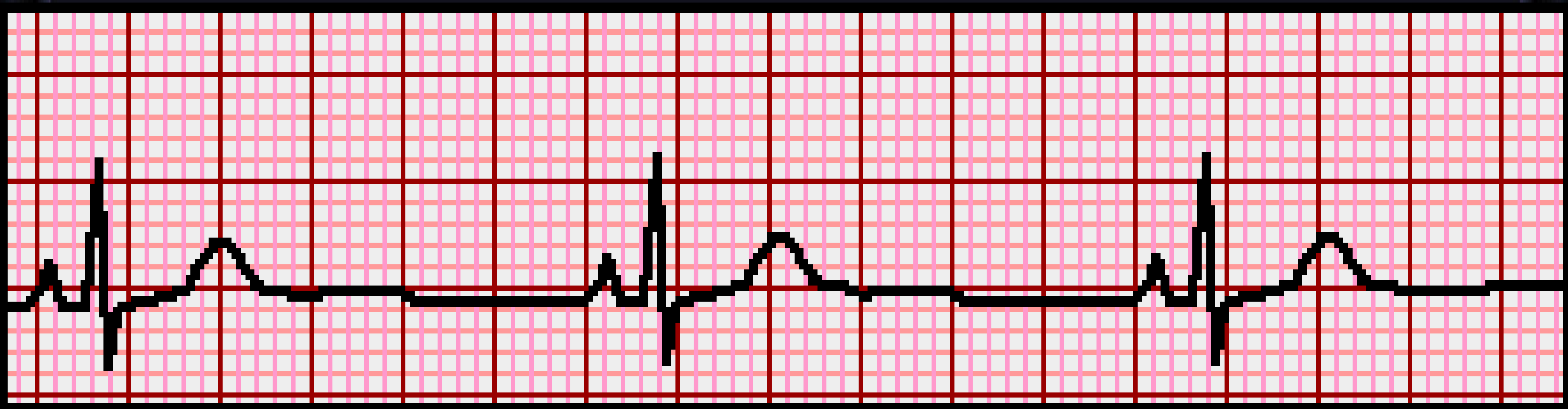
Figure 12–11

Plotting the mean electrical axis of the ventricles from two electrocardiographic leads (leads I and III).

Determining the Heart Rate

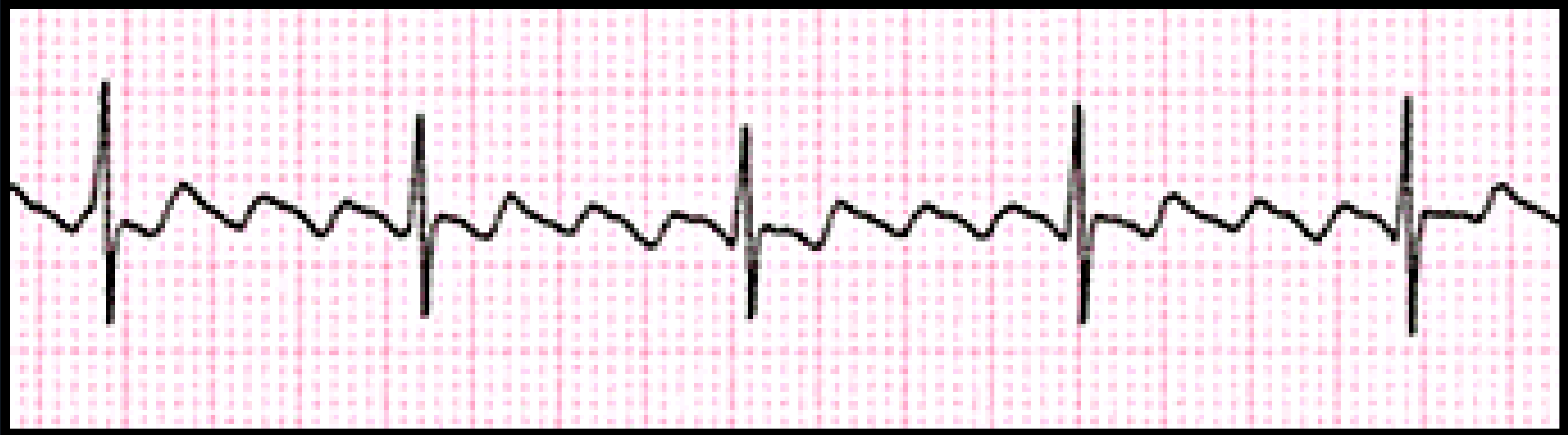
Take the number of “smallest boxes moved by the machine per minute” i.e. (1500) , and divide by the number of boxes between adjacent “R”-”R” waves.

H.R. = 1500 / # of squares b/w 2 “R - R” waves



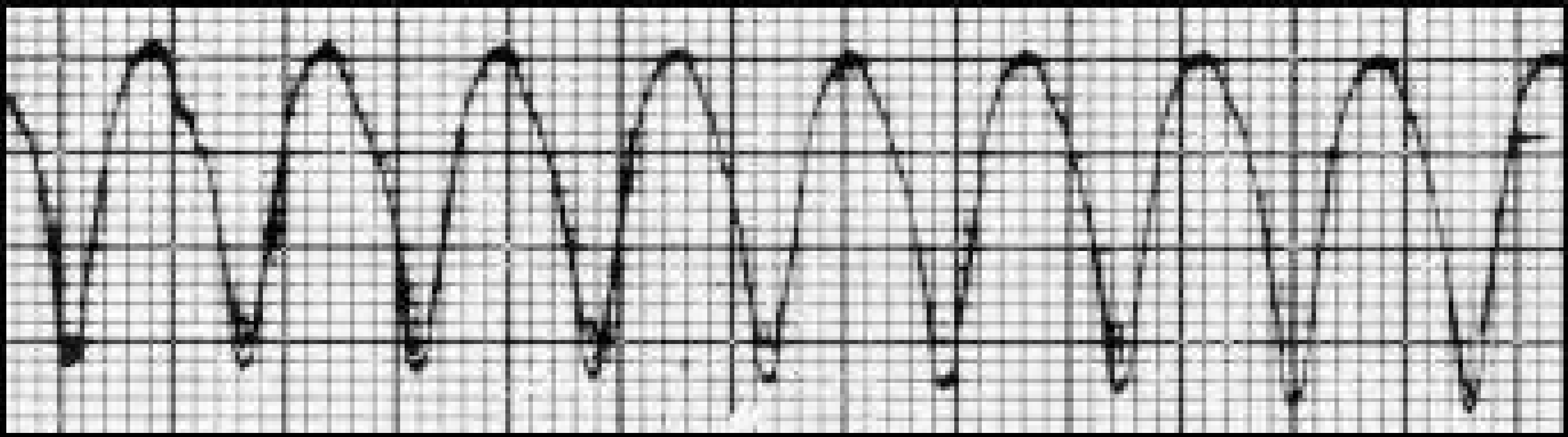
(1500 / 30) = 50 bpm

What is the heart rate?



(1500 / ~19) = ~ 79 bpm

What is the heart rate?



(1500 / 8) = 187 bpm