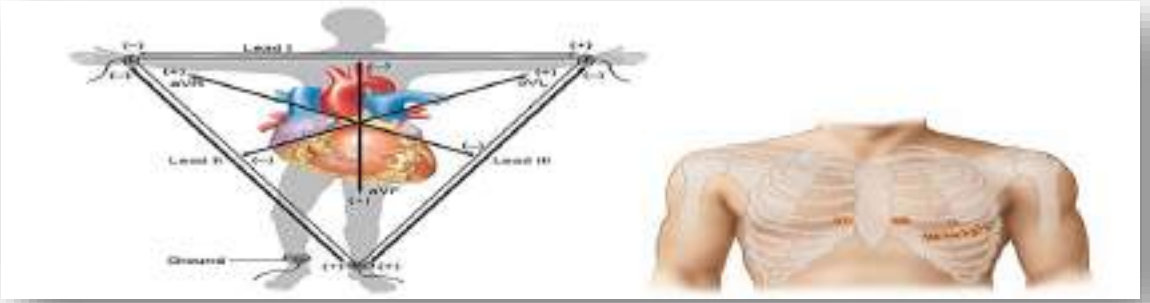
CVS MODULE
PHYSIOLOGY (LECTURE 7)
ECG (NORMAL)



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THE ELECTROCARDIOGRAM

Electrocardiogram (ECG or EKG):

- **Definition: It is the record of electrical events (fluctuations in potential) during the cardiac cycle.**

✓ Note that the ECG provides information concerning only the electrical activity of the heart.

- When action potentials occur simultaneously in many individual myocardial cells, currents are conducted through the body fluids around the heart and can be detected by recording electrodes at the surface of the skin.
- The ECG may be recorded by using an **active** or **exploring electrode** connected to an **indifferent electrode at zero potential (unipolar recording)** or by using **two active electrodes (bipolar recording).**

Apparatus: Electrocardiograph.

Electrocardiography may reveal the following:

- Abnormal cardiac rhythms and conduction.
- Presence, location, and extent of ischemia or infarction.
- Orientation of the heart in the thoracic cavity and size of chambers.
- Effects of abnormal electrolyte levels and some drugs.

ECG LEADS

ECG leads :

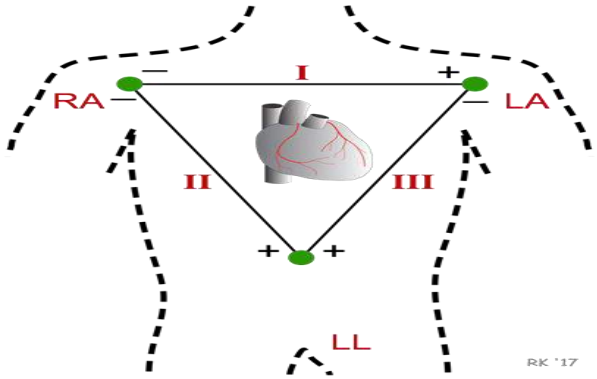
- ✓ A typical ECG makes use of **multiple combinations of recording locations on the limbs and chest** to obtain as much information as possible concerning different areas of the heart.
- ✓ **ECG consists of 12 leads that record the same electric events in cardiac muscle but from different situations**.
- ✓ **A 12-lead ECG includes:**
- Three standard bipolar limb leads I, II, and III.
- Six unipolar chest leads (V1–V6); and three augmented unipolar limb leads (aVL, aVR, and aVF).

BIPOLAR LEADS

The **standard bipolar limb leads** each **record the differences in potential between two limbs**.

There are 3 bipolar limb leads:

- **Lead I: This records the potential difference between the left arm (LA) (+ve) and the right arm (RA) (-ve) (LA-RA).**
- **Lead II: This records the potential difference between the left leg (LL) (+ve) and the RA (-ve) (LL-RA).**
- **Lead III: This records the potential difference between the LL (+ve) and the LA (-ve) (LL-LA).**



UNIPOLAR (V) LEADS

- **These measure the absolute (actual) potential at a certain point**.
- An additional **nine unipolar leads**, that is, **leads** that **record the potential difference between an exploring electrode and an indifferent electrode**, are commonly used in clinical electrocardiography.
- There are **six unipolar chest leads (precordial leads) designated V1–V6 and three unipolar limb leads: VR (right arm), VL (left arm), and VF (left foot)**.
- The indifferent electrode is constructed by connecting electrodes placed on the two arms and the left leg to a central terminal. This "V" lead effectively records a "zero" potential because they are situated such that the electrical activity should be cancelled out.
- **Augmented limb leads, designated by the letter a (aVR, aVL, aVF)**, are generally used.
- The augmented limb leads do not use the "V" electrode as the zero, rather, they are recordings between the one, augmented limb and the other two limbs. This increases the size of the potentials by 50% without any change in configuration from the non-augmented record.

Sites of unipolar chest (precordial) leads:

V1: Placed at the Rt side of the sternum at the level of 4th intercostal space.

V2: Placed at the Lt side of the sternum at the level of 4th intercostal space.

V3: Midway between V2 and V4.

V4: Placed at the Lt 5th intercostal space mid-clavicular line.

V5: Placed at the Lt 5th intercostal space anterior axillary line.

V6: Placed at the Lt 5th intercostal space mid- axillary line.

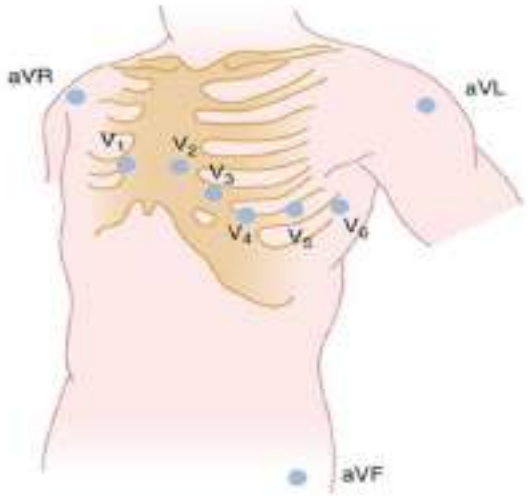
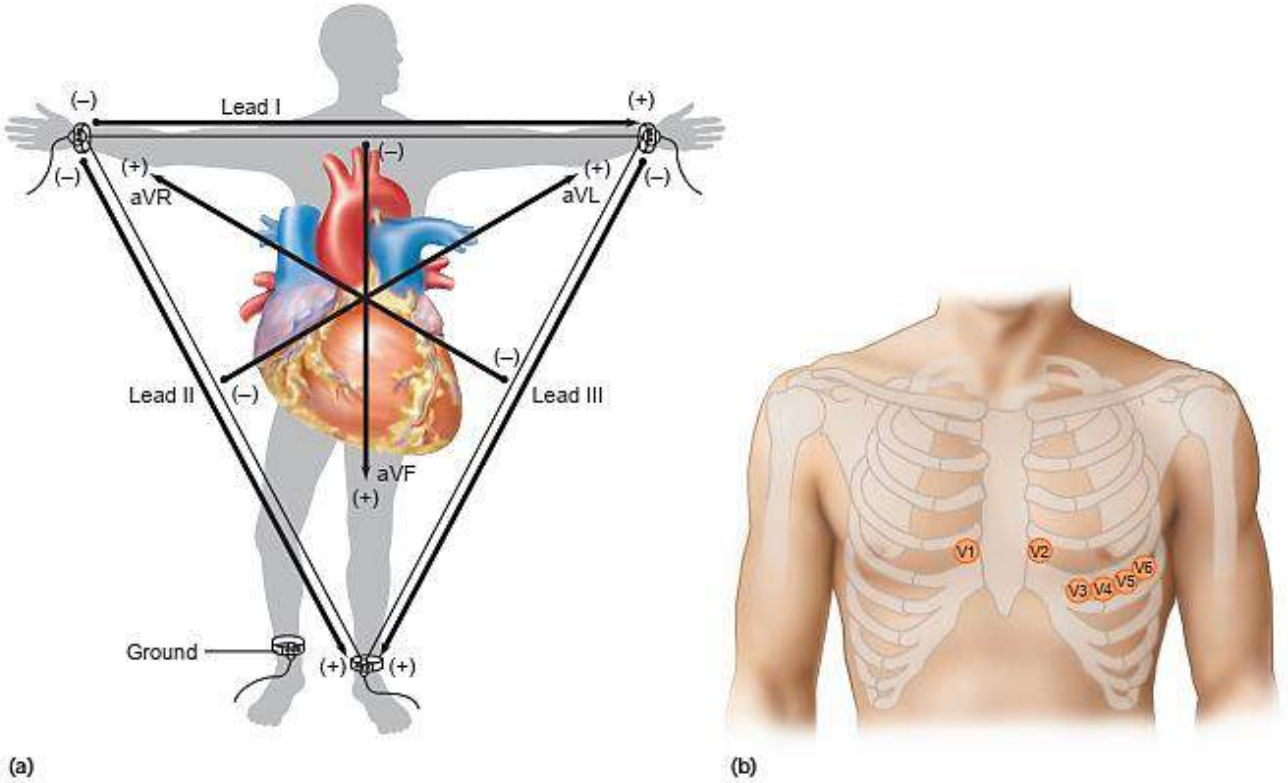


FIGURE 29–6 Unipolar electrocardiographic leads. Positional for standard unipolar leads are shown. The augmented extremity leads (aVR, aVL, and aVF) are shown on the right arm, left arm, and left leg, respectively. The six chest leads (V_1–V_6) are shown in their proper placement.


(–)
Lead I
(+)
(–)
(+)
aVR
(–)
(+)
aVL
(–)
(–)
Lead II
(–)
Lead III
aVF
(+)
Ground
(+)
(+)
V1
V2
V3
V4
V5
V6
(a)
(b)

Normal ECG

The normal ECG usually consists of 5 main waves:

- **Three positive (+ve) waves (P, R, T) & Two negative (–ve) waves (Q and S).**
- **Sometimes, there is additional wave following T wave called U wave.**
- **The Q, R and S waves form a complex called QRS complex (Q and S waves are normally not clear in some leads).**
- **The termination of QRS complex at isoelectric line is called J point.**
- **Waves are separated by segments and each starts and ends at the isoelectric line.**
- **The configuration of various ECG waves normally vary in different leads depending on the position of the exploring electrode in each lead.**

Normal ECG

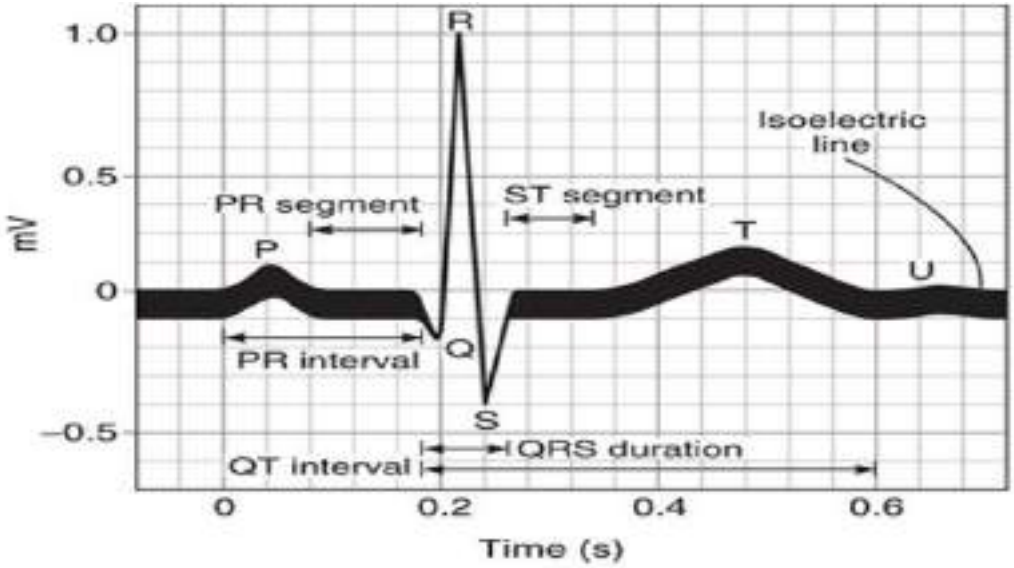
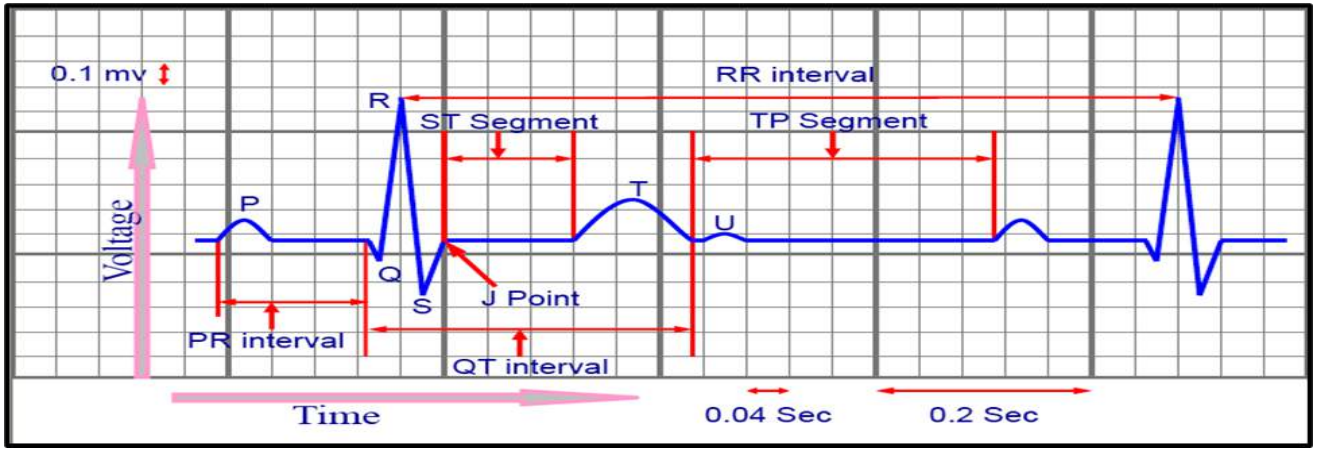


FIGURE 29–5 Waves of the ECG. Standard names for individual waves and segments that make up the ECG are shown. Electrical activity that contributes the observed deflections are discussed in the text and in Table 29–2. ECG, electrocardiogram.



Waves of ECG in leads that face the left ventricle:

P wave: positive wave

- ✓ It represents atrial depolarization.
- ✓ It starts by about 0.02 second before atrial systole.
- ✓ Normally, its amplitude is about 0.1 mv while its duration does not exceed 0.1 second.

QRS complex:

- o It represents ventricular depolarization.
- o Starts before ventricular systole by about 0.02 second.
- o Its duration is about 0.04-0.08 second.
- o It's composed of two negative waves Q&S and one positive R wave.

Q wave:

Negative wave. Represents depolarization of the interventricular septum, 0.02 second in duration. May be absent normally.

R wave:

Positive wave. Represents depolarization of most of the ventricular walls including the apex of the heart. It's the largest +ve wave **(1 mV)** in normal ECG. It's 0.04 second in duration.

S wave:

Negative wave. Represents depolarization of the remaining ventricular walls mainly the base of the ventricles. It's 0.02 second duration. May be absent normally.

T wave: Positive wave

It represents repolarization of ventricles.

It's 0.2 second in duration.

Its amplitude averages 0.2 up to 0.4 mV.

U wave:

- Small +ve wave that sometimes follows T wave.
- It is not constant.
- It is probably due to slow repolarization of either the papillary muscles or the Purkinje network (in which duration of AP is longer than in the ventricular myocardium).

N.B.

Atrial repolarization wave isn't recorded as it is masked by ventricular depolarization that occurs at the same time and its voltage is very low.

Abnormalities of the P wave:

1. Inverted → nodal rhythm.
2. Absent → atrial fibrillation (AF).
3. More than one → atrial flutter.

Abnormalities of the QRS complex:

Occur in cases of ventricular hypertrophy, infarction, extrasystoles, as well as in bundle branch block and most cases of electrolyte disturbance.

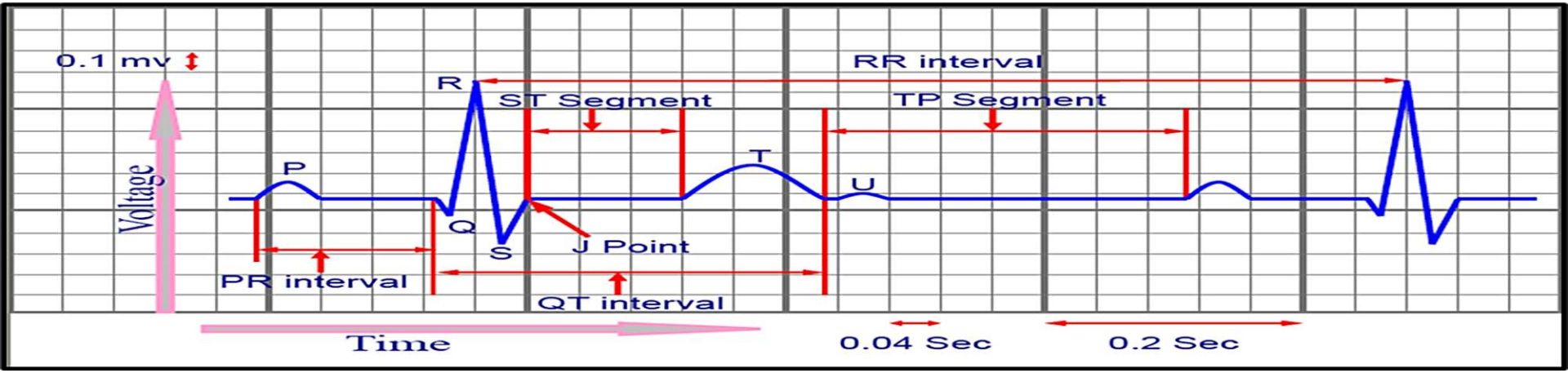
Abnormalities of the T wave:

1. Inverted or isoelectric → e.g. myocardial ischemia.
2. Increased amplitude → e.g. early myocardial infarction (MI) & sympathetic overactivity & hyperkalemia.

ECG intervals and segments

What is the difference between segment and interval?

- **Segment; is a straight (isoelectric) line connecting two waves.**
- **Interval; includes at least one wave plus the connecting straight line.**



PR interval:

- It's the period between the **beginning of P** wave to the **beginning of QRS** complex or usually the R wave in case of absent Q wave.
- Represents conduction in AV node (i.e. the time between the onset of atrial depolarization (P wave) and the onset of ventricular depolarization (QRS complex).
- Its duration: 0.12 – 0.2 second (< 0.12 second → short PR as in tachycardia OR > 0.2 second → prolonged PR as in bradycardia).

Abnormalities of PR interval:

1. Prolonged PR interval → means delayed conductivity (e.g. first degree HB, bradycardia and increased vagal tone).

2. Short PR interval → means rapid conductivity (e.g. nodal rhythm and tachycardia (sympathetic overactivity)).

QT interval:

- ✓ **It is the interval from the onset of Q wave to end of T wave.**
- ✓ **It is normally about 0.36-0.42 second.**
- ✓ **It is called electrical systole of heart.**
- ✓ **It provides a useful index of duration of ventricular action potential.**

ST Segment:

- o It's the line between **end of S wave and beginning of T wave**.
- o **During this period the ventricles are completely depolarized so, ST segment is an isoelectric line.** Its upward or downward deviation indicates myocardial damage.
- o **Its duration averages 0.1 sec.**

Normal ECG variations in different leads

P, QRS and T waves are all normally negative in aVR lead:

Atrial depolarization, ventricular depolarization, and ventricular repolarization move away from the exploring electrode, and the P wave, QRS complex, and T wave are therefore all negative (downward) deflections.

In right precordial leads (V1 & V2):

There are no Q waves but small R waves followed by deep S waves:

There is no Q wave in V1 and V2, and the initial portion of the QRS complex is a small upward deflection because ventricular depolarization first moves across the mid-portion of the septum from left to right toward the exploring electrode.

The wave of excitation then moves down the septum and into the left ventricle away from the electrode, producing a large S wave.

While in left precordial leads (V5 & V6):

There are small Q waves followed by large R waves:

An initial small Q wave (left to right septal depolarization), and there is a large R wave (left ventricular depolarization).

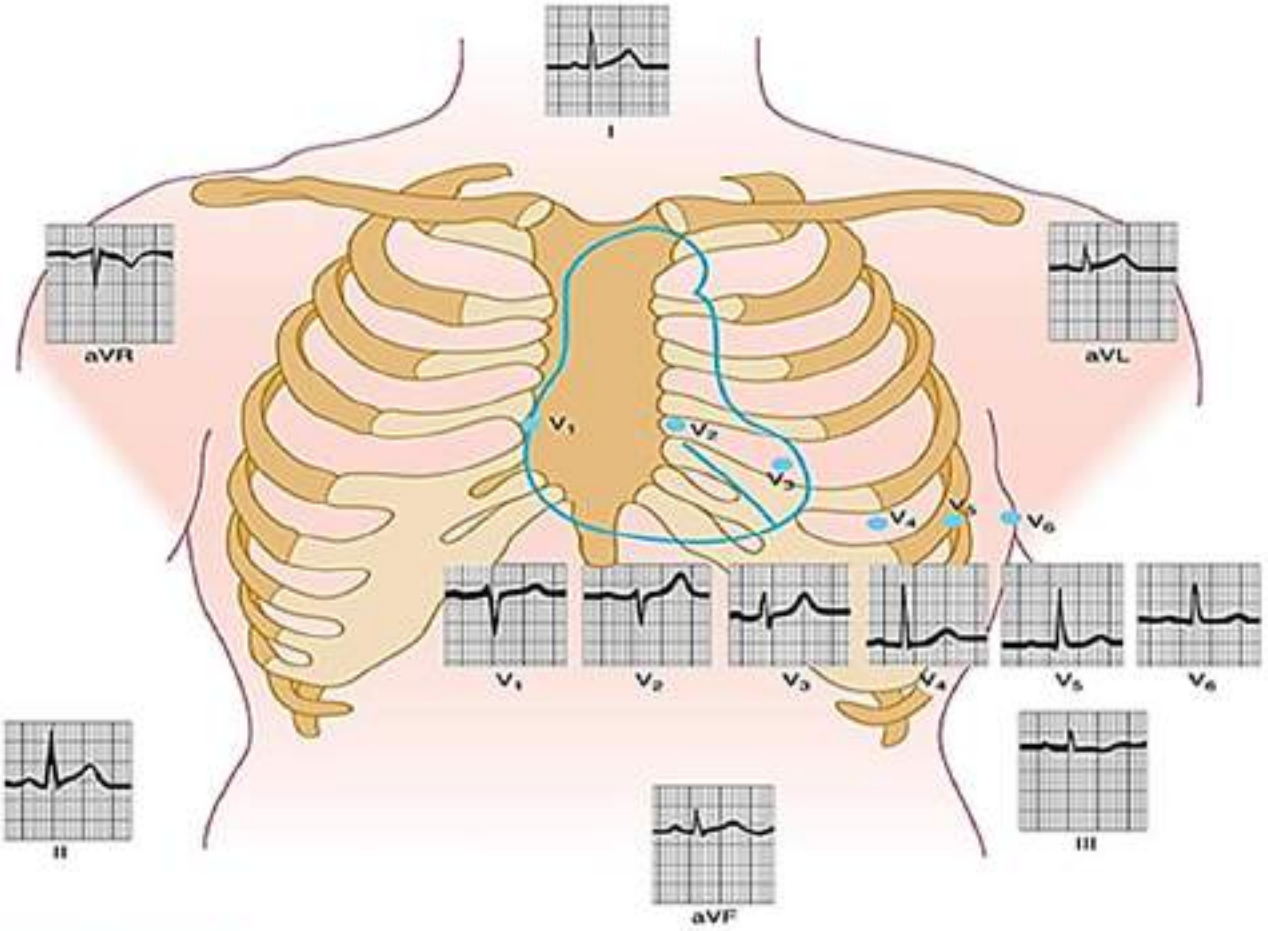
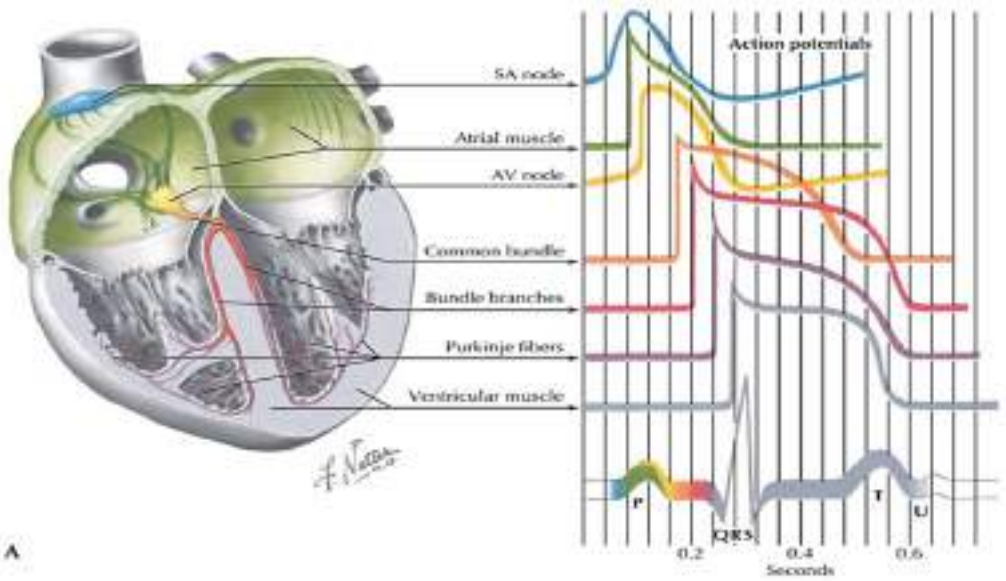


FIGURE 29–7 Normal ECG. Tracings from individual electrodes (positions marked in figure) are shown for a normal ECG. See text for additional details. ECG, electrocardiogram. (Reproduced with permission from Goldman MJ: *Principles of Clinical Electrocardiography*, 12th ed. Originally published by Appleton & Lange. Copyright © 1986 by McGraw-Hill.)

Relation between ECG and ventricular AP

ECG waves are produced by the APs generated in the ventricular muscle.

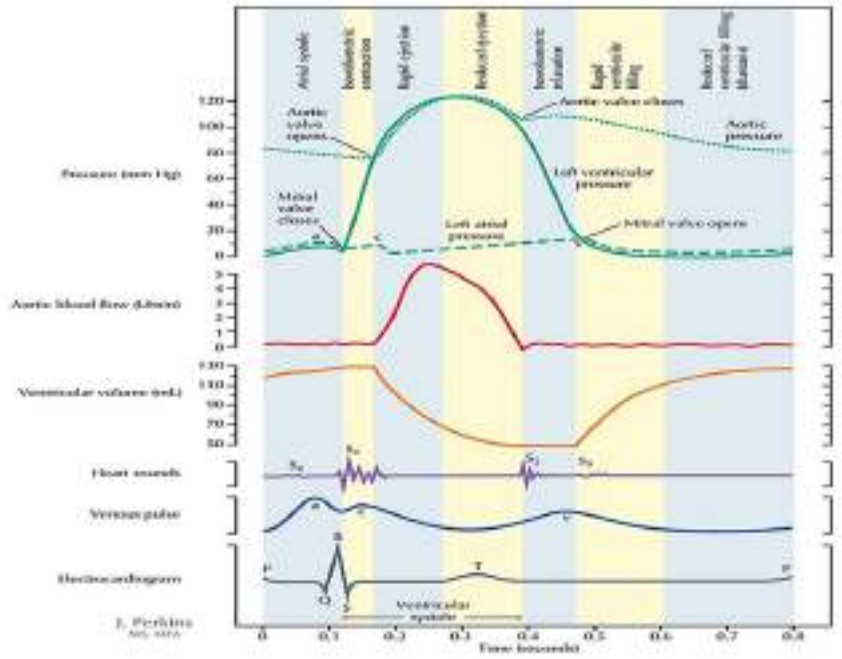
- ✓ **QRS complex corresponds to the upstroke of AP (depolarization; phase 0).**
- ✓ **ST segment to the plateau phase (phase 2).**
- ✓ **T wave to the rapid repolarization phase (phase 3).**
- ✓ **T-P segment to phase 4 of AP.**



ECG during cardiac cycle

Since the electric events in cardiac muscle precede the mechanical response:

- ✓ P wave precedes atrial systole and QRS precedes isovolumetric ventricular contraction phase (each by about 0.02 second).
- ✓ Also, the summit of R wave coincides with first heart sound (S1) while S2 coincides with the end of T wave.




Thank
you!