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Waveforms

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Terminology

- Waveform
  - Movement away from the baseline in either a positive or negative direction
- Segment
  - A line between waveforms
  - Named by the waveform that precedes or follows it
- Interval
  - A waveform and a segment
- Complex
  - Several waveforms

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Waveforms

- A waveform or deflection is movement away from the baseline in either a positive (upward) or negative (downward) direction
  - A waveform that is partly positive and partly negative is "biphasic"
  - A waveform or deflection that rests on the baseline is "isoelectric"

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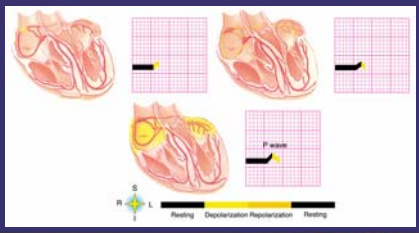
P Wave

- The first wave in the cardiac cycle
- Represents atrial depolarization and spread of the electrical impulse throughout the right and left atria



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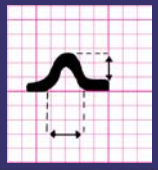
The Normal P Wave

- Smooth and rounded
- Usually no more than 2.5 mm in height and 0.10 second in duration
- Positive in leads I, II, aVF, and V_2 through V_6
- May be positive, negative, or biphasic in leads III, aVL, and V_1



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Abnormal P waves

- May be notched, tall and pointed (peaked), or inverted (negative)
- May be seen in conditions such as chronic obstructive pulmonary disease (COPD), congestive heart failure (CHF), or valvular disease

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PR Segment

- Part of the PR interval
  - Horizontal line between the end of the P wave and the beginning of the QRS complex
- Normally isoelectric (flat)
  - Used as a baseline from which to evaluate ST segment elevation or depression

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PR Interval

- The P wave plus the PR segment equals the PR interval
- Begins with the onset of the P wave and ends with the onset of the QRS complex
- Normally measures 0.12 to 0.20 second

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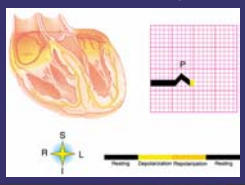
PR Interval

- Reflects:
  - Depolarization of the right and left atria (P wave)
  - Spread of the impulse through the AV node, bundle of His, right and left bundle branches, and Purkinje fibers (PR segment)



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Abnormal PR Interval

- Long PR interval (greater than 0.20 sec)
  - Indicates the impulse was delayed as it passed through the atria or AV junction
- Short PR interval (less than 0.12 sec)
  - May be seen when the impulse originates in the atria close to the AV node or in the AV junction

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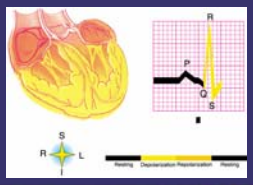
QRS Complex

- A QRS complex normally follows each P wave
- Consists of Q wave, R wave, and S wave
- Represents the spread of electrical impulse through the ventricles (ventricular depolarization)



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Q Wave

- The first negative, or downward, deflection following the P wave
- Always a negative waveform
- Represents depolarization of the interventricular septum

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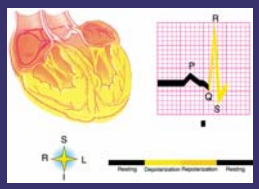
Q Wave

- Physiological Q waves
  - A normal Q wave is less than 25% of the amplitude of the R wave
  - Normal Q wave duration does not exceed 0.04 second
- Pathological Q waves
  - More than 0.04 second in duration
  - More than 25% of the amplitude of the following R wave in that lead



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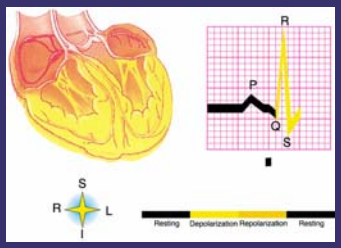
R Wave

- The first positive, or upward, deflection following the P wave
  - Always positive



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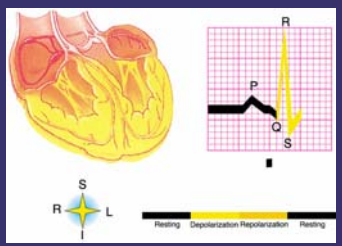
S Wave

- A negative waveform following the R wave
  - Always negative
- R and S waves represent simultaneous depolarization of the right and left ventricles



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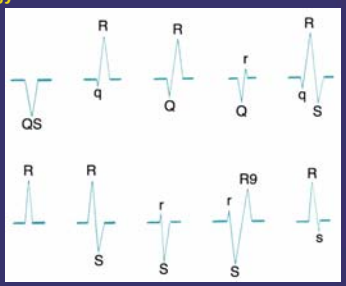
QRS Terminology

- If the QRS complex consists entirely of a positive waveform, it is called an R wave
- If the complex consists entirely of a negative waveform, it is called a QS wave



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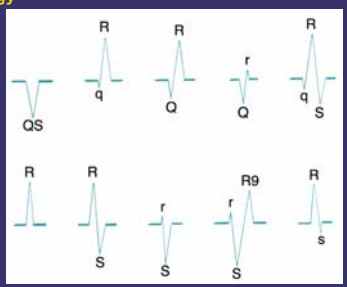
QRS Terminology

- If there are two positive deflections in the same complex, the second is called R prime and is written as R'
- If there are two negative deflections following an R wave, the second is written as S'



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QRS Measurement

- The width of a QRS complex is most accurately determined when it is viewed and measured in more than one lead
  - Measure the QRS complex with the longest duration and clearest onset and end
- Normal QRS duration in an adult varies between 0.06 and 0.10 second

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Abnormal QRS Complexes

- Duration of an abnormal QRS complex is greater than 0.10 second
- A QRS caused by an impulse originating in the Purkinje network or ventricular myocardium is usually greater than 0.12 second (often 0.16 second or greater)
- If the electrical impulse originates in a bundle branch, the duration of the QRS may be only slightly greater than 0.10 second

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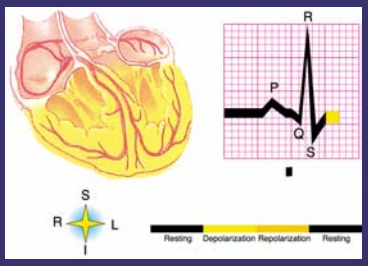
ST Segment

- The portion of the ECG tracing between the QRS complex and the T wave
- Represents the early part of repolarization of the right and left ventricles



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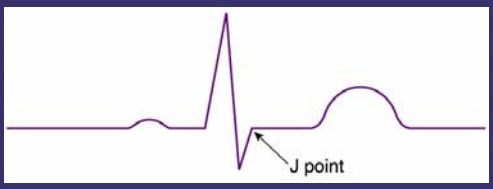
ST Segment

- The point at which the QRS complex and the ST segment meet = "J point" or junction
- Normally isoelectric (flat) in the limb leads



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Normal ST Segment

- Begins with the end of the QRS complex and ends with the onset of the T wave
- Limb leads
  - Normal ST segment is isoelectric (flat)
  - May normally be slightly elevated or depressed (usually less than 1 mm)
- Precordial leads
  - In some precordial leads, ST segment may be normally elevated by as much as 2 to 3 mm
  - In the left precordial leads, ST segment elevation is not normally greater than 1 mm

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ST Segment

- The PR segment used as the baseline from which to evaluate the degree of displacement of the ST segment from the isoelectric line (elevation or depression)
  - Measure at a point 0.04 second (one small box) after the end of the QRS complex (J point)

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ST Segment

- The ST segment is considered:
  - "Elevated" if the segment deviates above the baseline of the PR segment
  - "Depressed" if the segment deviates below it

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Abnormal ST Segment

- ST segment depression of more than 1 mm is suggestive of myocardial ischemia
- ST segment elevation of more than 1 mm is suggestive of myocardial injury
  - Pericarditis causes ST-segment elevation in virtually all leads

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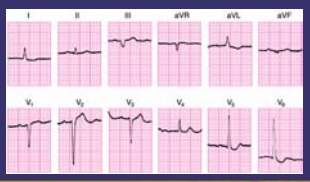
Abnormal ST Segment

- A horizontal ST segment (forms a sharp angle with the T wave) is suggestive of ischemia
- Digitalis causes a depression (scoop) of the ST segment
  - "Dig dip"



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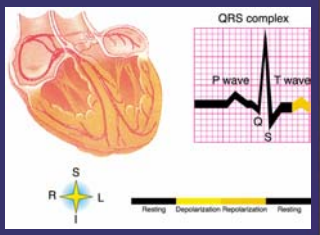
T Wave

- Represents ventricular repolarization
  - The beginning of the T wave is identified as the point where the slope of the ST segment appears to become abruptly or gradually steeper
  - The T wave ends when it returns to the baseline



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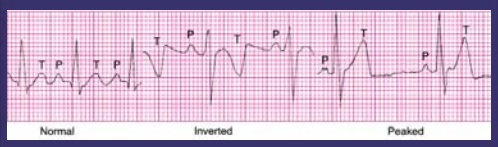
T Wave

- It may be difficult to clearly determine the onset and end of the T wave



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Normal T Waves

- Slightly asymmetrical
- Not normally more than 5 mm in height in any limb leads or 10 mm in any precordial lead
- Not normally less than 0.5 mm in height in leads I and II

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Abnormal T Waves

- The T wave following an abnormal QRS complex is usually opposite in the direction of the QRS
- Negative T waves suggest myocardial ischemia

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Abnormal T Waves

- Tall, pointed (peaked) T waves are commonly seen in hyperkalemia
- Significant cerebral disease (e.g., subarachnoid hemorrhage) may be associated with deeply inverted T waves
  - "Cerebral T waves"

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QT Interval

- QT interval represents total ventricular activity—the time from ventricular depolarization (activation) to repolarization (recovery)
- Duration of the QT interval varies according to age, gender, and heart rate
  - As heart rate increases, QT interval decreases
  - As heart rate decreases, QT interval increases

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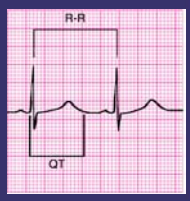
QT Interval

- Measured from the beginning of the QRS complex to end of the T wave
  - In the absence of a Q wave, measure the QT interval from the beginning of the R wave to the end of the T wave



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U Wave

- Significance is not definitely known
  - Thought to represent repolarization of Purkinje fibers
- Not easily identified due to its low amplitude

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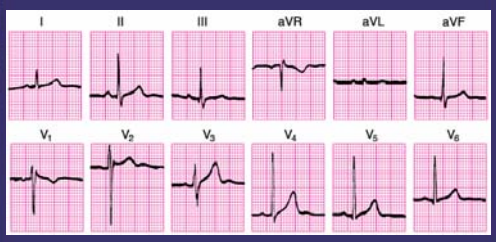
U Wave



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U Wave - Normal Characteristics

- Rounded and symmetrical
- Usually less than 2 mm in amplitude
- In general, a U wave of more than 1.5 mm in height in any lead is considered abnormal

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Abnormal U Waves

- Abnormally tall U waves may be the result of:
  - Electrolyte imbalance
  - Medications
  - Hyperthyroidism
  - Central nervous system disease
  - Long QT syndrome
- Negative U waves
  - Strongly suggestive of organic heart disease
  - May be seen in patients with ischemic heart disease

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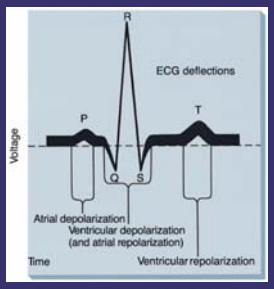
Waveforms – Review



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Segments & Intervals – Review