1 **Waveforms**

2 **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

3 **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”

4 **P Wave**

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

5 **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

6 **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

7 **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

8 **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

9 **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)

10 **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

11 **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)

12 **Q Wave**

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

13 **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

14 **R Wave**

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

15 **S Wave**

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

16 **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

17 **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'

18 **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

19 **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

20 **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

21 **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

22 **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

23 **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)

24 **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

25 **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

26 **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”

27 **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

28 **T Wave**

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

29 **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

30 **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

31 **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"

32 **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

33 **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

34 **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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36 **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

37 **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

38 **Waveforms – Review**

39 **Segments & Intervals – Review**