Chapter 23
Cardiovascular Anatomy & Physiology and ECG Interpretation

Chapter Goal
- Analyze & interpret ECGs/cardiac dysrhythmias

Learning Objectives
- Explain & defend purpose of ECG monitoring
- Describe how ECG waveforms are produced
- Correlate electrophysiological & hemodynamic events occurring throughout entire cardiac cycle with various ECG waveforms, segments, & intervals
- Identify how heart rates may be determined from ECG recordings
Learning Objectives

- List ECG limitations
- Describe systematic approach to analysis & interpretation of cardiac dysrhythmias
- Explain how to confirm ventricular fibrillation & asystole using 3-lead ECG

Anatomy & Physiology Review

- Heart (myocardium)
  - Right & left sides separated by interventricular septum
  - Endocardium—inner lining
  - Pericardium—set of 2 membranes surrounding heart
    - Visceral
    - Parietal
  - Atria—upper chambers
  - Ventricles—lower chambers

Anatomy & Physiology Review

- Deoxygenated blood → right atrium (via superior and inferior venae cavae) → tricuspid valve → right ventricle → pulmonary (semilunar) valve → main pulmonary artery → lungs

- Oxygenated blood → left atrium (via pulmonary veins) → mitral (bicuspid) valve → left ventricle → aortic (semilunar) valve → aorta
Cardiac cycle
- Begins with onset of cardiac contraction; ends with beginning of next contraction
- Pressure changes cause blood movement
  - From areas of high pressure to areas of low pressure
- Systole—contraction of atria & ventricles with simultaneous pumping of blood vessels
  - Systolic BP—pressure within arteries during systole
- Diastole—relaxation phase; blood fills heart
  - Diastolic BP—pressure during this phase & indicator of myocardial perfusion

Cardiac output
- Cardiac output = Stroke volume × Heart rate
- Starling’s law of the heart
- Ejection fracture
Anatomy & Physiology Review

- **Vascular system & circulation**
  - Arteries carry blood away from heart to body
  - Veins carry blood from body back to heart
  - Arterioles divide into capillaries
  - Venules merge to become veins
  - Veins merge to become superior & inferior venae cavae
  - **Afterload**—workload against which heart must pump
  - **Preload**—amount of blood heart must pump
  - **Pulmonary circulation**—carries deoxygenated blood through lungs to left side of heart
  - Left ventricle pumps it to body via **systemic circulation**

- **Coronary circulation**
  - Right main coronary artery
    - Nodal artery
    - Descending right artery
    - Posterior descending artery
  - Left main coronary artery
    - Left anterior descending artery
    - Diagonal artery
    - Circumflex artery
Electrophysiology

- Myocardial cells have 4 unique characteristics:
  - Automaticity
  - Excitability
  - Conductivity
  - Contractility
### Electrophysiology
- **Absolute refractory period**—time when no stimulus will depolarize myocyte.
- **Relative refractory period**—time when sufficiently strong stimulus will depolarize myocardium.

### Regulation of heart function
- **Chronotropy**
  - Heart rate
- **Dromotropy**
  - Rate of electrical conduction
- **Inotropy**
  - Strength of contraction

### Baroreceptors
- Sensory nerve endings that detect changes in BP & send messages to CNS
  - Carotid sinus
  - Aortic arch
  - Atria
  - Vena cava

### Chemoreceptors
- Receptors in blood vessels that detect changes in chemical composition of blood
  - Medulla
  - Aortic arch
  - Carotid bodies
Anatomy & Physiology Review

- Regulation of heart function
  - Parasympathetic stimulation
    - ↓ HR
    - Primarily affects AV node
  - Sympathetic stimulation
    - Alpha effects—vasoconstriction
    - Beta effects—↑ inotropy, dromotropy, chronotropy
  - Epinephrine
    - Greater stimulatory effect on beta receptors
  - Norepinephrine
    - Greater stimulatory effect on alpha receptors

ECG Monitoring

Components of normal ECG

- P wave
- QRS complex
- T wave

ECG Monitoring

Components of normal ECG
ECG Monitoring
Evaluate rate: Method 1

ECG Monitoring
Evaluate rate: Method 2

ECG Monitoring
Determine rhythm regularity
ECG Monitoring

Determine rhythm regularly.

3. by counting the small squares
between the P waves. *If calipers are not available, mark off the
distance between one P wave on a piece of
tape and compare this distance with the other
P-P intervals.

Regularly
Irregular rhythm

Occasionally
Irregular rhythm

Irregularly
Irregular rhythm

Abnormal P waves
ECG Monitoring

Normal P waves

Evaluate QRS complex

Normal QRS complexes

Evaluate QRS complex

Abnormal QRS complexes
ECG Monitoring

Normal PR intervals

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ECG Monitoring

Abnormal PR intervals

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ECG Monitoring

Evaluate ST segment

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ECG Monitoring

- Evaluate QT interval
- Evaluate T waves
- Evaluate U waves

Muscular tremor
AC interference
Loose electrodes

Biotelemetry interference
Chest compressions
Dysrhythmias

- Originate in SA node
  - Normal sinus rhythm
  - Sinus bradycardia
  - Sinus tachycardia
  - Sinus dysrhythmia
  - Sinus arrest

Dysrhythmias

- Originate in atria
  - Wandering atrial pacemaker
  - Premature atrial complexes
  - Supraventricular tachycardias
  - Atrial flutter
  - Atrial fibrillation

Dysrhythmias

- Originate in AV junction
  - Junctional rhythms
  - Premature junctional complex
  - Junctional escape complexes
  - Accelerated junctional rhythm
  - Junctional tachycardia
Dysrhythmias

- Originate in ventricles
  - PVCs
    - Bigeminal
    - Trigeminal
    - Quadrigeminal
    - Frequent
    - Couple
  - Ventricular tachycardia
  - Ventricular escape complexes
- Accelerated idioventricular rhythm
- Ventricular tachycardia
  - Monomorphic
  - Polymorphic
- Ventricular fibrillation
- Asystole
- Pulseless electrical activity

Dysrhythmias: NSR, SB, ST

Dysrhythmias: Sinus Dysrhythmias
Dysrhythmias: Sinus Arrest

Dysrhythmias: Wandering Atrial Pacemaker

Dysrhythmias: Premature Atrial Complex
Dysrhythmias: PVCs/VT

Dysrhythmias: Ventricular Escape Complexes

Dysrhythmias: Ventricular Tachycardia
Dysrhythmias

- Disorders of conduction
  - Heart blocks
    - First-degree AV block
    - Second-degree AV block, Mobitz type I
    - Second-degree AV block, Mobitz type II
    - Third-degree heart block

Dysrhythmias: First-Degree AV Block

Dysrhythmias: Second-Degree AV Block, Mobitz Type I (Wenckebach)
Dysrhythmias: Second-Degree AV Block, Mobitz Type II

Dysrhythmias: Third-Degree AV Block

Dysrhythmias: Identifying Heart Blocks
Dysrhythmias

- Pacemaker rhythms
  - Ventricular pacemaker
  - Atrial pacemaker
  - AV sequential pacemaker
- Disturbances of ventricular conduction
  - Delays in electrical conduction
  - Possible sites of block
- Preexcitation syndromes
  - Wolff-Parkinson-White syndrome
  - ECG features

Dysrhythmias

- Atrial pacing
- Ventricular pacing
- AV sequential pacing

Dysrhythmias: Bundle Branch Blocks

- Right bundle branch
- Left anterior hemi-branch
- Complete LBBB
- LBBB

Dysrhythmias
Dysrhythmias: Bundle Branch Blocks

Normal ventricular conduction

Dysrhythmias: Bundle Branch Blocks

Left bundle branch block

Right bundle branch block

Dysrhythmias: Left Anterior Hemiblock

Lead I

Lead II

Left anterior hemiblock

Lead aV1
Dysrhythmias: Wolff-Parkinson-White Syndrome

<table>
<thead>
<tr>
<th>Normal conduction</th>
<th>WP Wolff-Parkinson-White Syndrome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usual appearance when QRS complex is upright</td>
<td><img src="image1" alt="" /> or <img src="image2" alt="" /> Delta</td>
</tr>
<tr>
<td>Usual appearance when QRS complex is negative</td>
<td><img src="image3" alt="" /> or <img src="image4" alt="" /> Delta</td>
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Dysrhythmias

- ECG changes due to electrolyte imbalances
  - Potassium (K+)
    - Hyperkalemia
      - Peaked T waves
      - Flattened P waves
      - Prolonged PR interval
      - Widened QRS complex
      - Deepened S waves; merging of S & T waves
      - Multiventricular rhythm
      - VT
      - Sine wave-appearing ECG
      - VF, cardiac arrest

Dysrhythmias

<table>
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<th>Normal</th>
<th>Mild to Moderate Hyperkalemia</th>
<th>Marked Hyperkalemia</th>
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<tbody>
<tr>
<td><img src="image5" alt="" /></td>
<td><img src="image6" alt="" /></td>
<td><img src="image7" alt="" /></td>
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</table>
| T waves are tall and peaked with a narrow base; P wave amplitude decreases. The QRS complex widens and ultimately becomes sawtooth.
Dysrhythmias

- ECG changes due to electrolyte imbalances
  - Potassium (K+)
    - Hypokalemia
      - U waves
      - T-wave flattening
      - ST-segment changes (nonspecific)
      - Prolongation of QT interval
      - Dysrhythmias
      - PEA, asystole
  - Changes due to hypothermia
    - No specific ECG changes
    - Most common ECG changes:
      - Early hypothermia—sinus tachycardia
      - Moderate to severe hypothermia—bradydysrhythmias
      - Severe hypothermia—refractory VF or asystole
      - Flutter waves
      - Irregularly irregular SV rhythm
      - Digitalis toxicity—atrial fibrillation with a slow, regular ventricular response
      - Pacer
      - Mobitz type II block
      - Wenckebach

Dysrhythmias

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- T waves become flattened
- ST segments may be depressed
- U waves develop
- U waves increase in size
- The QT (which is actually the QRS interval) is prolonged
Summary

- Heart’s function: pump blood throughout body
- Arteries transport blood away from heart
- Veins transport blood back to heart
- \( O_2 \), \( CO_2 \) & nutrients & waste carried by capillaries

Summary

- Electrical nerve impulses cause heart to contract
- Autonomic nervous system & hormones control heart rate
- ECG is record of electrical activity of heart
- P wave represents atrial contraction

Summary

- QRS complex represents impulses through ventricles
- T wave & possible U wave represent completion of repolarization
- PR and ST segments represent electrical pauses
Summary

- 2 common methods of ECG analysis:
  - Observe rhythm on oscilloscope
  - Print out rhythm

Summary

- Dysrhythmias are irregularities of heart rhythm:
  - Originating in:
    - Sinus node
    - Atria
    - AV junction
    - Ventricles
    - Disorders of conduction

Questions?