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Interpreting ECGs

A Practical Approach

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Interpreting ECGs

A Practical Approach

Third Edition

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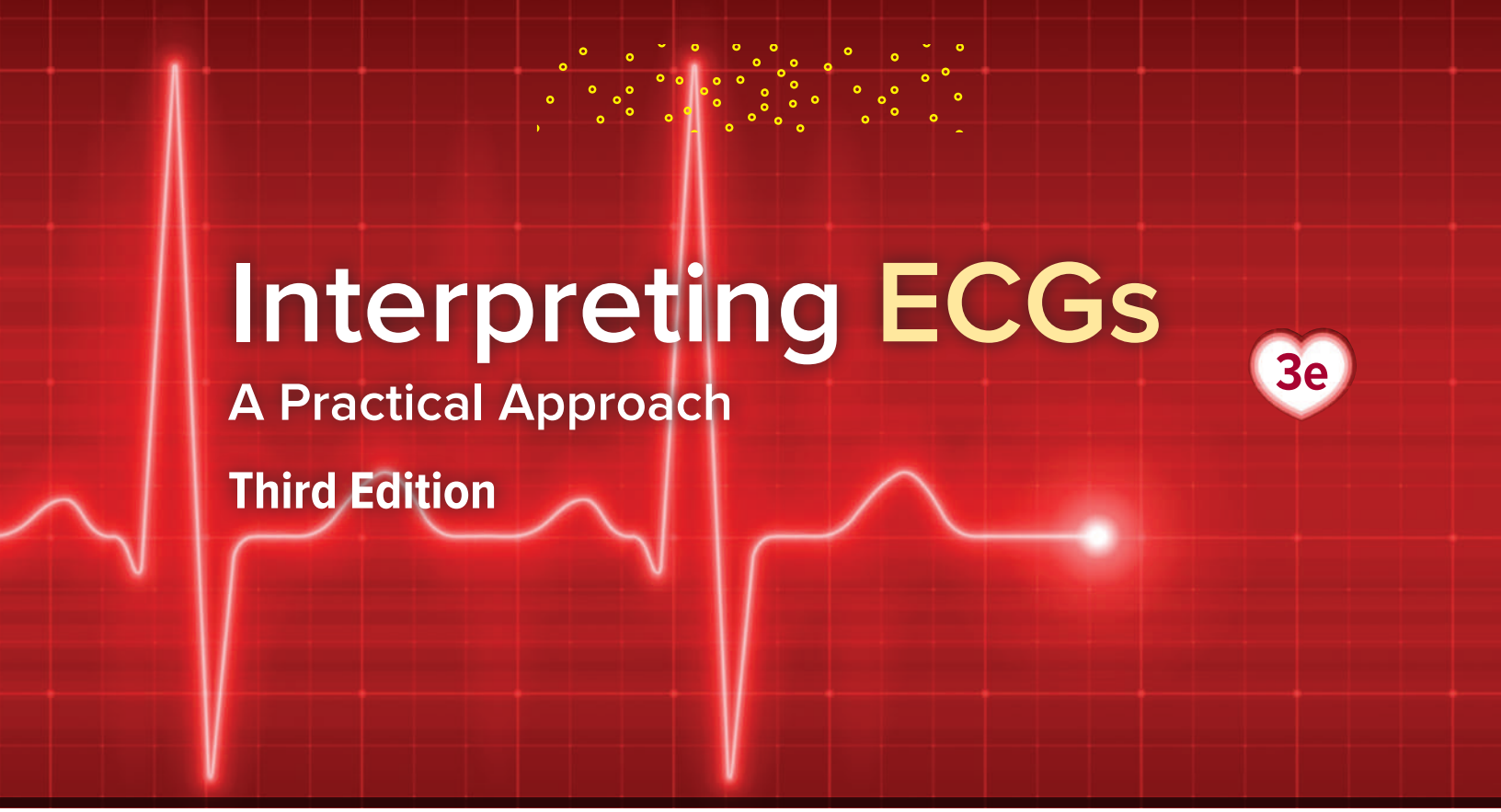

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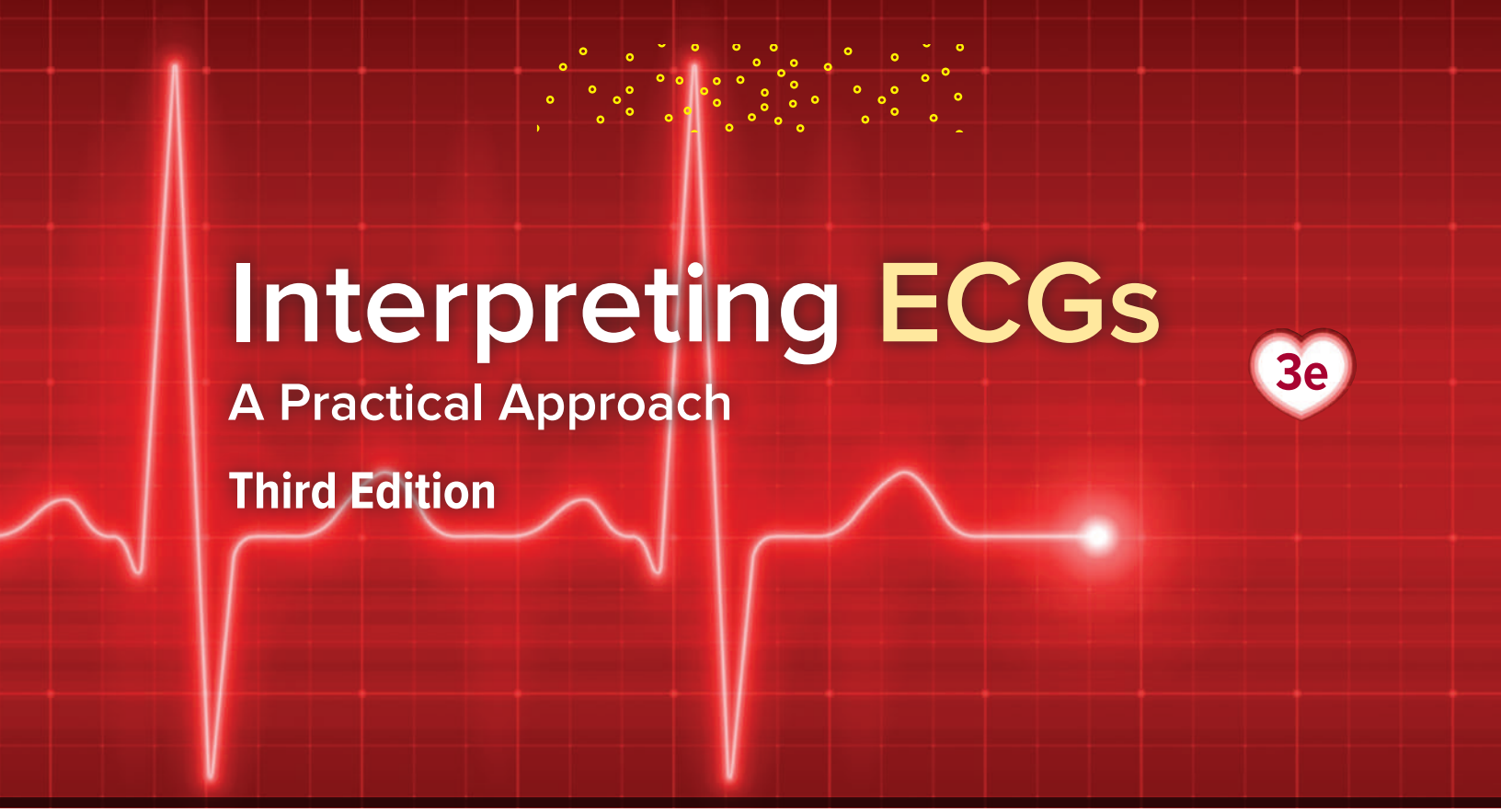

Bruce Shade

EMT-P, EMS-I, AAS

Mc Graw Hill Education

INTERPRETING ECGs

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About the Author

Courtesy Bruce Shade

Bruce Shade is currently employed as the EMS Educator for Cleveland Clinic Hillcrest Hospital in Northeast Ohio. He is also a paramedic instructor at Cuyahoga Community College (Tri-C) in Cleveland. Bruce is also a past Chairperson of the Ohio Emergency Medical Services Board and just recently retired as a part-time firefighter for the City of Willoughby.

Bruce has been involved in emergency services since 1972. He started as a volunteer firefighter/EMT for Granger Township and then served as paramedic, educational supervisor, paramedic training program director, and commissioner for the City of Cleveland's Division of Emergency Medical Service for the next 25 years. During those years, he also worked as a part-time firefighter/paramedic for Willowick Fire Department and the paramedic faculty at Lakeland Community College. For the remainder of his career with Cleveland, he served as an Assistant Public Safety Director. Since retiring, Bruce worked as a Homeland Security Consultant, Operations Director for Community Care Ambulance, and Assistant Safety-Service Director for the City of Elyria, all in Northeast Ohio.

Bruce is past President, Vice President, and Treasurer of the National Association of EMTs and chairperson of the Instructor Coordinator Society. He has served as president of several local associations and chairperson of many committees and task forces. Bruce has authored several EMS textbooks and written many EMS-related articles. He has lectured at local, regional, state, and national EMS conferences.

Dedication

This book is dedicated to my father, Elmer Shade, Jr. He recently passed away at the age of 97. He grew up during the depression, served in France during the Second World War, and worked hard his entire life. He was still mowing 20 acres of property each week at 96 years of age. A lifelong Cleveland sports fan, he had a keen sense of humor and a strong set of values and work ethic. He was known for his ability to tell stories and recall his life experiences. I can say, with great pride, that I acquired many of his traits. My ability to communicate information through textbooks can be directly attributed to what I learned from him.

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Preface

This book presents information similar to how an instructor delivers it in the classroom, with lots of illustrations, solid practical content, plentiful reinforcement of material, questions to prompt critical thinking, case presentations, and plentiful practice ECG tracings to promote the application of skills.

One of the first things readers will notice about this text is it is more of a "how-to book" than a "theoretical book." Although there is plenty of detail, the coverage is to the point, telling you and then showing you what you need to know. The breadth of information ranges from simple to complex, but regardless of how advanced the material, the explanations and visuals make the concepts easy to understand. Another aspect of this book is that it truly covers both dysrhythmia and 12-lead analysis and interpretation. It reinforces those core concepts from the beginning to the end using lots of repetition. This book includes plentiful pictures and figures to help readers see what is being discussed in actual use. We have also included coverage of the treatments used to manage the various dysrhythmias and cardiac conditions to give readers a broader perspective and better prepare them for applying what they have learned.

Structure of This Book

This book is divided into five sections:

- **Section 1, Preparatory,** looks at the underlying concepts of the anatomy and electrophysiology of the heart and the electrocardiogram itself.
- **Section 2, The Nine-Step Process,** comprises Chapters 3 through 9 and presents the Nine-Step Process of ECG interpretation. Each chapter provides an in-depth look at one of the steps and introduces the reader to the variances seen with that step.
- **Section 3, Origin and Clinical Aspects of Dysrhythmias,** comprises Chapters 10 through 17 and leads readers through an overview of heart disease and a thorough discussion regarding dysrhythmias. The section covers the origin of dysrhythmias, including the sinus node, the atria, the atrioventricular junction, the ventricles, atrioventricular heart blocks, and pacemakers. And it covers the clinical aspects of each dysrhythmia.
- **Section 4, 12-Lead ECGs,** introduces the concept of 12-lead ECGs in Chapter 18. Then Chapters 19 through 22 cover interpretation and recognition of myocardial ischemia, injury and infarction, bundle branch block and atrial enlargement and ventricular hypertrophy, and a host of other cardiac conditions and their effect on the ECG.
- **Section 5, Review and Assessment,** wraps it all up with the chapter "Putting It All Together" and more practice tracings.

Changes to the Book

Among the changes in this book is that we have retitled it to better reflect its comprehensive nature. While it is still easy to learn to interpret ECGs using this book, its volume and breadth of coverage make it difficult to read from cover to cover in a fast way. The third edition of ***Fast & Easy ECGs: A Self-Paced Learning Program*** by Bruce Shade is thorough, innovative, and greatly enhanced. We have changed the title to better reflect the comprehensive nature of this book. While we strive to make our approach fast and easy, there are many complicated aspects of learning how to analyze and interpret ECG tracings. For this reason, we cover the material in sufficient depth to provide the reader with everything they need to know in order to be proficient with this important skill.

Whereas the second edition had 22 chapters, this book is expanded and includes 23 chapters. The following chapter is brand new to this edition:

Chapter 10 provides an overview of heart disease, including what it is, the risks for developing it, and its causes and complications. Then we review the common types of heart disease. This chapter is designed to provide the reader with an understanding of how dysrhythmias and cardiac conditions occur. This will make it easier for the reader to understand the characteristics associated with each dysrhythmia and cardiac condition.

In addition to the expanded content, this book has more than 300 figures and close to 400 practice ECG tracings. It also introduces the reader to the treatment modalities for the various dysrhythmias and medical conditions.

We hope this book is beneficial to both students and instructors. Greater understanding of ECG interpretation will lead to better patient care everywhere.

Instructor Resources

Instructors, are you looking for additional resources? Be sure to visit www.mhhe.com/shade3e for answer keys, an Electronic Testbank, and accessible PowerPoint Presentations. Access is for instructors only and requires a user name and password from your McGraw-Hill Learning Technology Representative. To find your McGraw-Hill representative, go to www.mheducation.com and click "Contact," then "Contact a Sales Rep."

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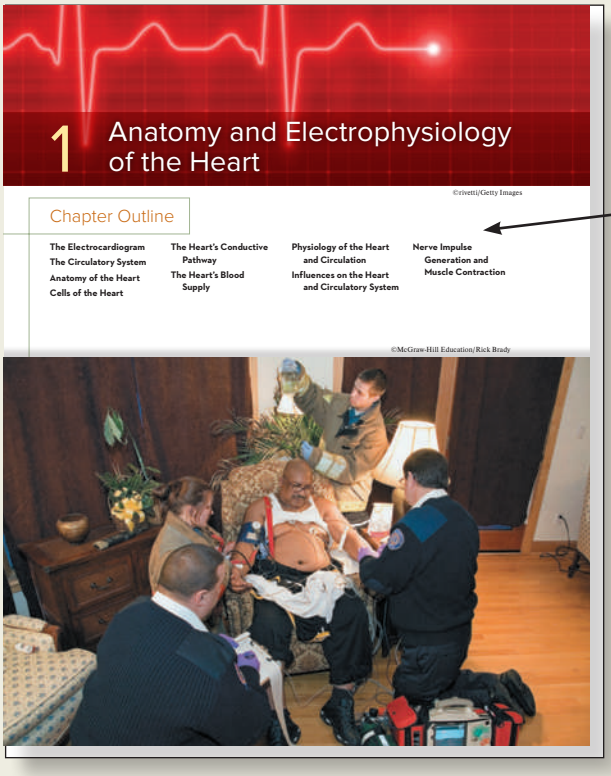
Features to Help You Study and Learn


1 Anatomy and Electrophysiology of the Heart

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Chapter Outline

The Electrocardiogram
The Circulatory System
Anatomy of the Heart
Cells of the Heart
The Heart's Conductive Pathway
The Heart's Blood Supply
Physiology of the Heart and Circulation
Influences on the Heart and Circulatory System
Nerve Impulse Generation and Muscle Contraction

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Preview the Chapter Content

Study the Chapter Outline to get an overview of the subjects to be covered in the chapter.

Learning Outcomes

- LO 1.1 Define the term *electrocardiogram*, list its uses, and describe how it works.
- LO 1.2 List the components of the circulatory system.
- LO 1.3 Describe the anatomy of the heart.
- LO 1.4 Identify and contrast the structure and function of the different types of heart cells.
- LO 1.5 Identify the structures of the heart's conduction system and describe what each does.
- LO 1.6 Identify how the heart receives most of its blood supply.
- LO 1.7 Recall how the heart and circulatory system circulates blood throughout the body.
- LO 1.8 Describe the influence of the autonomic nervous system on the heart and circulatory system.
- LO 1.9 Recall how nerve impulses are generated and muscles contract in the heart.

Review the Learning Outcomes to see what you will learn. Note that the Learning Outcomes numbers are keyed to the text and learning assessments.

Case History

Emergency medical services responds to the home of a 65-year-old man complaining of a dull ache in his chest for the past two hours which came on while mowing his lawn. He also complains of a "fluttering" in his chest and "shortness of breath." He has a history of hypertension, elevated cholesterol, and a one-pack-a-day smoking habit.

After introducing themselves, the paramedics begin their assessment, finding the patient's blood pressure to be 160/110, pulse 120 and irregular, respirations 20, and oxygen saturation 92% on room air. The patient is awake and alert, his airway is open, his breathing is slightly labored, and his pulses are strong.

Read the Case History for a real-world scenario that features the type of dysrhythmia covered in the chapter.

Visualize the Content

300 Full-Color Figures show you in detail where each dysrhythmia originates and teaches you step by step how to read the ECGs that demonstrate each dysrhythmia. In addition, algorithms and tables present content visually to help you memorize the most important elements of each type of dysrhythmia and condition.

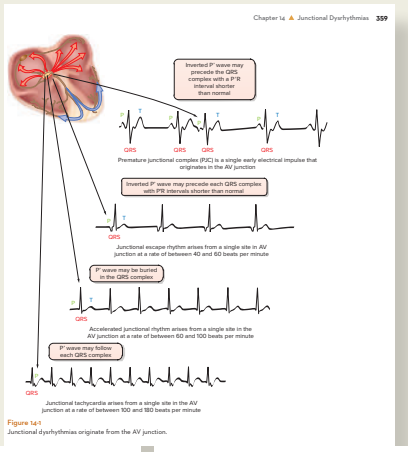


Figure 14-1
Junctional dysrhythmias originate from the AV junction.

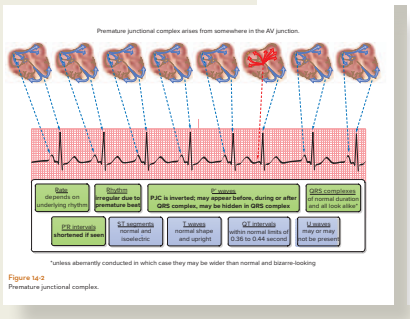


Figure 14-2
Premature junctional complex.

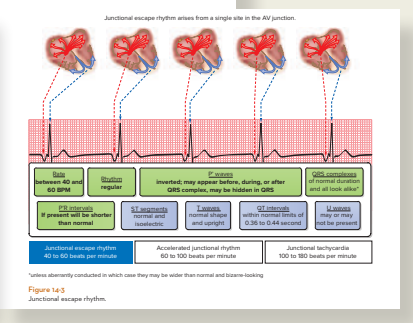
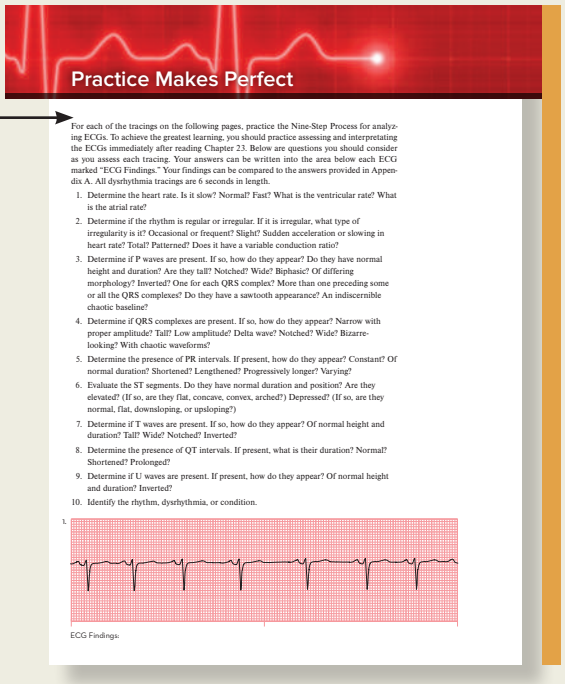


Figure 14-3
Junctional escape rhythm.

Review the Content

Practice Makes Perfect strips at the end of chapters and sections give you over 400 opportunities to interpret ECG strips using your new knowledge.


Practice Makes Perfect

For each of the tracings on the following pages, practice the Nine-Step Process for analyzing ECGs. To achieve the greatest learning, you should practice assessing and interpretating the ECGs immediately after reading Chapter 23. Below are questions you should consider as you assess each tracing. Your answers can be written into the area below each ECG marked "ECG Findings." Your findings can be compared to the answers provided in Appendix A. All dysrhythmia tracings are 6 seconds in length.

1. Determine the heart rate. Is it slow? Normal? Fast? What is the ventricular rate? What is the atrial rate?
2. Determine if the rhythm is regular or irregular. If it is irregular, what type of irregularity is it? Occasional or frequent? Slight? Sudden acceleration or slowing in heart rate? Total? Patterned? Does it have a variable conduction ratio?
3. Determine if P waves are present. If so, how do they appear? Do they have normal height and duration? Are they tall? Notched? Wide? Biphasic? Of differing morphology? Inverted? One for each QRS complex? More than one preceding some or all the QRS complexes? Do they have a sawtooth appearance? An indiscernible chaotic baseline?
4. Determine if QRS complexes are present. If so, how do they appear? Narrow with proper amplitude? Tall? Low amplitude? Delta wave? Notched? Wide? Bizarre-looking? With chaotic waveforms?
5. Determine the presence of PR intervals. If present, how do they appear? Constant? Of normal duration? Shortened? Lengthened? Progressively longer? Varying?
6. Evaluate the ST segments. Do they have normal duration and position? Are they elevated? (If so, are they flat, concave, convex, arched?) Depressed? (If so, are they normal, flat, downsloping, or upsloping?)
7. Determine if T waves are present. If so, how do they appear? Of normal height and duration? Tall? Wide? Notched? Inverted?
8. Determine the presence of QT intervals. If present, what is their duration? Normal? Shortened? Prolonged?
9. Determine if U waves are present. If present, how do they appear? Of normal height and duration? Inverted?
10. Identify the rhythm, dysrhythmia, or condition.

1.

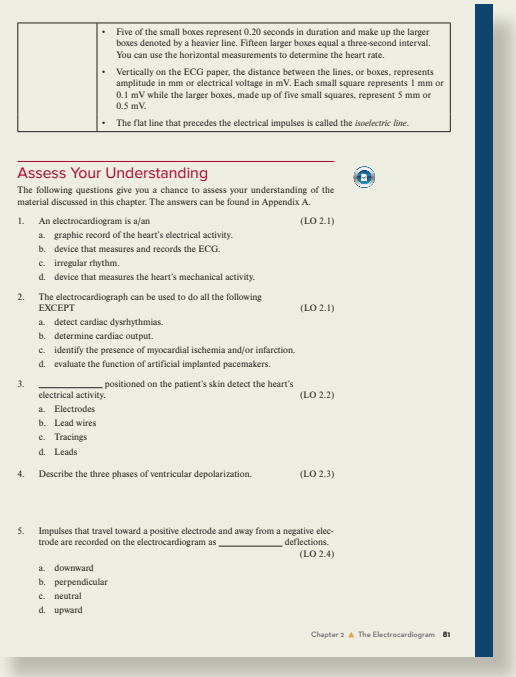
ECG Findings:

Key Points

LO 1.1	• The electrocardiogram is a graphic representation of the heart's electrical activity. It is used to identify irregularities in the heart rhythm and to reveal the presence of injury, death, or other physical changes in the heart muscle. • The electrocardiograph detects the electrical activity occurring in the heart through electrodes attached to the patient's skin. • When an impulse occurring in the heart moves toward a positive electrode of the ECG, it produces a positive waveform. When it moves away from the positive electrode (or toward a negative electrode), it produces a negative waveform.
LO 1.2	• The heart, blood, and blood vessels are the chief components of the circulatory system. • The circulatory system circulates enough blood to deliver needed oxygen and nutrients to the tissues and to remove waste products.
LO 1.3	• The heart is the pump; each time it contracts, it pushes blood throughout the body. • The heart is located between the lungs in the mediastinum behind the sternum, and it rests on the diaphragm with a front-to-back (anterior-posterior) orientation. • It is surrounded by a double-walled closed sac called the pericardium. The pericardium allows the heart to contract and expand within the chest cavity with minimal friction. • The heart wall consists of three layers: the myocardium, endocardium, and epicardium. • The heart consists of two upper chambers, the atria, and two lower chambers, the ventricles. • A muscular wall, the septum, separates the right side from the left side of the heart. • The right side of the heart receives blood from the systemic venous circulation and pumps it into the pulmonary circulation. • The left side of the heart receives blood from the pulmonary circulation and pumps it into the systemic circulation. • The skeleton of the heart provides firm support for the AV and semilunar valves and acts to separate and insulate the atria from the ventricles. • The four heart valves permit blood to flow through the heart in only one direction.
LO 1.4	• There are two basic types of cells in the heart: the myocardial cells (also referred to as the working cells), which contract to propel blood out of the heart's chambers, and the specialized cells of the electrical conduction system, which initiate and carry impulses throughout the heart. • The structure of the myocardial cells permits the rapid conduction of electrical impulses from one cell to another. This results in the cardiac muscle cells acting as a single unit, permitting coordinated contraction of a whole group of cells.
LO 1.5	• Depolarization of the myocardium progresses from the atria to the ventricles in an orderly fashion. The electrical stimulus causes the heart muscle to contract. • The wave of depolarization is carried throughout the heart via the heart's conduction system. The conduction system is a grouping of specialized tissues that form a network of connections, much like an electrical circuit. • The key structures of the conduction system are the SA node, intraatrial conductive pathway, internodal pathways, AV node, bundle of His, right and left bundle branches, and Purkinje fibers.

Key Points cover all of the pertinent content in the chapter.

Assess Your Understanding quizzes, with answers in Appendix A, help you recall the material and test your knowledge.



- Five of the small boxes represent 0.20 seconds in duration and make up the larger boxes denoted by a heavier line. Fifteen larger boxes equal a three-second interval. You can use the horizontal measurements to determine the heart rate.
- Vertically on the ECG paper, the distance between the lines, or boxes, represents amplitude in mm or electrical voltage in mV. Each small square represents 1 mm or 0.1 mV while the larger boxes, made up of five small squares, represent 5 mm or 0.5 mV.
- The flat line that precedes the electrical impulses is called the *isoelectric line*.

Assess Your Understanding

The following questions give you a chance to assess your understanding of the material discussed in this chapter. The answers can be found in Appendix A.

1. An electrocardiogram is a/an (LO 2.1)
   a. graphic record of the heart's electrical activity.
   b. device that measures and records the ECG.
   c. irregular rhythm.
   d. device that measures the heart's mechanical activity.

2. The electrocardiograph can be used to do all the following EXCEPT (LO 2.1)
   a. detect cardiac dysrhythmias.
   b. determine cardiac output.
   c. identify the presence of myocardial ischemia and/or infarction.
   d. evaluate the function of artificial implanted pacemakers.

3. _____ positioned on the patient's skin detect the heart's electrical activity. (LO 2.2)
   a. Electrodes
   b. Lead wires
   c. Tracings
   d. Leads

4. Describe the three phases of ventricular depolarization. (LO 2.3)

5. Impulses that travel toward a positive electrode and away from a negative electrode are recorded on the electrocardiogram as _____ deflections. (LO 2.4)
   a. downward
   b. perpendicular
   c. neutral
   d. upward

Chapter 2 ▲ The Electrocardiogram 81

First, I would like to thank Claire Merrick, the editor on the first edition of this textbook. It was her vision for the project that led to the original signing and publishing of ***Fast & Easy ECGs***. Next, I would like to thank Melinda Bilecki, the Freelance Product Developer for this edition. Melinda maintained a steady hand to get the chapters rewritten and figures redone despite my many delays. Even with these obstacles, she displayed incredible patience and helped guide completion of the book. Further, her hard work and attention to detail helped ensure the accuracy of the content.

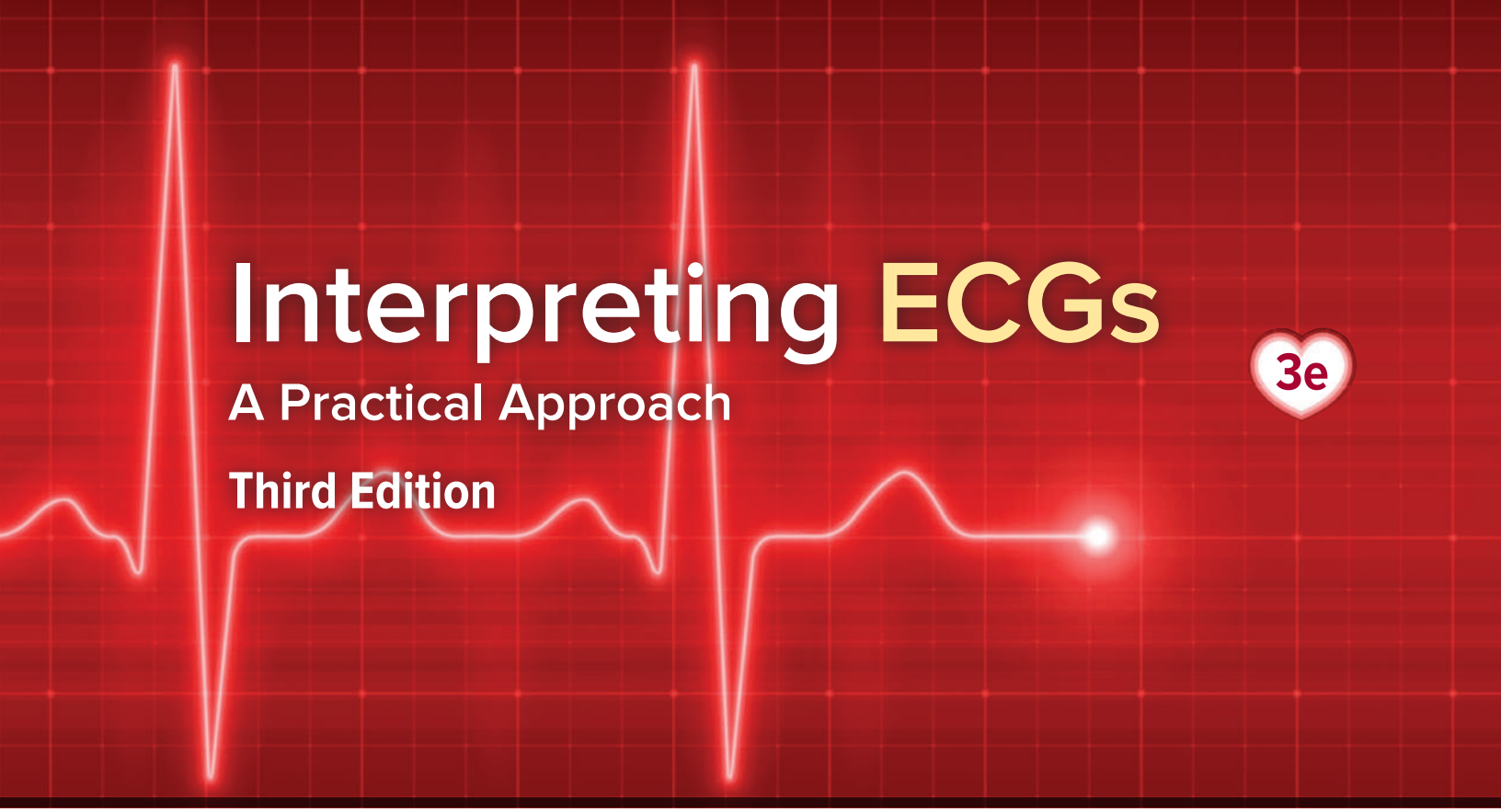
Many thanks go to, Michelle Flomenhoft, the Senior Product Developer, and William Lawrensen, the Executive Portfolio Manager with the Health Professions team at McGraw-Hill. They allowed me to significantly restructure the order of chapters, add more content and practice ECG tracings, and increase the footprint of the textbook. These features make a good book even better. They also convinced me of the need to rename the book to better reflect its comprehensive nature. As hard as it was for me to give up the former title, I recognize the importance of doing so.

Bruce Shade

Interpreting ECGs

A Practical Approach

Third Edition



Mc Graw Hill Education

section 1
Preparatory

Chapter 1: Anatomy and Electrophysiology of the Heart

Chapter 2: The Electrocardiogram

1 Anatomy and Electrophysiology of the Heart

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Chapter Outline

The Electrocardiogram
The Circulatory System
Anatomy of the Heart
Cells of the Heart
The Heart's Conductive Pathway
The Heart's Blood Supply
Physiology of the Heart and Circulation
Influences on the Heart and Circulatory System
Nerve Impulse Generation and Muscle Contraction

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Learning Outcomes

- **LO 1.1** Define the term *electrocardiogram,* list its uses, and describe how it works.
- **LO 1.2** List the components of the circulatory system.
- **LO 1.3** Describe the anatomy of the heart.
- **LO 1.4** Identify and contrast the structure and function of the different types of heart cells.
- **LO 1.5** Identify the structures of the heart's conduction system and describe what each does.
- **LO 1.6** Identify how the heart receives most of its blood supply.
- **LO 1.7** Recall how the heart and circulatory system circulates blood throughout the body.
- **LO 1.8** Describe the influence of the autonomic nervous system on the heart and circulatory system.
- **LO 1.9** Recall how nerve impulses are generated and muscles contract in the heart.

Case History

Emergency medical services responds to the home of a 65-year-old man complaining of a dull ache in his chest for the past two hours which came on while mowing his lawn. He also complains of a "fluttering" in his chest and "shortness of breath." He has a history of hypertension, elevated cholesterol, and a one-pack-a-day smoking habit.

After introducing themselves, the paramedics begin their assessment, finding the patient's blood pressure to be 160/110, pulse 120 and irregular, respirations 20, and oxygen saturation 92% on room air. The patient is awake and alert, his airway is open, his breathing is slightly labored, and his pulses are strong.

The paramedics apply oxygen by nasal cannula and attach the patient to a cardiac monitor by applying electrodes to his chest. The monitor shows a fast, narrow complex rhythm with frequent wide and bizarre-appearing extra complexes. On the basis of what they observe, the paramedics obtain a 12-lead electrocardiogram (ECG) to determine if signs of a heart attack are present. The 12-lead ECG confirms their suspicions. The patient is having a myocardial infarction.

The paramedics then administer aspirin, nitroglycerin, and medication for pain relief to the patient and transport him to the nearest appropriate facility. En route to the hospital, the patient states his pain is less and the paramedics notice that the extra complexes are gone from his heart rhythm.

1.1 The Electrocardiogram

In order for the muscles of the body to contract, they must first be stimulated by electrical impulses generated and conducted by the nervous system. The **electrocardiogram,** often referred to as an ECG or EKG, is a tracing or graphic representation of the heart's electrical activity over time. The device that detects, measures, and records the ECG is called an **electrocardiograph.** The name electrocardiogram is derived of different parts: electro, because it's related to electricity, cardio, a Greek word for heart, and gram, a Greek root meaning "to write."

The ECG provides healthcare professionals with valuable information (Figure 1-1). It is used to identify irregularities in the heart rhythm (called **dysrhythmias**); detect

(All Photos) Courtesy Philips Healthcare

Figure 1-1
The electrocardiogram provides valuable information in a host of clinical settings.

electrolyte disturbances and conduction abnormalities; and reveal the presence of injury, death, or other physical changes in the heart muscle. It is also used as a screening tool for ischemic heart disease during a cardiac stress test. It is occasionally helpful with diagnosing noncardiac conditions such as pulmonary embolism or hypothermia.

The ECG is used in the prehospital, hospital, and other clinical settings as both an assessment and diagnostic tool. It can also provide continuous monitoring of the heart's electrical activity, for instance, during transport to the hospital or in the coronary care unit. The ECG does not, however, tell us how well the heart is pumping. The presence of electrical activity on the cardiac monitor does not guarantee that the heart is contracting or producing a blood pressure. To determine that, we must assess the patient's pulse and blood pressure, as well as perform an appropriate physical examination.

How It Works

In simple terms, the electrocardiograph, or ECG machine, detects the electrical current activity occurring in the heart (Figure 1-2). It does this through electrodes placed on the patient's skin. The ECG electrode must be in good contact with the skin to properly detect the heart's electrical currents. Tips for achieving effective contact will be discussed further in Chapter 2. These impulses, which appear as a series of upward (positive) and downward (negative) deflections (waveforms), are then transferred to the ECG machine and displayed on a screen (called the **oscilloscope** or monitor), or they are printed onto graph paper (often referred to as an ECG tracing or strip).

As the impulse moves toward a positive electrode of the ECG, it produces a positive waveform (upright deflection). Refer to Figure 1-2. In this ECG tracing, all the waveforms (P, QRS, and T) are positive, meaning the impulses are traveling toward

Courtesy Physio-Control

Figure 1-2
The ECG detects electrical activity in the heart.

a positive electrode. When it moves away from a positive electrode or toward a negative electrode, it produces a negative waveform (downward deflection). The sites for the placement of the electrodes vary depending on which area of the heart's activity is being viewed. Different sites provide different views. We discuss this information in more depth in the next chapters.

This book is designed to teach you how to interpret what you see on an ECG. To do this, it is important for you to understand the anatomy and physiology of the circulatory system and the heart. We begin by reviewing the role of the circulatory system and discussing the location and structure of the heart. Then we talk about how the generation and conduction of nerve impulses leads to contraction of the heart chambers, which then pump blood throughout the body. Finally, we discuss the influence of the autonomic nervous system on the heart.

1.2 The Circulatory System

In order to achieve and maintain homeostasis in the body, the circulatory system performs a number of vital functions: It carries nutrients, gases, and wastes to and from the body's cells; it helps fight diseases; and it helps stabilize body temperature and pH. The term perfusion describes the circulatory system's delivery of oxygen and nutrients to the tissues and the removal of waste products from those tissues. Perfusion is necessary for the body's cells to function and survive. The body's cells die if there is insufficient blood supply to meet their needs. The chief elements of the circulatory system are the heart, blood, and blood vessels (Figure 1-3).

The circulatory system includes the pulmonary circulation, a "loop" through the lungs, and the systemic circulation, a "loop" through the rest of the body to provide oxygenated blood to the body's cells. The arteries of the systemic circulation carry oxygenated blood, whereas the veins carry deoxygenated blood. The reverse is true in the pulmonary circulation, where the pulmonary artery carries deoxygenated blood to the lungs and the pulmonary veins carry oxygenated blood back to the heart. The circulatory system of an average adult contains roughly 4.7 to 5.7 L of blood, which consists of plasma that contains red blood cells, white blood cells, and platelets.

1.3 Anatomy of the Heart

The heart is an amazing organ. It is the pump of the circulatory system. Each time it contracts, it pushes blood throughout the body. The typical adult heart beats an average of 75 times a minute, 24 hours a day, 365 days a year, never stopping to take a rest. In an average day it pumps between 7000 and 9000 liters (L) of blood! This circulates enough blood to deliver needed oxygen and nutrients to the tissues and to remove waste products. Depending on the requirements of the body, the heartbeat can either be sped up (during exercise) or slowed down (while resting or sleeping). Try this experiment: count your pulse rate while sitting or lying comfortably reading this book. Then, if you are physically able, go for a brisk walk (or perhaps run) and then recheck your pulse rate. Your heart should be beating faster;

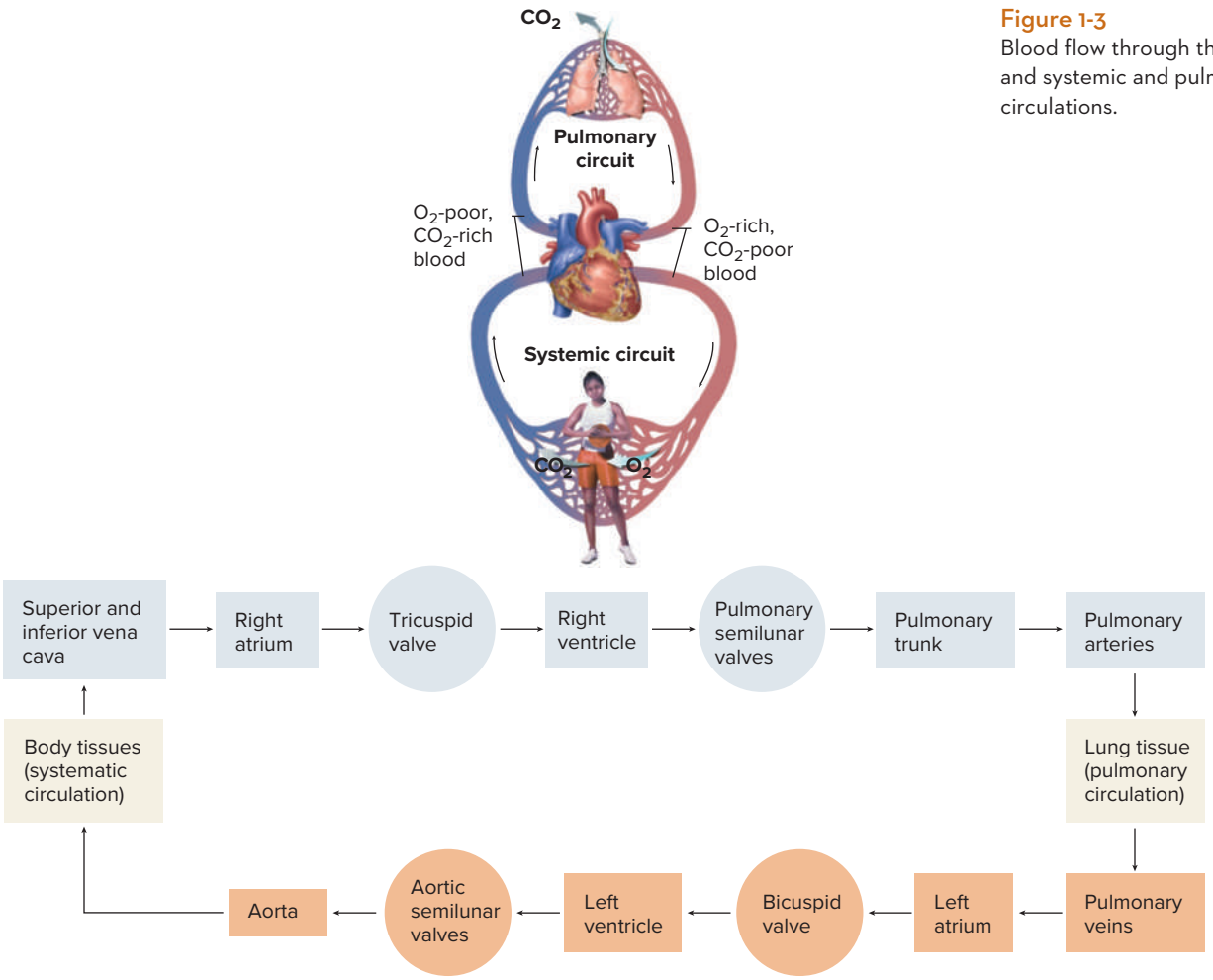

Figure 1-3
Blood flow through the heart and systemic and pulmonary circulations.

you may even feel the sensation of it pounding in your chest. Your body increases the heart rate and strength of contractions to circulate more blood (and oxygen and nutrients) to your cells and to remove the waste products that have been produced by those working cells.

Shape and Position of the Heart

Make a fist. Your heart is about the same size as your closed fist (Figure 1-4A). It is shaped like an inverted blunt cone. Its top (called the *base*) is the larger, flat part whereas its inferior end (called the *apex*) tapers to a blunt, rounded point. The heart is located between the lungs in the **mediastinum** behind the sternum (Figure 1-4B). It lies on the diaphragm in front of the trachea, esophagus, and thoracic vertebrae. About two-thirds of the heart is situated in the left side of the chest cavity. Its base is directed posteriorly and slightly superiorly at the level of the second intercostal space. Its **apex** is directed anteriorly and slightly inferiorly at the level of the fifth intercostal space in the left midclavicular line. This gives it a front-to-back (anterior-posterior) orientation. In this position the right ventricle is closer to the front of the left chest whereas the left ventricle is closer to the side of the left chest (Figure 1-4C). This informa-

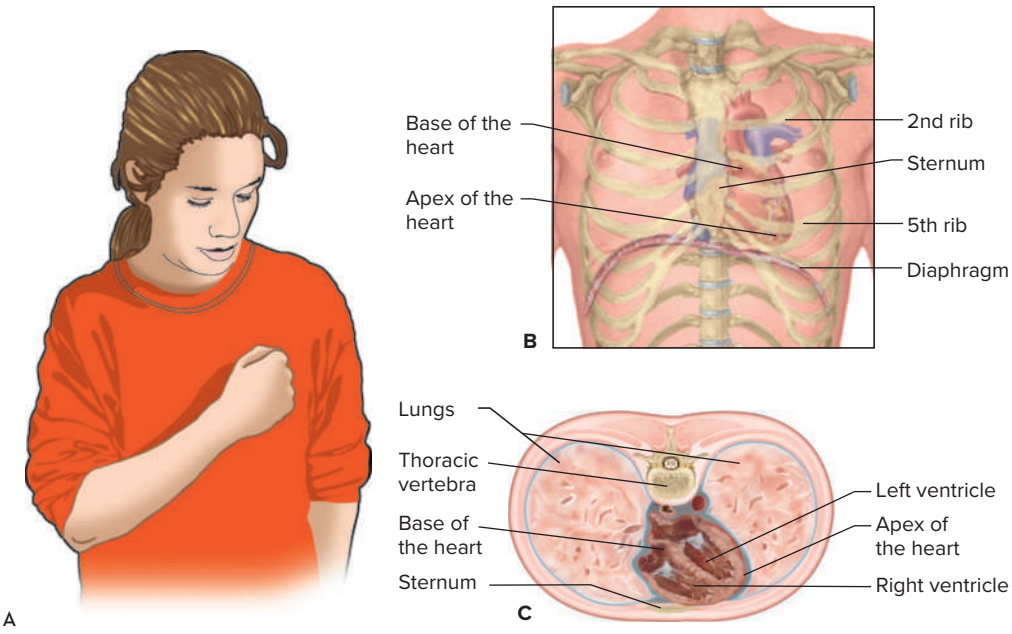

Figure 1-4
(A) The heart is about the size of a closed fist. (B) The position of the heart in the chest. (C) Cross section of the thorax at the level of the heart.

tion will be particularly useful to you when we discuss placement of the various leads in later chapters.

Knowing the position and orientation of the heart will help you to understand why certain ECG waveforms appear as they do when the electrical impulse moves toward a positive or negative electrode. The location of the various ECG leads permits us to look at the heart from several different directions.

The Pericardial Sac

The heart is surrounded by the pericardial sac (also called the **pericardium**), a double-walled closed sac (Figures 1-5 and 1-6). The tough, fibrous, outer layer is called the *fibrous pericardium* whereas the inner, thin, transparent lining is called the *serous pericardium.* Above the heart, the fibrous pericardium is continuous with the connective tissue coverings of the great vessels, and below, the heart is attached to the surface of the diaphragm. This anchors the heart within the mediastinum. The serous pericardium has two parts: the parietal pericardium, which lines the fibrous pericardium; and the visceral pericardium, which covers the surface of the heart. The pericardial cavity, located between the parietal pericardium and the visceral pericardium, holds a small amount of clear lubricating fluid that allows the heart to contract and expand within the chest cavity with minimal friction.

The accumulation of additional fluid in the pericardial space can restrict the heart's ability to contract. This leads to a condition called *pericardial tamponade.* Pericardial tamponade can be life-threatening.

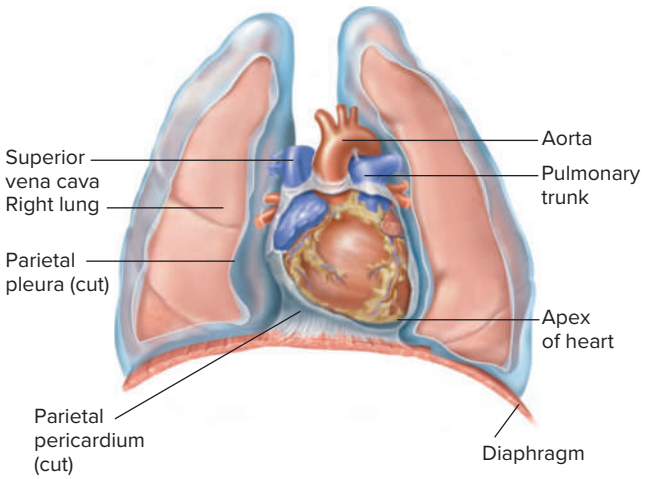

Figure 1-5
The pericardium is the protective sac that surrounds the heart.

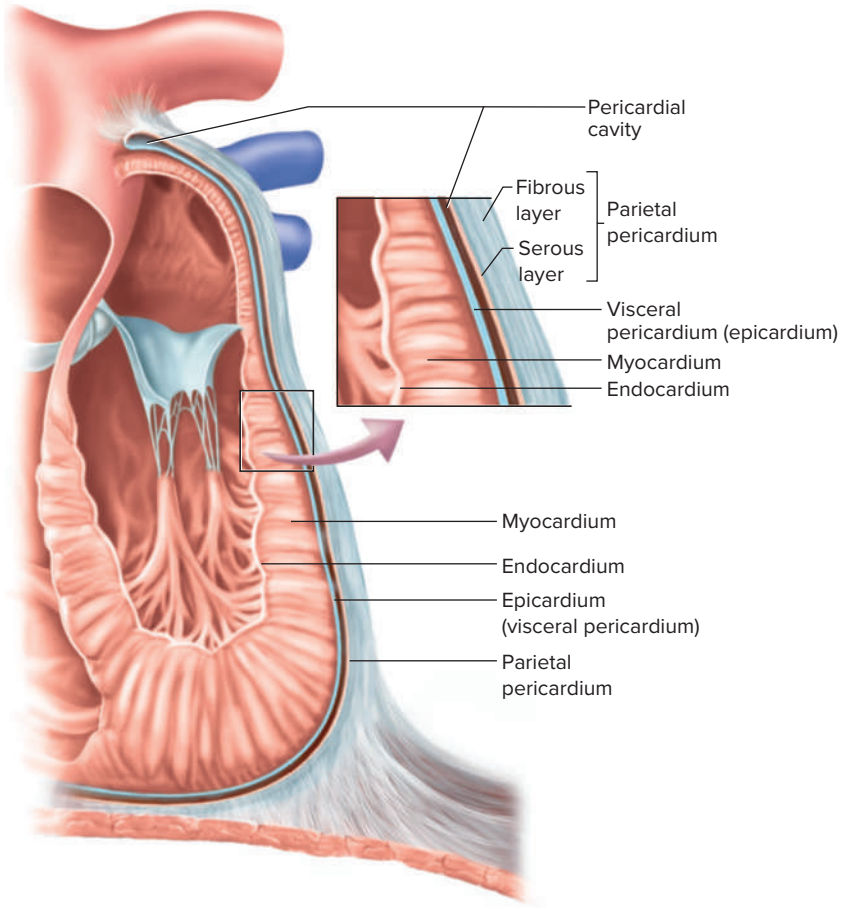

Figure 1-6
This cross section shows the structure of the heart. The enlarged section shows that the wall of the heart has three distinct layers of tissue: the endocardium, myocardium, and epicardium. Also note its relationship to the pericardium.

The Heart Wall

The heart wall is comprised of three layers (see Figure 1-6). The middle layer, the muscular layer, is called the **myocardium.** *Myo* means muscle whereas *cardia* means heart. It is the thickest of the three layers and is composed of cylindrical cells that look similar to skeletal muscle.