ELECTROCARDIOGRAPHY

FOR HEALTHCARE PROFESSIONALS

Fourth Edition

Kathryn A. Booth, RN-BSN, RPT, RMA (AMT), CPhT, MS

Thomas E. O'Brien, AS, CCT, CRAT, RMA

Mc Graw Hill Education

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Dedication

To the individuals using this book, you have chosen a worthwhile and rewarding career. Thank you; your skills and services are truly needed. To my youngest grandaughter, Harper Kathryn, so happy you are in my life.

Kathryn Booth

I want to thank my beautiful wife, Michele, and our wonderful children, Thomas, Robert, and Kathryn. Without their love and support, I would have nothing. They inspire me every day to make a difference in people's lives. I also want to express my sincere thanks to the faculty, staff, and students of Remington College for their encouragement and guidance. Today's students are the difference makers of tomorrow!

Thomas O'Brien

About the Author

Kathryn A. Booth, RN-BSN, RMA (AMT), RPT, CPhT, MS, is a registered nurse (RN) with CPR and ACLS training as well as a master's degree in education and certifications in phlebotomy, pharmacy tech, and medical assisting. She is an author, educator, and consultant for Total Care Programming, Inc. She has over 30 years of teaching, nursing, and healthcare work experience that spans five states. As an educator, Kathy has been awarded the teacher of the year in three states where she taught various health sciences. She serves on the American Medical Technologists registered Phlebotomy Technician Examinations, Qualifications, and Standards Committee. She stays current in the field by practicing her skills in various settings as well as by maintaining and obtaining certifications. In addition, Kathy volunteers at a free healthcare clinic and teaches online. She is a member of advisory boards at two educational institutions. Her larger goal is to develop up-to-date, dynamic healthcare educational materials to assist other educators as well as to promote the healthcare professions. In addition, Kathy enjoys presenting innovative new learning solutions for the changing healthcare and educational landscape to her fellow professionals nationwide.

Thomas E. O'Brien, AS, CCT, CRAT, RMA, is the Allied Health Program chairperson at Remington College, Fort Worth, Texas. Tom also works as an author of CME activities and editor with Practical Clinical Skills (www.practicalclinicalskills.com). He is also on the Board of Trustees and Exam Chair for the Certified Cardiographic Technician and Certified Rhythm Analysis Technician Registry Examinations working with Cardiovascular Credentialing International (CCI). His background includes over 24 years in the U.S. Air Force and U.S. Army Medical Corps. Tom's medical career as an Air Force Independent Duty Medical Technician (IDMT) has taken him all over the United States and the world. He has several years' experience working in the Emergency Services and Critical Care arena (Cardiothoracic Surgery and Cardiac Cath Lab). He was awarded Master Instructor status by the U.S. Air Force in 1994 upon completion of his teaching practicum. He now has over 15 years of teaching experience; subjects include Emergency Medicine, Cardiovascular Nursing, Fundamentals of Nursing, Dysrhythmias, and 12-Lead ECG Interpretation. His current position provides challenges to meet the ever-changing needs of the medical community and to provide first-rate education to a diverse adult education population.

Brief Contents

Contents

Preface

Healthcare is an ever-changing and growing field that needs well-trained individuals who can adapt to change. Flexibility is key to obtaining, maintaining, and improving a career in electrocardiography. Obtaining ECG training and certification, whether it be in addition to your current career or as your career, will make you employable or a more-valued employee. This fourth edition of ***Electrocardiography for Healthcare Professionals*** will prepare users for a national ECG certification examination, but most importantly provides comprehensive training and practice for individuals in the field of electrocardiography.

The fact that you are currently reading this book means that you are willing to acquire new skills or improve the skills you already possess. This willingness translates into your enhanced value, job security, marketability, and mobility. Once you complete this program, taking a certification examination is a great next step for advancing your career.

This fourth edition of ***Electrocardiography for Healthcare Professionals*** can be used in a classroom as well as for distance learning. Checkpoint Questions and Connect exercises correlated to the Learning Outcomes make the learning process interactive and promote increased comprehension. The variety of materials included with the program provides for multiple learning styles and ensured success.

Text Organization

The text is divided into 14 chapters:

- *Chapter 1 Electrocardiography* includes introductory information about the field as well as legal, ethical, communication, safety, and patient education information. In addition, basic vital signs and troubleshooting are addressed.
- *Chapter 2 The Cardiovascular System* provides a complete introduction and review of the heart and its electrical system. The information focuses on what you need to know to understand and perform an ECG. Specific topics include anatomy of the heart, principles of circulation, cardiac cycle, conduction system and electrical stimulation, and the ECG waveform.
- *Chapter 3 The Electrocardiograph* creates a basic understanding of the ECG, including producing the ECG waveform, the ECG machine, electrodes, and ECG graph paper.
- *Chapter 4 Performing an ECG* describes the procedure for performing an ECG in a simple step-by-step fashion. Each part of the procedure is explained in detail, taking into consideration the latest guidelines. The chapter is divided into the following topics: preparation, communication, anatomical landmarks, applying the electrodes and leads, safety

and infection control, operating the ECG machine, checking the tracing, reporting results, and equipment maintenance. Extra sections are included regarding pediatric ECG, cardiac monitoring, special patient circumstances, and emergencies. Procedure checklists are included to practice performing both an ECG and continuous monitoring.

- *Chapter 5 Rhythm Strip Interpretation and Sinus Rhythms* introduces the five-step criteria for classification approach to rhythm interpretation that will be utilized throughout Chapters 5 to 10. With updated, realistic rhythm strip figures, explanations, and Checkpoint Questions, the user learns to interpret the sinus rhythms, including criteria for classification, how the patient may be affected, basic patient care, and treatment.
- *Chapter 6 Atrial Dysrhythmias* provides an introduction to and interpretation of the atrial dysrhythmias, including criteria for classification, how the patient may be affected, basic patient care, and treatment.
- *Chapter 7 Junctional Dysrhythmias* provides an introduction to and interpretation of the junctional dysrhythmias, including criteria for classification, how the patient may be affected, basic patient care, and treatment.
- *Chapter 8 Heart Block Dysrhythmias* provides an introduction to and interpretation of the heart block dysrhythmias, including criteria for classification, how the patient may be affected, basic patient care, and treatment.
- *Chapter 9 Ventricular Dysrhythmias* provides an introduction to and interpretation of the ventricular dysrhythmias, including criteria for classification, how the patient may be affected, basic patient care, and treatment.
- *Chapter 10 Pacemaker Rhythms and Bundle Branch Block* provides an introduction to pacemaker rhythms, evaluation of pacemaker function, and complications related to the ECG tracing. An introduction to bundle branch block dysrhythmias, including criteria for classification, how the patient may be affected, basic patient care, and treatment, is also included.
- *Chapter 11 Exercise Electrocardiography* provides the information necessary to assist with the exercise electrocardiography procedure. The competency checklist provides the step-by-step procedure for practice and developing proficiency at the skill.
- *Chapter 12 Ambulatory Monitoring* includes the latest information about various types of ambulatory monitors and includes what you need to know to apply and remove a monitor. A procedure checklist is also provided for this skill.
- *Chapter 13 Clinical Presentation and Management of the Cardiac Patient* expands on the anatomy of the coronary arteries and relates them to typical and atypical cardiac symptoms. STEMI, non-STEMI, and heart failure are introduced. The chapter includes a section about sudden cardiac death as compared to myocardial infarction and finishes with assessment, immediate care, and continued treatment of the cardiac patient.
- *Chapter 14 Basic 12-Lead ECG Interpretation* provides an introduction to 12-lead ECG interpretation. It includes anatomic views of the coronary arteries and correlates the arteries with the leads and views obtained on a 12-lead ECG. It also identifies the morphologic changes in the tracing that occur as a result of ischemia, injury, and infarction. Axis deviation, bundle branch block, and left ventricular hypertrophy round out the chapter concepts. The last section helps users put all of these concepts together for 12-lead interpretation.

These chapters can be utilized in various careers and training programs. Following are some suggested examples:

- Telemetry technicians (Chapters 1–12, depending on requirements)
- EKG/ECG technicians (the entire book, depending on requirements)
- Medical assistants (the entire book, depending on where they work)
- Cardiovascular technicians working in any number of specialty clinics, such as cardiology or internal medicine (the entire book)
- Remote monitoring facilities personnel (transtelephonic medicine) (Chapters 1–10, 12–14)
- Emergency medical technicians (Chapters 2, 5–10, 14, possibly more depending on where they work)
- Paramedics (Chapters 2–14)
- Nursing, especially for cross-training or specialty training (Chapters 2–14)
- Patient care tech or nursing assistant (Chapters 2–4, 12, perhaps more depending on job requirements)
- Polysomnography technologist (Chapters 2–10)
- Echocardiography technologist (Chapters 2, 5–11)
- Cardiac cath lab technologist (Chapters 2–10, 14)

New to the Fourth Edition

- Over 25 new photos and revised figures for an improved, up-to-date, and realistic look that also provides additional student practice.
- Complete revision of Chapter 1 including new and expanded sections on safety and infection control and basic vital signs.
- Modified Bloom's specific learning outcomes providing one learning outcome per level 1 heading and corresponding questions to ensure student understanding and success.
- Added and updated content about the following essential topics: cardiac anatomy, lead descriptions, law and ethics, cardiac output, vagal tone, stroke volume, premature complexes, Wolff-Parkinson-White syndrome, Torsades de Pointes, pacemakers, exercise electrocardiography (including a new table for common stress test chemicals), and ambulatory monitoring.
- Modified and simplified descriptions of arrhythmias; changed the term *configuration* to *morphology* when appropriate for accuracy.

Features of the Text

- **Key Terms and Glossary:** Key terms are identified at the beginning of each chapter. These terms are in **bold, color** type within the chapter and are defined both in the chapter and in the glossary at the end of the book.
- **Checkpoint Questions:** At the end of each main heading in the chapter are short-answer Checkpoint Questions. Answer these questions to make sure you have learned the basic concepts presented.
- **Troubleshooting:** The Troubleshooting feature identifies problems and situations that may arise when you are caring for patients or performing a procedure. At the end of this feature, you are asked a question to answer in your own words.

- **Safety & Infection Control:** You are responsible for providing safe care and preventing the spread of infection. This feature presents tips and techniques to help you practice these important skills relative to electrocardiography.
- **Patient Education & Communication:** Patient interaction and education and intrateam communication are integral parts of healthcare. As part of your daily duties, you must communicate effectively, both orally and in writing, and you must provide patient education. Use this feature to learn ways to perform these tasks.
- **Law & Ethics:** When working in healthcare, you must be conscious of the regulations of HIPAA (Health Insurance Portability and Accountability Act) and understand your legal responsibilities and the implications of your actions. You must perform duties within established ethical practices. This feature helps you gain insight into how HIPAA, law, and ethics relate to the performance of your duties.
- **Real ECG Tracings:** Actual ECG tracings, or rhythm strips, have been provided for easy viewing and to make the task of learning the various dysrhythmias easier and more realistic. Use of these ECG rhythm strips for activities and exercises throughout the program improves comprehension and accommodates visual learners.
- **Chapter Summary:** Once you have completed each chapter, take time to read and review the summary table. It has been correlated to key concepts and learning outcomes within each chapter and includes handy page number references.
- **Chapter Review:** Complete the chapter review questions, which are presented in a variety of formats. These questions help you understand the content presented in each chapter. Chapters 4, 11, and 12 also include Procedure Checklists for you to use to practice and apply your knowledge.

Resources

A one-stop spot to present, deliver, and assess digital assets available from McGraw-Hill Education: McGraw-Hill Connect® for Booth/O'Brien: **Electrocardiography for Healthcare Professionals**

McGraw-Hill Connect® for Electrocardiography provides online presentation, assignment, and assessment solutions. It connects your students with the tools and resources they'll need to achieve success. With Connect you can deliver assignments, quizzes, and tests online. A robust set of questions and activities—including all of the end-of-chapter questions, additional algorithmic math exercises focused on the three calculation methods, and interactive exercises—are presented and aligned with the text's learning outcomes. As an instructor, you can edit existing questions and create entirely new problems. Connect enables you to track individual student performance—by question, by assignment, or in relation to the class overall—with detailed grade reports. You can integrate grade reports easily with Learning Management Systems (LMSs) such as Blackboard, Desire2Learn, or eCollege—and much more. **McGraw-Hill Connect® Electrocardiography** provides students with all the advantages of Connect Electrocardiography *plus* 24/7 online access to an eBook. This media-rich version of the textbook is available through the McGraw-Hill Connect platform and allows seamless integration of text, media, and assessments. To learn more, visit **http://connect.mheducation.com.**

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Additional Instructor Resources

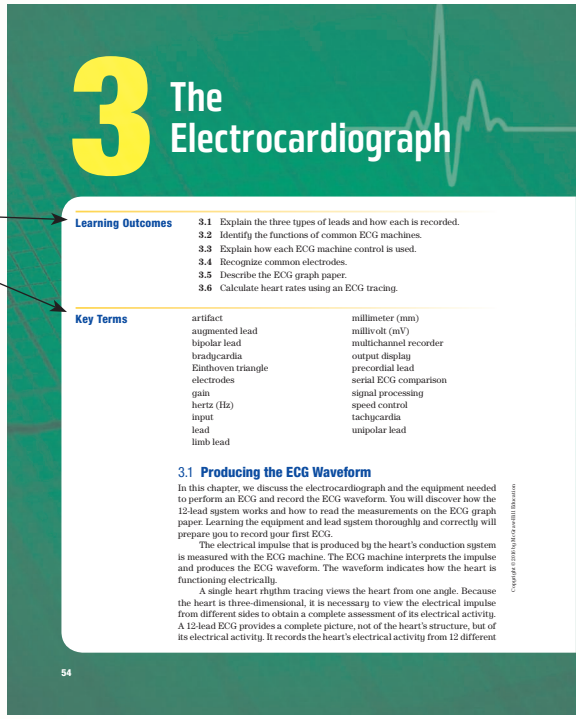
- **Instructor's Manual** with course overview, lesson plans, answers to CheckPoint and End-of-Chapter Review questions, competency correlations, sample syllabi, and more.
- **PowerPoint Presentations** for each chapter, containing teaching notes correlated to learning outcomes. Each presentation seeks to reinforce key concepts and provide an additional visual aid for students.
- **Test Bank** and answer key for use in class assessment. The comprehensive test bank includes a variety of question types, with each question linked directly to a learning outcome from the text. Questions are also tagged with relevant topic, Bloom's Taxonomy level, difficulty level, and competencies, where applicable. The test bank is available in Connect, and Word and EZ Test versions are also available.
- **Conversion Guide** with a chapter-by-chapter breakdown of how the content has been revised between editions. The guide is helpful if you are currently using **Electrocardiography for Healthcare Professionals** and moving to the new edition, or if you are a first-time adopter.
- **Instructor Asset Map** to help you find the teaching material you need with a click of the mouse. These online chapter tables are organized by Learning Outcomes and allow you to find instructor notes, PowerPoint slides, and even test bank suggestions with ease! The Asset Map is a completely integrated tool designed to help you plan and instruct your courses efficiently and comprehensively. It labels and organizes course material for use in a multitude of learning applications.

All of these helpful materials can be found within your Connect course under the Instructor Resources.

Guided Tour

Features to Help You Study and Learn

Learning Outcomes and Key Terms, and an Introduction begin each chapter to introduce you to the chapter and help prepare you for the information that will be presented.



3 The Electrocardiograph

Learning Outcomes

3.1 Explain the three types of leads and how each is recorded.
3.2 Identify the functions of common ECG machines.
3.3 Explain how each ECG machine control is used.
3.4 Recognize common electrodes.
3.5 Describe the ECG graph paper.
3.6 Calculate heart rates using an ECG tracing.

Key Terms

artifact
augmented lead
bipolar lead
bradycardia
Einthoven triangle
electrodes
gain
hertz (Hz)
input
lead
limb lead
millimeter (mm)
millivolt (mV)
multichannel recorder
output display
precordial lead
serial ECG comparison
signal processing
speed control
tachycardia
unipolar lead

3.1 Producing the ECG Waveform

In this chapter, we discuss the electrocardiograph and the equipment needed to perform an ECG and record the ECG waveform. You will discover how the 12-lead system works and how to read the measurements on the ECG graph paper. Learning the equipment and lead system thoroughly and correctly will prepare you to record your first ECG.

The electrical impulse that is produced by the heart's conduction system is measured with the ECG machine. The ECG machine interprets the impulse and produces the ECG waveform. The waveform indicates how the heart is functioning electrically.

A single heart rhythm tracing views the heart from one angle. Because the heart is three-dimensional, it is necessary to view the electrical impulse from different sides to obtain a complete assessment of its electrical activity. A 12-lead ECG provides a complete picture, not of the heart's structure, but of its electrical activity. It records the heart's electrical activity from 12 different

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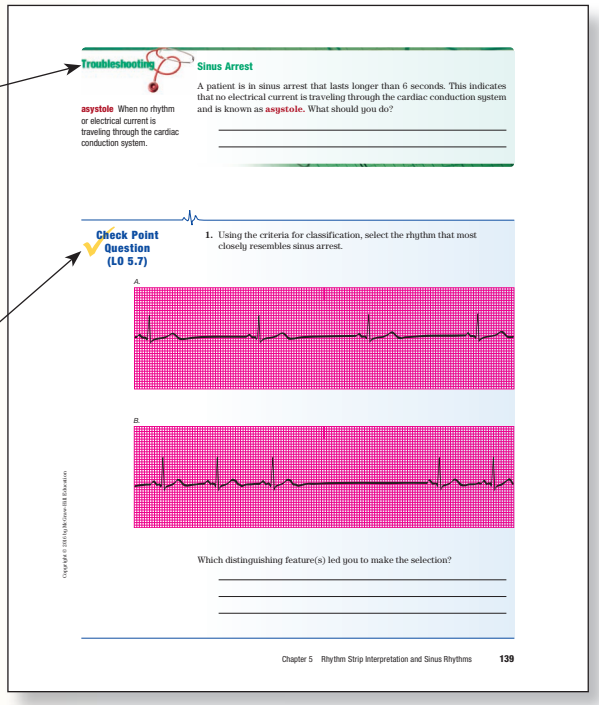
Troubleshooting exercises identify problems and situations that may arise on the job. You may be asked to answer a question about the situation.

Checkpoint Questions are provided at the end of each section in the chapter to help you understand the information you just read.



Troubleshooting

Sinus Arrest

A patient is in sinus arrest that lasts longer than 6 seconds. This indicates that no electrical current is traveling through the cardiac conduction system and is known as **asystole.** What should you do?

asystole When no rhythm or electrical current is traveling through the cardiac conduction system.

Check Point Question (LO 5.7)

1. Using the criteria for classification, select the rhythm that most closely resembles sinus arrest.

A.

B.

Which distinguishing feature(s) led you to make the selection?

Chapter 5 Rhythm Strip Interpretation and Sinus Rhythms 139

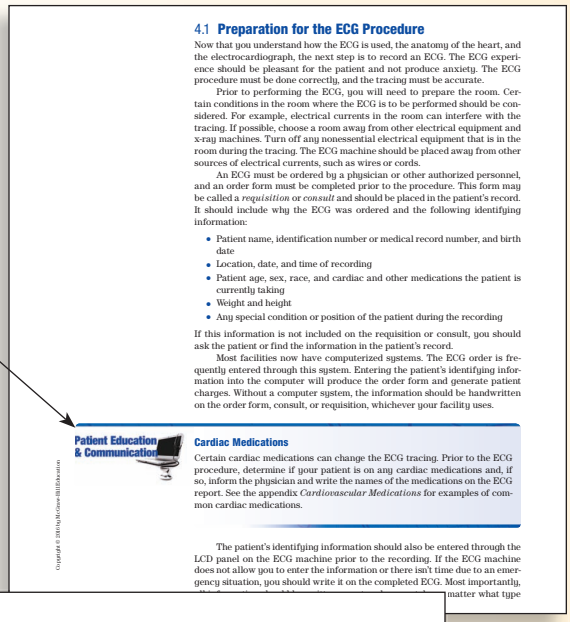
"I have been examining textbooks for approximately eight years now and this ECG text provides students with the most complete and accurate information without overwhelming them."
Donna Folmar, Belmont Technical College

Patient Education & Communication boxes give you helpful information for communicating effectively—both orally and written—with patients.

Interpret-TIP features throughout Chapters 5–10 provide simple and easy guidelines to help you recognize each of the ECG rhythms presented.

Safety & Infection Control boxes present tips and techniques for you to apply on the job.

Law & Ethics boxes help you gain insight into necessary information related to the performance of your duties.



4.1 **Preparation for the ECG Procedure**

Now that you understand how the ECG is used, the anatomy of the heart, and the electrocardiograph, the next step is to record an ECG. The ECG experience should be pleasant for the patient and not produce anxiety. The ECG procedure must be done correctly, and the tracing must be accurate.

Prior to performing the ECG, you will need to prepare the room. Certain conditions in the room where the ECG is to be performed should be considered. For example, electrical currents in the room can interfere with the tracing. If possible, choose a room away from other electrical equipment and x-ray machines. Turn off any nonessential electrical equipment that is in the room during the tracing. The ECG machine should be placed away from other sources of electrical currents, such as wires or cords.

An ECG must be ordered by a physician or other authorized personnel, and an order form must be completed prior to the procedure. This form may be called a *requisition* or *consult* and should be placed in the patient's record. It should include why the ECG was ordered and the following identifying information:

- Patient name, identification number or medical record number, and birth date
- Location, date, and time of recording
- Patient age, sex, race, and cardiac and other medications the patient is currently taking
- Weight and height
- Any special condition or position of the patient during the recording

If this information is not included on the requisition or consult, you should ask the patient or find the information in the patient's record.

Most facilities now have computerized systems. The ECG order is frequently entered through this system. Entering the patient's identifying information into the computer will produce the order form and generate patient charges. Without a computer system, the information should be handwritten on the order form, consult, or requisition, whichever your facility uses.

Patient Education & Communication

Cardiac Medications

Certain cardiac medications can change the ECG tracing. Prior to the ECG procedure, determine if your patient is on any cardiac medications and, if so, inform the physician and write the names of the medications on the ECG report. See the appendix *Cardiovascular Medications* for examples of common cardiac medications.

The patient's identifying information should also be entered through the LCD panel on the ECG machine prior to the recording. If the ECG machine does not allow you to enter the information or there isn't time due to an emergency situation, you should write it on the completed ECG. Most importantly, matter what type

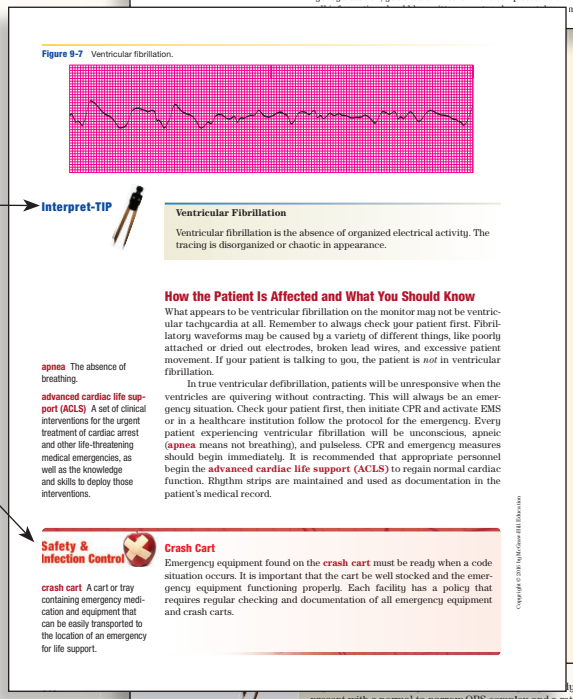


Figure 9-7 Ventricular fibrillation.

Interpret-TIP

Ventricular Fibrillation

Ventricular fibrillation is the absence of organized electrical activity. The tracing is disorganized or chaotic in appearance.

How the Patient Is Affected and What You Should Know

What appears to be ventricular fibrillation on the monitor may not be ventricular tachycardia at all. Remember to always check your patient first. Fibrillatory waveforms may be caused by a variety of different things, like poorly attached or dried out electrodes, broken lead wires, and excessive patient movement. If your patient is talking to you, the patient is *not* in ventricular fibrillation.

In true ventricular defibrillation, patients will be unresponsive when the ventricles are quivering without contracting. This will always be an emergency situation. Check your patient first, then initiate CPR and activate EMS or in a healthcare institution follow the protocol for the emergency. Every patient experiencing ventricular fibrillation will be unconscious, apneic (**apnea** means not breathing), and pulseless. CPR and emergency measures should begin immediately. It is recommended that appropriate personnel begin the **advanced cardiac life support (ACLS)** to regain normal cardiac function. Rhythm strips are maintained and used as documentation in the patient's medical record.

apnea The absence of breathing.

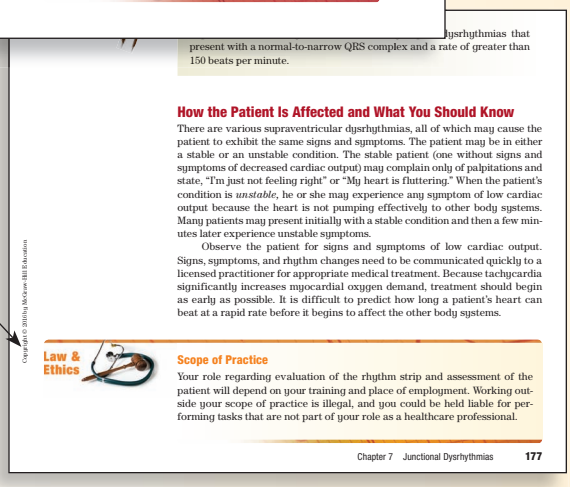
advanced cardiac life support (ACLS) A set of clinical interventions for the urgent treatment of cardiac arrest and other life-threatening medical emergencies, as well as the knowledge and skills to deploy those interventions.

Safety & Infection Control

Crash Cart

Emergency equipment found on the **crash cart** must be ready when a code situation occurs. It is important that the cart be well stocked and the emergency equipment functioning properly. Each facility has a policy that requires regular checking and documentation of all emergency equipment and crash carts.

crash cart A cart or tray containing emergency medication and equipment that can be easily transported to the location of an emergency for life support.



dysrhythmias that present with a normal-to-narrow QRS complex and a rate of greater than 150 beats per minute.

How the Patient Is Affected and What You Should Know

There are various supraventricular dysrhythmias, all of which may cause the patient to exhibit the same signs and symptoms. The patient may be in either a stable or an unstable condition. The stable patient (one without signs and symptoms of decreased cardiac output) may complain only of palpitations and state, "I'm just not feeling right" or "My heart is fluttering." When the patient's condition is *unstable*, he or she may experience any symptom of low cardiac output because the heart is not pumping effectively to other body systems. Many patients may present initially with a stable condition and then a few minutes later experience unstable symptoms.

Observe the patient for signs and symptoms of low cardiac output. Signs, symptoms, and rhythm changes need to be communicated quickly to a licensed practitioner for appropriate medical treatment. Because tachycardia significantly increases myocardial oxygen demand, treatment should begin as early as possible. It is difficult to predict how long a patient's heart can beat at a rapid rate before it begins to affect the other body systems.

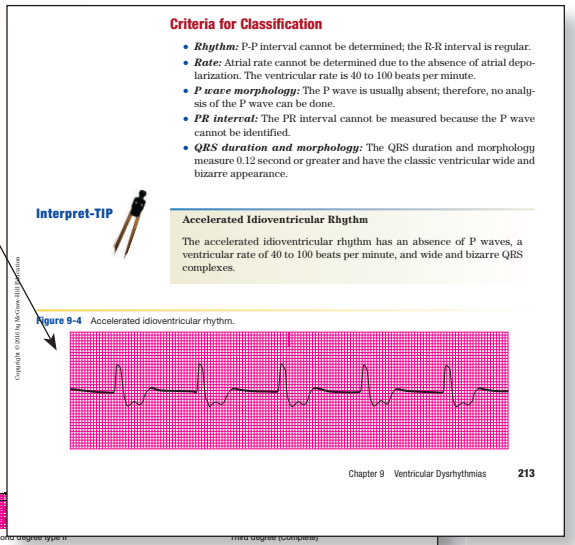
Law & Ethics

Scope of Practice

Your role regarding evaluation of the rhythm strip and assessment of the patient will depend on your training and place of employment. Working outside your scope of practice is illegal, and you could be held liable for performing tasks that are not part of your role as a healthcare professional.

ECG Rhythm Strips make the task of learning the various dysrhythmias easier and more realistic. Over 200 strips are included within the textbook.

"Practice ECG rhythm strips are key tools for practicing rhythm recognition. An excellent comprehensive textbook for the Electrocardiography student."
Stephen Nardozzi, Westchester Community College



Criteria for Classification

- ***Rhythm:*** P-P interval cannot be determined; the R-R interval is regular.
- ***Rate:*** Atrial rate cannot be determined due to the absence of atrial depolarization. The ventricular rate is 40 to 100 beats per minute.
- ***P wave morphology:*** The P wave is usually absent; therefore, no analysis of the P wave can be done.
- ***PR interval:*** The PR interval cannot be measured because the P wave cannot be identified.
- ***QRS duration and morphology:*** The QRS duration and morphology measure 0.12 second or greater and have the classic ventricular wide and bizarre appearance.

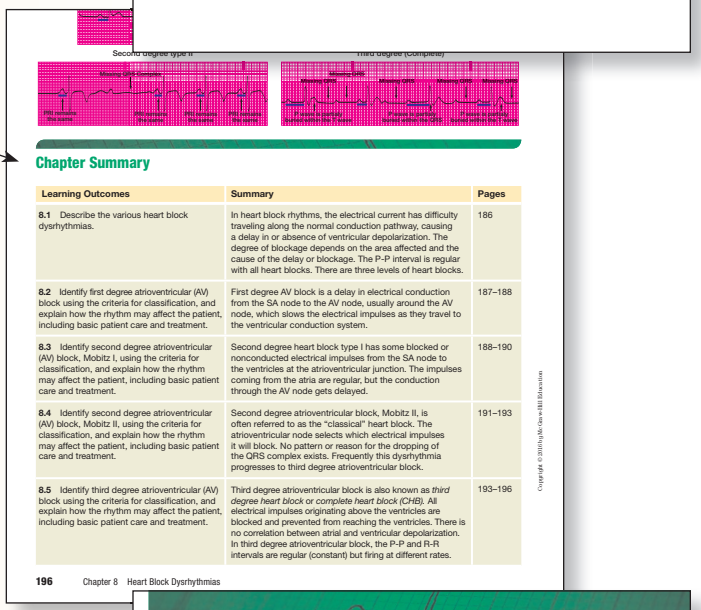
Interpret-TIP

Accelerated Idioventricular Rhythm

The accelerated idioventricular rhythm has an absence of P waves, a ventricular rate of 40 to 100 beats per minute, and wide and bizarre QRS complexes.

Figure 9-4 Accelerated idioventricular rhythm.

Key Points correlated to the learning outcomes in each Chapter Summary help you review what was just learned.

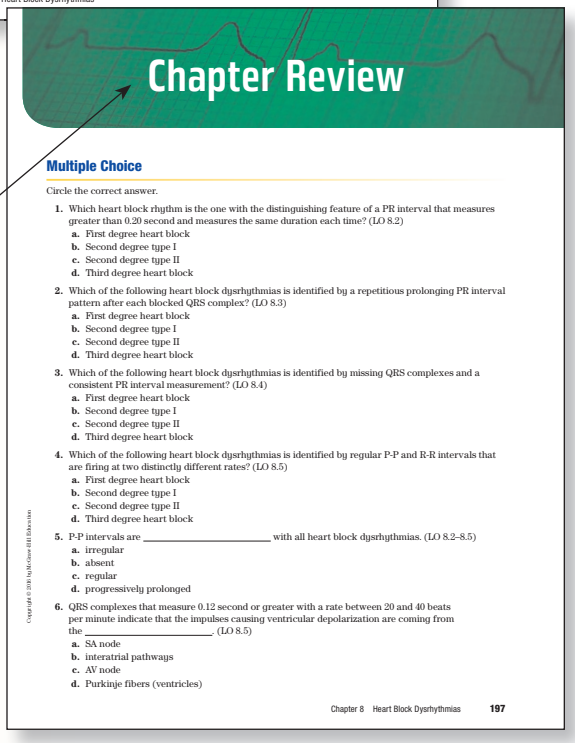


Chapter Summary

Learning Outcomes	Summary	Pages
8.1 Describe the various heart block dysrhythmias.	In heart block rhythms, the electrical current has difficulty traveling along the normal conduction pathway, causing a delay in or absence of ventricular depolarization. The degree of blockage depends on the area affected and the cause of the delay or blockage. The P-P interval is regular with all heart blocks. There are three levels of heart blocks.	186
8.2 Identify first degree atrioventricular (AV) block using the criteria for classification, and explain how the rhythm may affect the patient, including basic patient care and treatment.	First degree AV block is a delay in electrical conduction from the SA node to the AV node, usually around the AV node, which slows the electrical impulses as they travel to the ventricular conduction system.	187–188
8.3 Identify second degree atrioventricular (AV) block, Mobitz I, using the criteria for classification, and explain how the rhythm may affect the patient, including basic patient care and treatment.	Second degree heart block type I has some blocked or nonconducted electrical impulses from the SA node to the ventricles at the atrioventricular junction. The impulses coming from the atria are regular, but the conduction through the AV node gets delayed.	188–190
8.4 Identify second degree atrioventricular (AV) block, Mobitz II, using the criteria for classification, and explain how the rhythm may affect the patient, including basic patient care and treatment.	Second degree atrioventricular block, Mobitz II, is often referred to as the "classical" heart block. The atrioventricular node selects which electrical impulses it will block. No pattern or reason for the dropping of the QRS complex exists. Frequently this dysrhythmia progresses to third degree atrioventricular block.	191–193
8.5 Identify third degree atrioventricular (AV) block using the criteria for classification, and explain how the rhythm may affect the patient, including basic patient care and treatment.	Third degree atrioventricular block is also known as *third degree heart block* or *complete heart block (CHB).* All electrical impulses originating above the ventricles are blocked and prevented from reaching the ventricles. There is no correlation between atrial and ventricular depolarization. In third degree atrioventricular block, the P-P and R-R intervals are regular (constant) but firing at different rates.	193–196

Chapter Reviews consist of various methods of quizzing you. True/false, multiple choice, matching, and critical thinking questions, among others, appeal to all types of learners.

At the end of each chapter, you will be directed to visit the Internet to experience more interactive activities about the information you just learned.



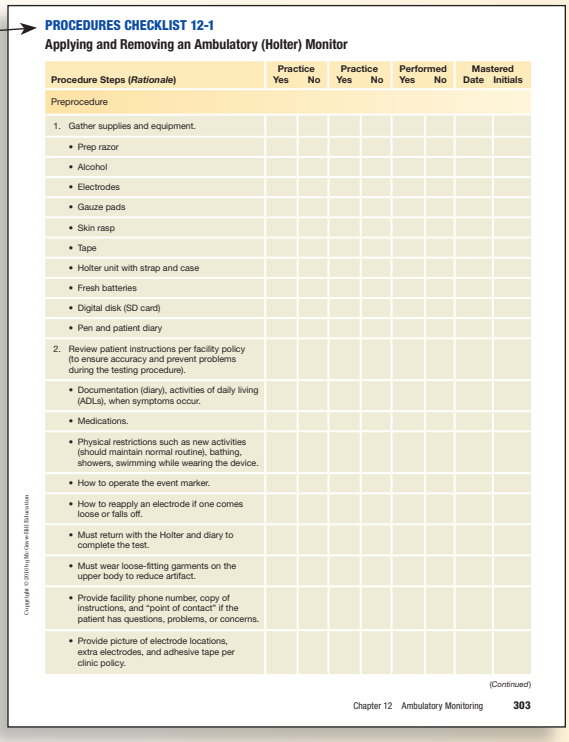
Chapter Review

Multiple Choice

Circle the correct answer.

1. Which heart block rhythm is the one with the distinguishing feature of a PR interval that measures greater than 0.20 second and measures the same duration each time? (LO 8.2)
   a. First degree heart block
   b. Second degree type I
   c. Second degree type II
   d. Third degree heart block
2. Which of the following heart block dysrhythmias is identified by a repetitious prolonging PR interval pattern after each blocked QRS complex? (LO 8.3)
   a. First degree heart block
   b. Second degree type I
   c. Second degree type II
   d. Third degree heart block
3. Which of the following heart block dysrhythmias is identified by missing QRS complexes and a consistent PR interval measurement? (LO 8.4)
   a. First degree heart block
   b. Second degree type I
   c. Second degree type II
   d. Third degree heart block
4. Which of the following heart block dysrhythmias is identified by regular P-P and R-R intervals that are firing at two distinctly different rates? (LO 8.5)
   a. First degree heart block
   b. Second degree type I
   c. Second degree type II
   d. Third degree heart block
5. P-P intervals are _____ with all heart block dysrhythmias. (LO 8.2–8.5)
   a. irregular
   b. absent
   c. regular
   d. progressively prolonged
6. QRS complexes that measure 0.12 second or greater with a rate between 20 and 40 beats per minute indicate that the impulses causing ventricular depolarization are coming from the _____. (LO 8.5)
   a. SA node
   b. interatrial pathways
   c. AV node
   d. Purkinje fibers (ventricles)

Procedure Checklists help you learn and apply the knowledge presented.



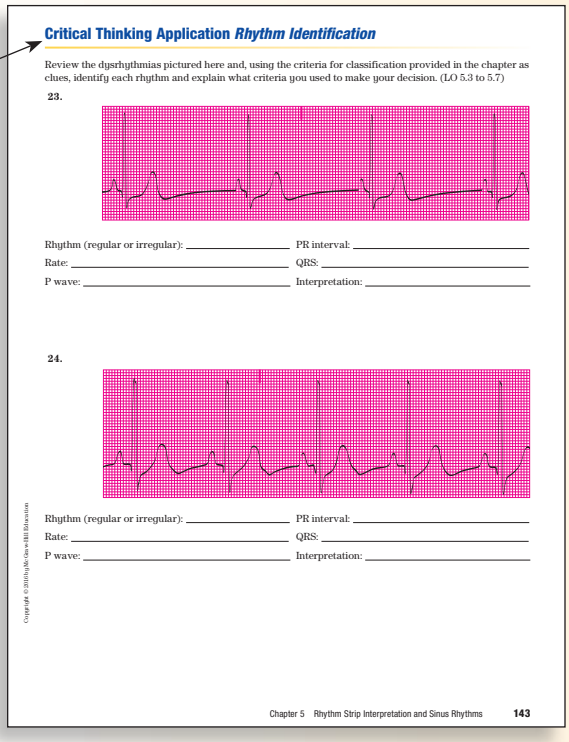
PROCEDURES CHECKLIST 12-1

Applying and Removing an Ambulatory (Holter) Monitor

Procedure Steps (*Rationale*)	Practice Yes	Practice No	Practice Yes	Practice No	Performed Yes	Performed No	Mastered Date	Mastered Initials
Preprocedure								
1. Gather supplies and equipment.								
• Prep razor								
• Alcohol								
• Electrodes								
• Gauze pads								
• Skin rasp								
• Tape								
• Holter unit with strap and case								
• Fresh batteries								
• Digital disk (SD card)								
• Pen and patient diary								
2. Review patient instructions per facility policy (to ensure accuracy and prevent problems during the testing procedure).								
• Documentation (diary), activities of daily living (ADLs), when symptoms occur.								
• Medications.								
• Physical restrictions such as new activities (should maintain normal routine), bathing, showers, swimming while wearing the device.								
• How to operate the event marker.								
• How to reapply an electrode if one comes loose or falls off.								
• Must return with the Holter and diary to complete the test.								
• Must wear loose-fitting garments on the upper body to reduce artifact.								
• Provide facility phone number, copy of instructions, and "point of contact" if the patient has questions, problems, or concerns.								
• Provide picture of electrode locations, extra electrodes, and adhesive tape per clinic policy.								

(Continued)

Review and Practice Rhythm Identification throughout textbook activities provide ample practice opportunities.



Critical Thinking Application *Rhythm Identification*

Review the dysrhythmias pictured here and, using the criteria for classification provided in the chapter as clues, identify each rhythm and explain what criteria you used to make your decision. (LO 5.3 to 5.7)

23.

Rhythm (regular or irregular): _____ PR interval: _____

Rate: _____ QRS: _____

P wave: _____ Interpretation: _____

24.

Rhythm (regular or irregular): _____ PR interval: _____

Rate: _____ QRS: _____

P wave: _____ Interpretation: _____

Acknowledgments

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Electrocardiography

1

Learning Outcomes

1.1 Describe the history and the importance of the ECG.

1.2 Identify the uses of an ECG and opportunities for an electrocardiographer.

1.3 Troubleshoot legal, ethical, patient education, and communication issues related to the ECG.

1.4 Perform safety and infection control measures required for the ECG.

1.5 Compare basic vital sign measurements related to the ECG.

Key Terms

auscultated blood pressure
automatic external defibrillator (AED)
body mechanics
cardiac output
cardiopulmonary resuscitation (CPR)
cardiovascular disease (CVD)
cardiovascular technologist
Code Blue
coronary artery disease (CAD)
defibrillator
diastolic blood pressure
dysrhythmia
ECG monitor technician
electrocardiogram (ECG)
electrocardiograph
electrocardiograph (ECG) technician
ethics
healthcare providers
hypertension
hypotension
isolation precautions
law
libel
medical professional liability
myocardial infarction (MI)
personal protective equipment (PPE)
slander
standard precautions
stat
systolic blood pressure
telemedicine
vital signs

cardiovascular disease (CVD) Disease related to the heart and blood vessels (veins and arteries).

coronary artery disease (CAD) Narrowing of the arteries around the heart, causing a reduction of blood flow.

myocardial infarction (MI; heart attack) Damage to the heart muscle caused by lack of oxygen due to a blockage of one or more of the coronary arteries.

electrocardiograph An instrument used to record the electrical activity of the heart.

electrocardiogram (ECG) A tracing of the heart's electrical activity recorded by an electrocardiograph.

1.1 The ECG and Its History

The number one cause of death in the United States every year since 1918 is **cardiovascular disease (CVD),** or a disease of the heart and blood vessels. Approximately 2,500 Americans die every day because of **coronary artery disease (CAD),** which is narrowing of the arteries of the heart, which causes a reduction of blood flow. Unbelievably, one out of every three American adults has some form of CAD. You may know someone who has hypertension (high blood pressure) or other heart conditions. Maybe someone you know has had a **myocardial infarction (MI)** or **heart attack.**

An instrument known as an **electrocardiograph** allows the heart's electrical activity to be recorded and studied. It is used to produce an electrical (electro) tracing (graph) of the heart (cardio). This tracing is known as an **electrocardiogram (ECG).**

Scientists have known since 1887 that electrical currents are produced during the beating of the human heart and can be recorded. An English physician, Dr. Augustus D. Waller (1856–1922), showed that electrical currents are produced during the beating of the human heart and can be recorded. Willem Einthoven (1860–1927) invented the first electrocardiograph, which resulted in a Nobel Prize in Physiology or Medicine in 1924. Advancements in this technology have brought about today's modern ECG machines (see Figure 1-1). Computer technology continues to improve the availability and speed of computer interpretation and quickly communicates this information to a healthcare professional. Digital communication allows healthcare professionals to monitor patients from remote locations miles away.

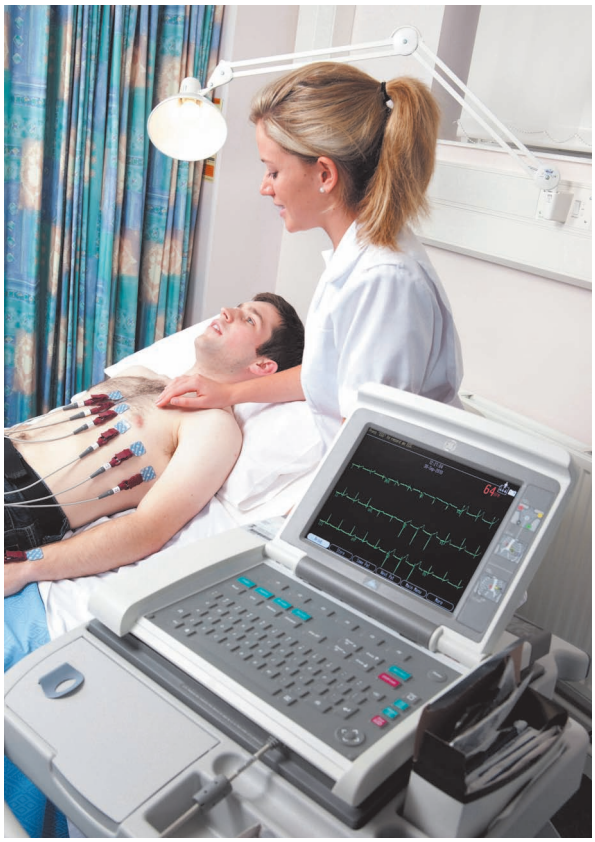

Figure 1-1 Today's 12-lead ECG machine is attached to the patient's chest, arms, and legs using electrodes and lead wires. It records a tracing of the electrical activity of the heart.

Performing the actual ECG procedure is not difficult; however, it must be performed competently. The tracing of the electrical current of the heart must be accurate because it is used to make decisions about a patient's care. An inaccurate tracing could result in a wrong decision about the patient's medication or treatment. These decisions could result in a negative outcome for the patient.

Checkpoint Questions (LO 1.1)

1. What is the leading cause of death in the United States?

2. Who is credited with determining that the human heart produces electrical currents that can be recorded?

1.2 Uses of an ECG

healthcare providers Physicians and other medically trained personnel who are licensed by individual states to provide healthcare to patients. The scope of practice for each type of healthcare provider is determined by the state license.

Healthcare providers study the ECG tracing to determine many things about the patient's heart. They look for changes from the normal ECG tracing or from a previous ECG tracing. The American Heart Association (AHA) recommends that individuals over the age of 40 have an ECG done annually as part of a complete physical. This baseline tracing assists the physician in diagnosing abnormalities of the heart. A sample of a normal tracing is shown in Figure 1-2. Normal and abnormal ECG tracings are discussed in the chapters *The Cardiovascular System* and *Rhythm Strip Interpretation and Sinus Rhythms*.

Electrocardiography can be performed in a number of healthcare settings. The type of ECG tracing produced depends on the setting and the type of ECG machine used.

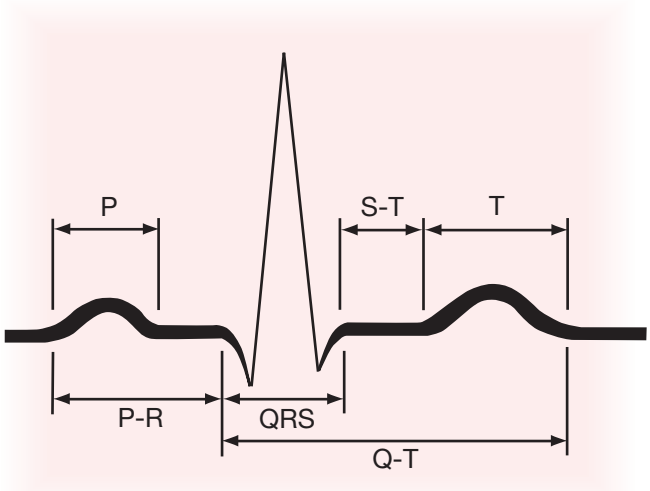

Figure 1-2 A normal ECG tracing is a horizontal line with upward and downward spikes or deflections that indicate electrical activity within the heart.

Code Blue A common name for an alert that notifies healthcare providers that a patient is unresponsive and needs assistance immediately.

stat Immediately.

In the Hospital (Acute Care)

A 12-lead ECG is one of the most commonly used ECGs in the hospital setting. A 12-lead ECG provides a tracing of the electrical activity in the patient's heart at the exact time the ECG tracing is done. In the hospital, a 12-lead ECG is done as a routine procedure or during an emergency frequently called a **Code Blue.** An emergency ECG may be required **stat,** or immediately. These are done when a patient experiences chest pain or has a change in cardiac rhythm. Routine ECGs are also frequently done before surgery.

Remain Calm

It is essential that you remain calm when recording a stat ECG. Remaining calm is necessary to avoid stress to the patient and to reduce confusion during the emergency.

What would be an appropriate way to tell a patient you are doing a stat ECG?

_____

_____

Another use of the ECG tracing in the hospital is during continuous monitoring. The purpose of continuous monitoring is to observe the pattern of the electrical activity of the patient's heart over time. During continuous monitoring, electrodes are attached to the patient's chest and the tracing is viewed on a monitor. Patients on continuous monitoring are usually in an intensive care unit (ICU), coronary care unit or cardiac care unit (CCU), surgical intensive care unit (SICU), or emergency department (ED). Continuous monitoring is also done routinely during surgery.

Another type of continuous monitoring done in a hospital is known as *telemetry monitoring.* Telemetry monitors are small boxes with electrodes and lead wires attached to the chest. The monitor is usually housed in a case and is attached to the patient so he or she can move about. The ECG tracing is transmitted to a central location for evaluation. When several patients are on a telemetry unit, the tracings of all the patients are recorded on multiple monitors at the nursing or patient care station.

Doctors' Offices and Ambulatory Care Clinics

A 12-lead ECG is a routine diagnostic test performed in almost any doctor's office or ambulatory care facility. It may be performed as part of a general or routine examination. This routine ECG provides a baseline tracing to be used for comparison if problems arise with a patient. The physician or trained expert looks for changes in a tracing that may indicate different types of health problems. Table 1-1 provides a complete list of conditions that may be diagnosed by an ECG. The procedure for performing a 12-lead ECG is discussed in the chapter *Performing an ECG.*

Two other ECG-type tests that may be performed in an office include treadmill stress testing and the ambulatory monitor, or Holter monitor,

TABLE 1-1 Conditions Evaluated by the ECG

- Disorders in heart rate or rhythm and the conduction system.
- Presence of electrolyte imbalance.
- Condition of the heart prior to defibrillation.
- Damage assessment during and after a myocardial infarction (heart attack).
- Symptoms related to cardiovascular disorders, including weakness, chest pain, or shortness of breath.
- Diagnosis of certain drug toxicities.
- Diagnosis of metabolic disorders such as hyper- or hypokalemia, hyper- or hypocalcemia, hyper- or hypothyroidism, acidosis, and alkalosis.
- Heart condition prior to surgery for individuals at risk for undiagnosed or asymptomatic heart disease.
- Damage assessment following blunt or penetrating chest trauma or changes after trauma or injury to the brain or spinal cord.
- Assessment of the effects of cardiotoxic or antiarrhythmic therapy.
- Suspicion of congenital heart disease.
- Evaluation of pacemaker function.

testing (Figure 1-3 and Figure 1-4). The treadmill stress test, also known as *exercise electrocardiography,* is done to determine whether the heart gets adequate blood flow during stress or exercise. The stress test is discussed in more detail in the chapter *Exercise Electrocardiography.*

A Holter monitor, or ambulatory monitor, is a small box that is strapped to a patient's waist, neck, or shoulder to monitor the heart for 24 to 48 hours or even up to 30 days as the patient performs normal daily activities. After the monitoring period, the ECG tracing is then analyzed and interpreted by the physician. The ambulatory monitor is discussed in detail in the chapter *Ambulatory Monitoring.*

Figure 1-3 This patient is performing a treadmill stress test, also known as exercise electrocardiography. During the exercise, the patient's heart and blood pressure are monitored carefully.

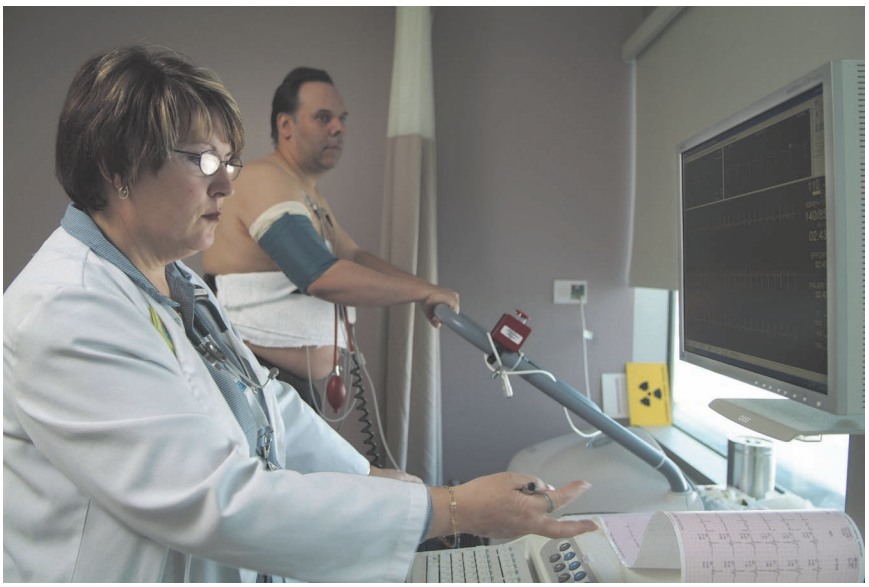

Figure 1-4 The Holter, or ambulatory, monitor allows the patient to participate in routine daily activities while the electrical activity of the heart is being recorded.

Outside of a Healthcare Facility

Outside of a healthcare facility, the ECG is used during cardiac emergencies such as a myocardial infarction. Emergency medical technicians and paramedics are equipped with portable ECG machines that can produce an ECG tracing at the site of the emergency. Whether the patient is at home, in a car, or in a crowded football stadium, emergency personnel can trace and monitor the electrical activity of the heart. Figure 1-5 shows one example of a portable ECG machine. In an emergency setting, the tracing can be evaluated for an abnormal ECG pattern. It is either transmitted back to the physician for evaluation or assessed by the emergency medical personnel at the scene. An abnormal pattern may require immediate treatment.

Defibrillators

defibrillator A machine that produces and sends an electrical shock to the heart in an attempt to correct the electrical pattern of the heart.

Treatment for abnormal rhythms includes use of a defibrillator and/or administration of cardiac medications. A **defibrillator** produces an electrical shock to the heart that is intended to correct the heart's electrical pattern. A defibrillator is commonly used in emergencies such as a Code Blue in the hospital or other care facilities or at the site of the emergency by appropriate personnel. If the heart is not beating effectively, the heart must be defibrillated quickly. The survival rate of the victim decreases by 7% to 10% for every minute a normal heartbeat is not restored.

Automatic External Defibrillators

automatic external defibrillator (AED) A lightweight, portable device that recognizes an abnormal rhythm and determines whether it is considered a "shockable rhythm."

dysrhythmia Abnormal heartbeat.

Automatic external defibrillators (AEDs) have enabled lay rescuers to help patients with sudden cardiac arrest and serious **dysrhythmias** (Figure 1-6). AEDs are available in public and private places where large numbers of people gather or live. They may also be kept by people who are at high risk for heart attacks. An AED is a lightweight, portable device that recognizes an abnormal rhythm and determines if the rhythm is considered a "shockable rhythm." The equipment is placed only on patients who are

Figure 1-5 A portable ECG monitor is transported to the scene during a cardiac emergency and is attached to the patient. The ECG tracing is recorded and viewed by the emergency personnel. In addition, the tracing can be transmitted to the hospital, where a physician can evaluate and determine the necessary drugs and treatment for the patient based upon the heart rhythm viewed and the report from the emergency personnel.

Figure 1-6 Automatic external defibrillators (AEDs) can deliver an electrical impulse that may correct an abnormal heart rhythm and increase the survival rate of myocardial infarction victims. AEDs can be found in public places and require minimal training to operate.

cardiopulmonary resuscitation (CPR) The provision of ventilations (breaths) and chest compressions (blood circulation) for a person who shows no signs of breathing or having a heartbeat.

unresponsive to stimulation (who cannot be aroused) and have no evidence of breathing or a pulse. AEDs shock only abnormal rhythms that do not produce a heartbeat. Learning about normal and abnormal rhythms is part of rhythm strip interpretation which is discussed in later chapters. When the machine recognizes other rhythms that cause the patient to be unresponsive, the AED recommends beginning **cardiopulmonary resuscitation (CPR).** Individuals using an AED should consider safety for themselves and the patient. A healthcare-provider-level CPR course is best for learning this technique. The patient should be checked for nitroglycerin patches, pacemakers, and

metal objects that could cause burns. In addition, do not use an AED when the patient is in water.

Once the equipment is placed on the patient's bare chest, it analyzes the rhythm to determine if it is likely to respond to an electric shock. Once the machine has positively identified the abnormal rhythm, it may indicate that a "SHOCK IS ADVISED." Everone near the patient must move back and not touch the patient. One person will then announce, "I'm clear, you're clear, we are all clear" and press the shock button. After the shock has been provided, the rescuers continue administering CPR until the patient wakes up, the machine indicates to defibrillate again, or specially trained healthcare professionals take over. AEDs make it possible for laypersons to perform defibrillation safely. The AED is being viewed as a necessary piece of equipment—similar to a fire extinguisher.

Telemedicine

telemedicine A monitoring system in which ECG tracings are communicated from a patient outside of a medical facility to the physician via a telephone or digital system.

Another use of the ECG tracing outside of a healthcare facility is **telemedicine.** In telemedicine, ECG tracings are communicated to the physician via the telephone or digital system. *Transtelephonic monitoring* means transmitted (trans) over the telephone (telephonic). The improvements in solid-state digital technology have expanded transtelephonic transmission of ECG data and enhanced the accuracy of software-based analysis systems. *Digital monitoring* allows ECG data to be recorded with a personal computer and then transmitted over the Internet to the healthcare facility. Transtelephonic monitoring requires a licensed practitioner to read and evaluate the tracing, whereas the digital monitoring provides a report that is validated by the licensed practitioner.

Both of these types of monitoring help physicians evaluate the ECG tracing of a patient over time. They are useful for patients with symptoms of heart disease that did not occur while they were in the healthcare facility. The recorded monitoring can be accomplished with magnetic tape (transtelephonic) or digital (computerized) recordings that can be used for up to 30 days. A transtelephonic monitor is connected to a digital phone, and the ECG is transmitted to a healthcare facility on specific days throughout the monitoring period (Figure 1-7). Individuals using a transtelephonic monitor must understand when and how to record and send a transmission.

There are two specific types of telemedicine monitors. One monitors the heart continuously, and the other records the ECG tracing when the patient is having symptoms. Continuous telemedicine monitoring is programmed to record the ECG tracing constantly. It is useful to record the ECG tracing before, during, and after a patient has symptoms. These symptoms may include chest pain, shortness of breath, dizziness, or palpitations. This type of monitor is a small device that attaches to the patient's chest with two electrodes. The smallest monitor available is about the size and shape of a jump drive or a thin credit card.

Symptom-based telemedicine monitoring is in the form of either a handheld or a wristwatch device. The handheld type has electrode feet that are pressed against the patient's chest after symptoms occur. Currently, one type is as small as a credit card and can be carried in a pocket or wallet. The wristwatch-type monitor is worn on the nondominant arm at all times. The patient must turn on this type of monitor when symptoms begin.

Telemedicine monitoring is generally used to evaluate artificial pacemaker functioning. In addition, monitors are sometimes given to patients

Figure 1-7 Transtelephonic monitoring uses a cellular phone device (circled) to transmit the patient's ECG tracing to a central location for monitoring.

after an emergency room visit. If the patient has symptoms of cardiac problems but is not admitted to the hospital, the physician often orders telemedicine monitoring so the patient can record an ECG when the symptoms recur. It is less expensive to give patients a monitor to take home than to admit them to the hospital.

Opportunities in Electrocardiography

Many healthcare professionals work with electrocardiography as a part of their profession. Some examples include medical assistants, nurses, emergency medical technicians, and paramedics. There are a few careers that work exclusively with the ECG. These include the ECG technician, the ECG monitoring technician, and the cardiovascular technologist

electrocardiograph (ECG) technician An individual who has the technical knowledge and skills to record an ECG and prepare it for the physician.

An **electrocardiograph (ECG) technician** is an individual who records the ECG and prepares the report for the physician. ECG technicians should be able to determine if a tracing is accurate and recognize abnormalities caused by interference during the recording procedure. Most ECG technicians are employed in hospitals, but they may also work in medical offices, cardiac centers, cardiac rehabilitation centers, and other healthcare facilities. In some large hospitals, ECG technicians work in the home healthcare branch. They take the ECG machine to the patient's home; record the ECG; and give, send, or telecommunicate the report to the physician for interpretation. With the development of multiple tests to evaluate the heart, the ECG technician who obtains continuing education can expect a rewarding career.

ECG monitor technician An individual who has the technical knowledge and skills to view and evaluate the electrical tracings of patients' hearts on a monitor and, when necessary, alert the appropriate healthcare professional to treat abnormalities.

ECG monitor technicians view and evaluate the electrical tracings of patients' hearts on a monitor (Figure 1-8). ECG monitor technicians are employed at hospitals or other inpatient facilities where patients are attached to continuous or telemetry monitors. The main responsibility of an ECG monitor technician is to view the ECG tracings and, if an abnormal heart