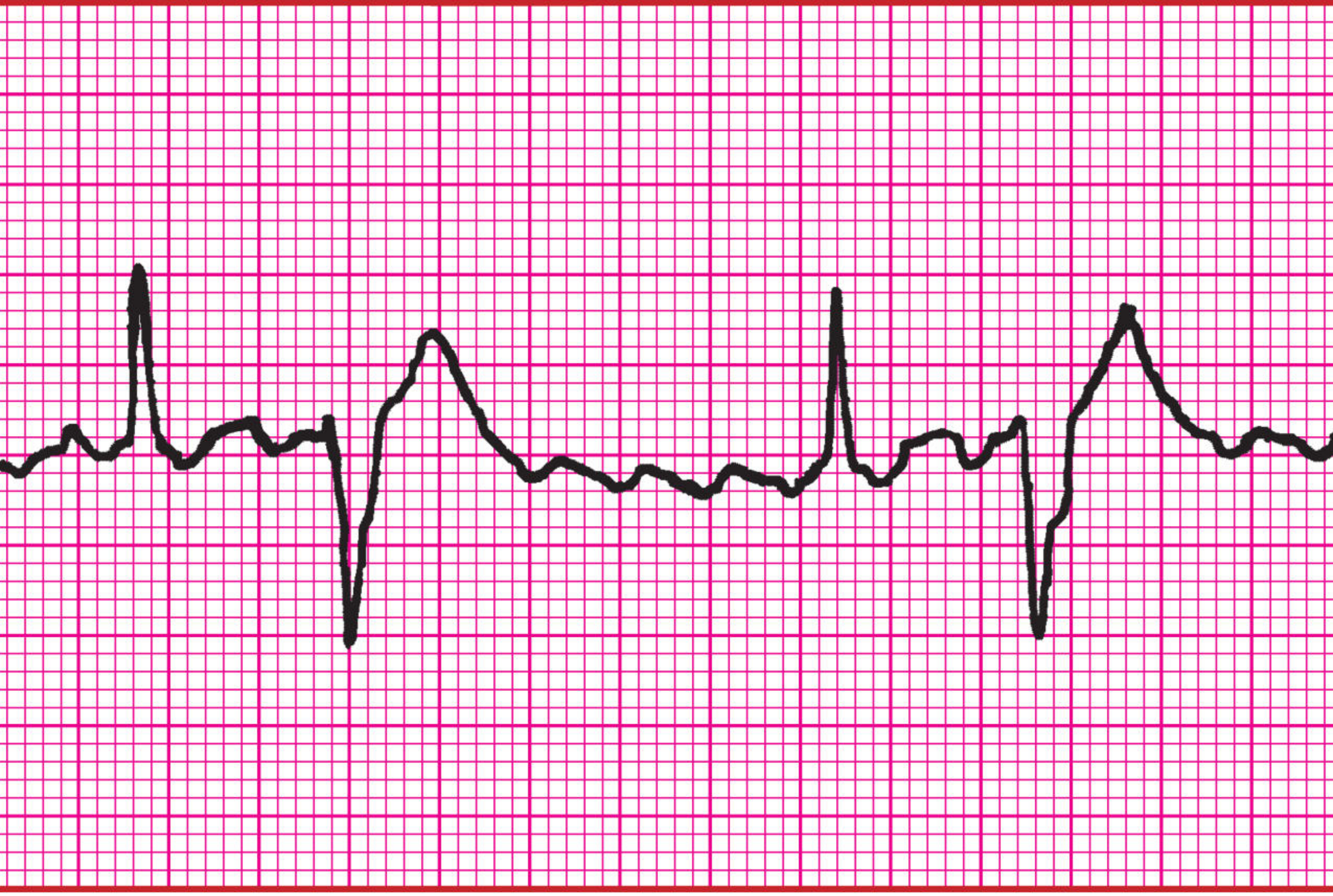
Basic Arrhythmias

NINTH EDITION

WITH 12-LEAD EKGS



Gail Walraven

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Library of Congress Cataloging-in-Publication Data
Names: Walraven, Gail, 1949- author.
Title: Basic arrhythmias: With 12-Lead EKGs / Gail Walraven.
Description: Ninth edition. | [Hoboken, NJ] : Pearson, [2024] | Revised edition of: Basic arrhythmias / Gail Walraven. Eighth edition. 2016.
Identifiers: LCCN 2023053103 | ISBN 9780138164959 (paperback) | ISBN 0138164959 (print) | ISBN 9780138164911 (ebook) | ISBN 9780138165079 (other ebook)
Subjects: LCSH: Arrhythmia--Diagnosis--Programmed instruction. | Electrocardiography--Programmed instruction.
Classification: LCC RC685.A65 W33 2024 | DDC 616.1/28--dc23/eng/20231214
LC record available at https://lccn.loc.gov/2023053103

$PrintCode

Pearson

ISBN-10: 0-13-816495-9
ISBN-13: 978-0-13-816495-9

Dedication

To the men in my life:
Bruce, Kellen, Dustin, and Case

Contents

Preface

There are many ways to learn electrocardiography and many levels of expertise within this complex field. For ease of reference, the various levels of knowledge/ability can be outlined as follows:

Type	Level	Knowledge/Ability
Single Lead (Arrhythmias)	**I**	Ability to recognize a limited number of familiar patterns, usually the major life-threatening rhythms. No understanding of rules or mechanisms.
	II	Basic understanding of the rules and mechanisms of common arrhythmias according to pacemaker sites. No familiarity with more sophisticated features that complicate basic arrhythmias.
	III	Ability to interpret arrhythmias that include more sophisticated features such as sinus arrest, pacemakers, aberrancy, and blocked beats.
12-Leads (Complexities)	**IV**	Familiarity with 12-lead EKGs (e.g., bundle branch block, infarction location, axis deviation).
	V	Ability to distinguish subtle EKG findings (e.g., concealed conduction, reciprocal conduction, trifascicular block, His bundle recordings).

It is best for a student to move through these levels in a relatively logical progression from simple to complex. Unfortunately, new students often lack a solid foundation upon which to build more sophisticated understanding. *Basic Arrhythmias* is designed to provide that sound conceptual base. Its primary area of concentration is Level II: basic understanding of common, uncomplicated rhythms. It is hoped that *Basic Arrhythmias* will provide an enjoyable and interesting way for people to develop the framework that will later support continued learning in the area of electrocardiography.

Basic Arrhythmias is designed to provide a solid foundation for ongoing EKG learning. For this reason, great care has been taken to instill simple, basic concepts while avoiding misconceptions or erroneous impressions. The driving goal has always been to build a very strong, but *basic*, understanding of arrhythmia interpretation. A fair amount of legitimate information was necessarily omitted from the text because it is considered beyond the scope of a basic foundation. However, over the years, readers lobbied strongly for some areas to be added. In those cases, the content was included as appendices, rather than as part of the basic, programmed section of the book. Examples include: Cardiac Anatomy and Physiology, Pathophysiology and Clinical Implications of Arrhythmias, 12-Lead Electrocardiography, Basic 12-Lead Interpretation, and Pacemakers. The Appendices are the only sections in the book not considered "basic" arrhythmia interpretation.

About the Ninth Edition

Basic Arrhythmias has been well received for many years and has been used successfully by hundreds of thousands of students as they begin to study electrocardiography. It is always a challenge to update and refresh it without detracting from what makes it such a success. With this edition, we've fixed a few bugs, switched out some troublesome EKG strips, added some new illustrations and upgraded some old ones, expanded some sections, and clarified a few ambiguous areas. Please note that a compiled list of learning objectives is presented later in this section. These objectives outline in depth what you can be expected to learn and do after completing each chapter.

In addition, we have expanded and improved the digital learning resources for the *Basic Arrhythmias* program. The new Pearson eTextbook integrates an updated version of our Rhythm Randomizer an innovative self-study exercise where you can use virtual calipers and test your strip-reading knowledge against a database of over 600 strips.

I am very excited about this ninth edition of *Basic Arrhythmias* and hope you find it as enjoyable as I do. With all its upgrades and its fresh new look, it promises to continue the long tradition of helping students embark on their studies of electrocardiography.

Acknowledgments

It is impossible to fully acknowledge all the people who have contributed over the years to making *Basic Arrhythmias* what it is today. There have been literally hundreds of people over the years from all across the country who have offered ideas and suggestions, contributed strips, provided clinical reviews, and debated interpretation with me. Without that clinical help, this book would not have achieved the reputation for excellence that it enjoys today.

Coupled with the clinical excellence, the team at Brady Publishing has set the standard for excellence in the publication of such works. Going all the way back to the original family members at Brady Publishing, countless publishing professionals have added their mark to this book. In recent years, Pearson has continually moved us to new heights with its print and media expertise. It is always a joy to work with such professionals. Thank you.

GAIL WALRAVEN
La Jolla, California

Instructor Reviewers

The reviewers of *Basic Arrhythmias* provided excellent suggestions for improving the text. Their reviews were an important aid in the revision and updating of material, and their assistance is greatly appreciated.

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Navigating Through the Text

The text is broken up into three sections: Section 1: Self-Instructional Unit, Section II: Practice Strips, and Section III: Appendices. The first eight chapters of this text, found in Section 1 are structured as a self-instructional unit in a "programmed learning" format. As such, it is an entirely self-contained learning package; the only additional materials you will need are a pencil and a set of EKG calipers, which are available at most medical supply houses and medical bookstores. Everything else is provided here in a format designed to make this learning an enjoyable and worthwhile process. The internal structure of the individual chapters is as follows:

SECTION I: Self-Instructional Unit

Chapters 1–8 each include the following sections:

- **Programmed Content** The narrative will teach you any rules and explanatory materials you'll need to know to interpret arrhythmias. Each content section (called a frame) is numbered. As you are asked to respond, write your answer in the blank space provided. The answers are given in the right-hand margin directly across from the question. If you have trouble with an answer, go back over the referenced frames to find the explanation.
- **Flash Cards** Some of the chapters will ask you to take time out from the program to memorize material such as specific rules for each arrhythmia. For your convenience, material that must be committed to memory has been printed on the flash cards that are provided with this book. This is an effective method of memorizing material in a short period of time.
- **Key Points** All major points contained in a chapter are presented in a bulleted list at the end of that chapter. This is provided for your review as you complete the chapter, and as a reference should you need to look up a point in the future.
- **Self-Test** Each chapter closes with a self-test of the important information contained in that chapter. The format of the self-tests is very similar to the format of the text, except that each question is keyed back to the frames in the chapter that provide the answer to that specific question. Since the self-test is intended to tell you whether or not you learned the material in the chapter, you will want to let a little time pass between completing the chapter and beginning the self-test. If you take the test immediately after finishing the chapter, you might simply be recognizing familiar terms, rather than truly understanding the information. So, once you finish the chapter, take a break from the subject for an hour or two. Then come back to take the test. If you do well on the test, go on to the next chapter. If your results indicate that you did not really learn the material, go back and remedy that before you move on. Otherwise, you won't have a solid foundation for learning future subjects well.
- **Practice Strips** Starting in Chapter 2, practice rhythm strips are provided at the end to illustrate key points in the chapter, and to allow the student to practice what was learned in that chapter.

SECTION II: Practice Strips

Chapters 9 and 10 both have collections of EKG strips to practice analyzing; however, each has its own purpose.

- **Ch 9: Practice Strips** This collection of strips is designed for practice only.
- **Ch 10: Self-Test** This collection is a fully weighted self-test in case you'd like to see how you're doing.

SECTION III: Appendices

Over the years, a number of topics have been requested by readers, some of which were beyond the scope of the original introductory course. Those topics have been added as appendices to differentiate them from the original scope of the book. The format in the appendices is not self-instructional; it is covered in a more traditional text style.

Learning Objectives

The objectives below outline in depth what you can be expected to learn and do after completing each chapter.

Section I: Self-Instructional Unit

Chapter 1 ELECTROPHYSIOLOGY

1 Describe the electrophysiologic basis of cardiac arrhythmias.
- 1.1 Give the uses and limitations of cardiac arrhythmia monitoring.
  - 1.1.1 Distinguish between the electrical and the mechanical functions of the heart.
  - 1.1.2 Relate cardiac arrhythmia monitoring to pulse/perfusion assessment.
- 1.2 Explain how cardiac impulses are formed.
  - 1.2.1 Briefly describe the sodium pump.
  - 1.2.2 Define polarization and describe the polarized state.
  - 1.2.3 Define depolarization and explain how it occurs.
  - 1.2.4 Define repolarization and explain how it occurs.
- 1.3 Describe the heart's electrical conduction system.
  - 1.3.1 Identify the five major areas of electrical conduction.
  - 1.3.2 Outline the physical layout of the conduction system.
  - 1.3.3 Describe the usual pattern of electrical flow through the conduction system.
  - 1.3.4 Give the inherent rates for the SA node, the AV junction, and the ventricles.
- 1.4 Explain the influence of the nervous system on rate of cardiac impulse formation.
  - 1.4.1 Differentiate between irritability and escape.
  - 1.4.2 Name the nervous system that exerts an influence over rate of cardiac impulse formation.
  - 1.4.3 Identify the two opposing branches of the above-named nervous system, and tell how each would influence the heart if stimulated.
  - 1.4.4 Describe the effect on the heart if one of the branches is blocked.

Chapter 2 WAVES AND MEASUREMENTS

2 Convey cardiac electrical stimuli to a visible graphic medium suitable for arrhythmia interpretation.
- 2.1 Demonstrate the monitoring equipment used to detect cardiac electrical activity.
  - 2.1.1 Prepare equipment/materials for monitoring.
  - 2.1.2 Demonstrate electrode placement for basic arrhythmia monitoring.
  - 2.1.3 Optimize contact between electrode and skin.
  - 2.1.4 Select a lead that gives good wave visibility for arrhythmia interpretation.
- 2.2 Cite specifications of the graph paper used to display cardiac electrical activity.
  - 2.2.1 Given the standardized speed at which EKG graph paper is run through the EKG machine, identify the time intervals associated with each of the following:
    - a. time notches in the margins
    - b. one small box
    - c. one large box
- 2.3 Relate the components of a single cardiac cycle to the electrophysiological events that created them.
  - 2.3.1 Differentiate between the following graphic deflections:
    - a. wave
    - b. segment
    - c. interval
    - d. complex
  - 2.3.2 Given a single cardiac cycle, locate each of the following components and describe the electrical events that created it:
    - a. P wave
    - b. PR segment
    - c. PR interval
    - d. Q wave
    - e. R wave
    - f. S wave
    - g. QRS complex
    - h. ST segment
    - i. T wave
  - 2.3.3 Give the normal time duration for each of the following:
    - a. PR interval
    - b. QRS complex
  - 2.3.4 Identify the two phases of the refractory period.
  - 2.3.5 Identify the vulnerable phase of the cardiac cycle.
  - 2.3.6 Recognize deflections on an EKG tracing that were created by something other than cardiac electrical activity.
- 2.4 Differentiate between a single cardiac cycle and an EKG rhythm strip.

Chapter 3 ANALYZING EKG RHYTHM STRIPS

3 Utilize an organized analysis format to gather necessary data from a rhythm strip to interpret the presenting arrhythmia.
- 3.1 Relate the use of a systematic analysis format to the eventual interpretation of an arrhythmia.
- 3.2 Outline the five components of an organized approach to rhythm strip analysis.
  - 3.2.1 Describe the pertinent aspects of a systematic analysis of *regularity*, including R–R intervals, P–P intervals, patterns, and ectopics.
  - 3.2.2 Describe the pertinent aspects of a systematic analysis of *rate*.
  - 3.2.3 Describe the pertinent aspects of a systematic analysis of *P waves*, including location, morphology, and patterns.
  - 3.2.4 Describe the pertinent aspects of a systematic analysis of *PR intervals*, including duration, changes, and patterns.
  - 3.2.5 Describe the pertinent aspects of a systematic analysis of *QRS complexes*, including duration, morphology, and patterns.

Chapter 4 SINUS RHYTHMS

4 Recognize arrhythmias that originate in the sinus node.
- 4.1 Describe the characteristics of a sinus pacemaker.
  - 4.1.1 Outline the physiologic mechanisms common to the sinus node.
  - 4.1.2 Describe the expected path of conduction for an impulse originating from a sinus pacemaker.
  - 4.1.3 Identify EKG features common to all arrhythmias in the sinus category.
- 4.2 Outline the identifying features specific to each of the arrhythmias originating in the sinus node.
  - 4.2.1 Describe *Normal Sinus Rhythm*, including etiology, conduction, and resulting EKG features (regularity, rate, P waves, PR intervals, and QRS complexes).
  - 4.2.2 Describe *Sinus Bradycardia*, including etiology, conduction, and resulting EKG features (regularity, rate, P waves, PR intervals, and QRS complexes).
  - 4.2.3 Describe *Sinus Tachycardia*, including etiology, conduction, and resulting EKG features (regularity, rate, P waves, PR intervals, and QRS complexes).
  - 4.2.4 Describe *Sinus Arrhythmia*, including etiology, conduction, and resulting EKG features (regularity, rate, P waves, PR intervals, and QRS complexes).

Chapter 5 ATRIAL RHYTHMS

5 Recognize arrhythmias that originate within the atria.
- 5.1 Describe the characteristics of an atrial pacemaker.
  - 5.1.1 Outline the physiologic mechanisms common to atrial pacemakers.
  - 5.1.2 Describe the expected path of conduction for an impulse originating from within the atria.
  - 5.1.3 Identify EKG features common to all arrhythmias in the atrial category.
- 5.2 Outline the identifying features specific to each of the arrhythmias originating within the atria.
  - 5.2.1 Describe *Wandering Pacemaker*, including etiology, conduction, and resulting EKG features (regularity, rate, P waves, PR intervals, and QRS complexes).
  - 5.2.2 Describe *Premature Atrial Complexes*, including etiology, conduction, and resulting EKG features (regularity, rate, P waves, PR intervals, and QRS complexes).
  - 5.2.3 Describe *Atrial Tachycardia*, including etiology, conduction, and resulting EKG features (regularity, rate, P waves, PR intervals, and QRS complexes).
  - 5.2.4 Describe *Atrial Flutter*, including etiology, conduction, and resulting EKG features (regularity, rate, P waves, PR intervals, and QRS complexes).
  - 5.2.5 Describe *Atrial Fibrillation*, including etiology, conduction, and resulting EKG features (regularity, rate, P waves, PR intervals, and QRS complexes).

Chapter 6 JUNCTIONAL RHYTHMS

6 Recognize arrhythmias that originate in the AV junction.
- 6.1 Describe the characteristics of a junctional pacemaker.
  - 6.1.1 Outline the physiologic mechanisms common to junctional pacemakers.
  - 6.1.2 Describe the expected path of conduction for an impulse originating in the AV junction.
  - 6.1.3 Identify EKG features common to all arrhythmias in the junctional category.
- 6.2 Outline the identifying features specific to each of the arrhythmias originating in the AV junction.
  - 6.2.1 Describe *Premature Junctional Complexes*, including etiology, conduction, and resulting EKG features (regularity, rate, P waves, PR intervals, and QRS complexes).
  - 6.2.2 Describe *Junctional Escape Rhythm*, including etiology, conduction, and resulting EKG features (regularity, rate, P waves, PR intervals, and QRS complexes).

6.2.3 Describe *Junctional Tachycardia*, including etiology, conduction, and resulting EKG features (regularity, rate, P waves, PR intervals, and QRS complexes).

6.2.4 Describe *Accelerated Junctional Rhythm*, including etiology, conduction, and resulting EKG features (regularity, rate, P waves, PR intervals, and QRS complexes).

6.2.5 Describe the term *Supraventricular Tachycardia*, and define circumstances in which it can be used appropriately.

Chapter 7 HEART BLOCKS

7 Recognize arrhythmias that are manifestations of conduction defects at the AV node.

7.1 Describe the characteristics of the category of arrhythmias known as AV heart blocks.

7.1.1 Outline the physiologic mechanisms involved in AV heart block.

7.1.2 Describe the conduction defects encountered in AV heart blocks.

7.1.3 Identify EKG features common to all arrhythmias in the heart block category.

7.2 Outline the identifying features specific to each of the arrhythmias included in the heart block category.

7.2.1 Describe *First-Degree Heart Block*, including etiology, conduction, and resulting EKG features (regularity, rate, P waves, PR intervals, and QRS complexes).

7.2.2 Describe *Type I Second-Degree Heart Block (Wenckebach)*, including etiology, conduction, and resulting EKG features (regularity, rate, P waves, PR intervals, and QRS complexes).

7.2.3 Describe *Type II Second-Degree Heart Block*, including etiology, conduction, and resulting EKG features (regularity, rate, P waves, PR intervals, and QRS complexes).

7.2.4 Describe *Third-Degree Heart Block*, including etiology, conduction, and resulting EKG features (regularity, rate, P waves, PR intervals, and QRS complexes).

Chapter 8 VENTRICULAR RHYTHMS

8 Recognize arrhythmias that originate in the ventricles.

8.1 Describe the characteristics of a ventricular pacemaker.

8.1.1 Outline the physiologic mechanisms common to ventricular pacemakers.

8.1.2 Describe the expected path of conduction for an impulse originating in the ventricles.

8.1.3 Identify EKG features common to all arrhythmias in the ventricular category.

8.2 Outline the identifying features specific to each of the arrhythmias originating in the ventricles.

8.2.1 Describe *Premature Ventricular Complexes*, including etiology, conduction, and resulting EKG features (regularity, rate, P waves, PR intervals, and QRS complexes).

8.2.2 Describe *Ventricular Tachycardia*, including etiology, conduction, and resulting EKG features (regularity, rate, P waves, PR intervals, and QRS complexes).

8.2.3 Describe *Ventricular Fibrillation*, including etiology, conduction, and resulting EKG features (regularity, rate, P waves, PR intervals, and QRS complexes).

8.2.4 Describe *Idioventricular Rhythm*, including etiology, conduction, and resulting EKG features (regularity, rate, P waves, PR intervals, and QRS complexes).

8.2.5 Describe *Asystole*, including etiology, conduction, and resulting EKG features (regularity, rate, P waves, PR intervals, and QRS complexes).

Section II: Practice Strips

Chapter 9 PRACTICE MAKES PERFECT

9 Identify basic cardiac arrhythmias as presented on 6-second rhythm strips.

9.1 Apply techniques learned in Chapters 1–8 to analyze each of the rhythm strips in Chapter 9.

9.1.1 Use a methodical process to approach data collection (regularity, rate, P waves, PR intervals, and QRS complexes).

9.1.2 Analyze collected data and apply it to rules of each arrhythmia to identify the presenting arrhythmia.

Chapter 10 FINAL CHALLENGE

10 Test yourself on your ability to identify basic cardiac arrhythmias as presented on 6-second rhythm strips.

10.1 Apply techniques learned in Chapters 1–8 to analyze each of the rhythm strips in Chapter 10.

10.1.1 Use a methodical process to approach data collection (regularity, rate, P waves, PR intervals, and QRS complexes).

10.1.2 Analyze collected data and apply it to rules of each arrhythmia to identify the presenting arrhythmia.

10.2 Demonstrate your competency by approaching all 100 strips in a self-test format, without referring to outside resources.

Section III: Appendices

Appendix A CARDIAC ANATOMY AND PHYSIOLOGY

A.1 Describe the heart's location and structure.

A.2 Identify the four internal chambers of the heart.

A.3 Describe the heart walls and the pericardial sac.
- A.3.1 Name the walls between the heart's chambers.
- A.3.2 Describe the three layers of the heart wall.
- A.3.3 Differentiate between left and right heart pumping functions.
- A.3.4 Describe the pumping activity in a single cardiac cycle.

A.4 Explain the heart's valves.
- A.4.1 Name the four valves.
- A.4.2 Explain the valves' role in the heart's pumping cycle.

A.5 Identify the four heart sounds.
- A.5.1 Explain the first and second heart sounds.
- A.5.2 Explain the third and fourth heart sounds.
- A.5.3 Explain gallop rhythms.
- A.5.4 Explain heart murmurs.

A.6 Explain systole and diastole.
- A.6.1 Describe atrial diastole and systole.
- A.6.2 Describe ventricular diastole and systole.

A.7 Explain coronary circulation.
- A.7.1 State the purpose of coronary circulation.
- A.7.2 Describe the functions of the coronary arteries, cardiac veins, and coronary sinus.

A.8 Identify the heart's surfaces.

Appendix B PATHOPHYSIOLOGY AND CLINICAL IMPLICATIONS OF ARRHYTHMIAS

B.1 Describe the clinical effects of arrhythmias.
- B.1.1 Define cardiac output.
- B.1.2 Give the formula for a calculated cardiac output.
- B.1.3 Name three categories of arrhythmia that can interfere with cardiac output.
- B.1.4 List eight symptoms of reduced cardiac output.

B.2 Explain the general principles of treating arrhythmias.
- B.2.1 Name additional measures that may be needed to support perfusion.
- B.2.2 Explain the role of the American Heart Association in developing and maintaining Advanced Cardiac Life Support recommendations for treating arrhythmias.

B.3 Explain the significance of each of the 22 basic arrhythmias in this book, and describe the clinical picture of each.

Appendix C 12-LEAD ELECTROCARDIOGRAPHY

C.1 Explain the advantage of a 12-lead EKG tracing.

C.2 State the fundamental rules of electrocardiography.

C.3 Explain leads and electrode placement.
- C.3.1 Differentiate between bipolar and unipolar leads.
- C.3.2 Define monitoring lead.
- C.3.3 Describe the placement of leads on the frontal and horizontal planes.

C.4 Explain the vectors and axis of electrical flow through the heart.
- C.4.1 Define mean QRS axis.
- C.4.2 Explain lead axes.
- C.4.3 Explain the EKG features of R waves, Q waves, S waves, QS waves, Intrinsicoid Deflections, J Points, and QT Intervals.
- C.4.4 Explain vector relationships.
- C.4.5 Describe axis deviation and give the significance of left and right axis deviation.
- C.4.6 Describe a method for quickly estimating QRS axis.

C.5 Describe the standardized format for a printed 12-lead EKG report.
- C.5.1 Explain the importance of learning to recognize normal in 12-lead EKGs.

C.6 State the limitations of 12-lead EKGs.

Appendix D BASIC 12-LEAD INTERPRETATION

D.1 Explain interpreting myocardial damage on the EKG.
- D.1.1 Define ischemia.
- D.1.2 Define myocardial infarction.
- D.1.3 Describe EKG changes associated with myocardial damage.
- D.1.4 Describe the evolution of ischemic changes (age of infarction).
- D.1.5 State which leads identify damage on specific surfaces of the heart.

D.2 Explain interpreting chamber enlargement on the EKG.
- D.2.1 State causes of chamber enlargement.
- D.2.2 Describe the appearance of chamber enlargement on the EKG.

D.3 Explain interpreting bundle branch block on the EKG.
- D.3.1 Define bundle branch block.
- D.3.2 Describe the appearance of bundle branch block on the EKG.
- D.3.3 Differentiate between right and left bundle branch block on the EKG.

D.4 Explain interpreting other abnormalities on the EKG.
- D.4.1 Describe the appearance of pericarditis on the EKG.
- D.4.2 Describe the appearance of digitalis toxicity on the EKG.
- D.4.3 Describe the appearance of hyperkalemia and hypokalemia on the EKG.
- D.4.4 Describe the appearance of hypercalcemia and hypocalcemia on the EKG.

D.5 Explain the format for analyzing a 12-lead EKG.
- D.5.1 Explain the importance of a methodical approach to analysis.
- D.5.2 Name the subjects that the summary analysis of an EKG should address.

Appendix E PACEMAKERS

E.1 Describe pacemakers.
- E.1.1 Explain the purpose of artificial pacemakers.
- E.1.2 Define capture.
- E.1.3 Name the three components of pacemakers.

E.2 Name the chambers of the heart that a pacemaker may pace.

E.3 Describe a “smart” pacemaker.

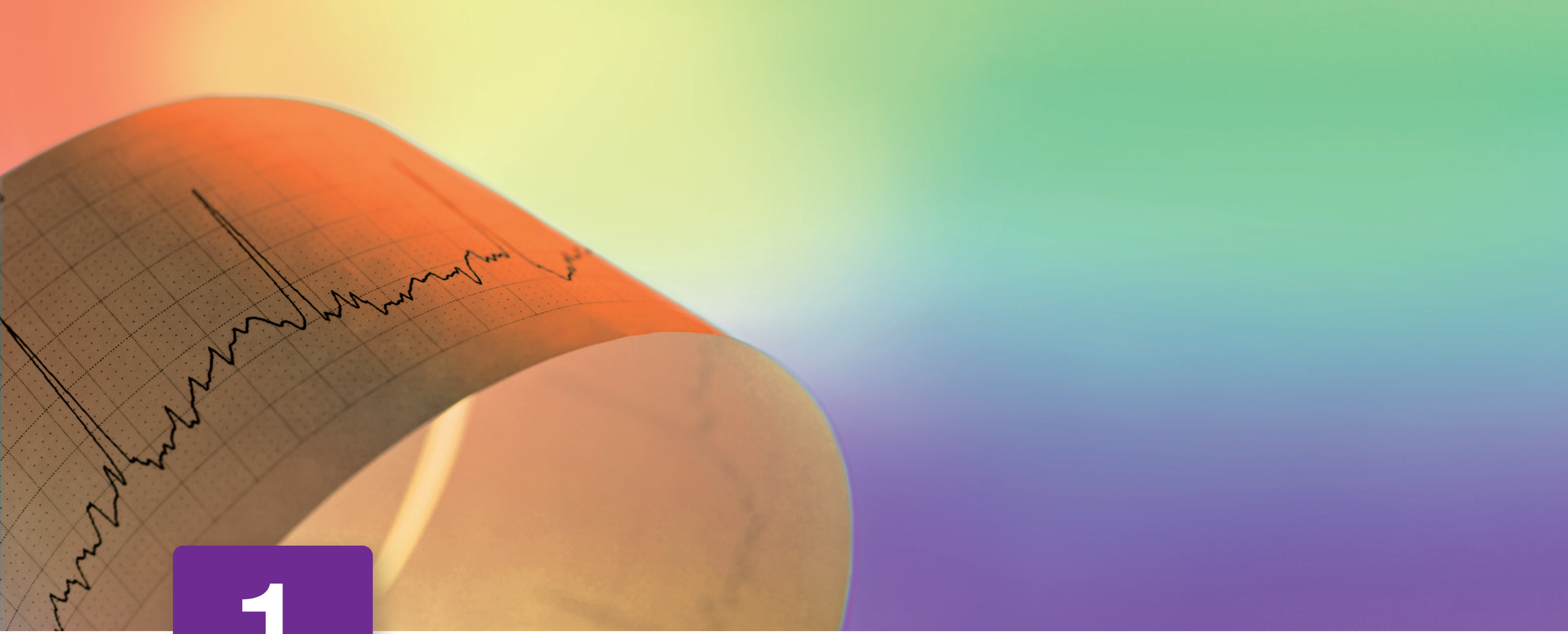
E.4 Explain the two basic ways in which pacemakers can initiate impulses.
- E.4.1 Define triggered pacemaker.
- E.4.2 Define inhibited pacemaker.

E.5 Explain the three-letter code system used to classify pacemakers.

E.6 Explain assessment of pacemaker function.
- E.6.1 Describe the appearance of pacemakers on the EKG.
- E.6.2 Describe the basic sequence of assessing pacemaker function.
- E.6.3 Name the information that can be revealed by the relationship between pacemaker spikes and the patient’s complexes.

E.7 Name and describe four common types of pacemaker malfunctions.

E.8 Explain how pacemaker malfunction is treated.



1

Electrophysiology

Overview

IN THIS CHAPTER, you'll learn how cardiac arrhythmias reflect what is actually happening electrically in the heart. You will explore the uses and limitations of cardiac arrhythmia monitoring. You will learn how cardiac impulses are formed and how the heart's electrical system conducts electrical impulses throughout the heart. You will also learn how the nervous system can influence the rate at which the heart forms electrical impulses.

Electrical vs. Mechanical Function

1. The human heart is intended to pump blood to the rest of the body. This process has two distinct components:

- The *electrical* impulse that tells the heart to beat
- The *mechanical* beating of the heart in response to the electrical stimulation, resulting in pumping of blood

To perform these two functions, the heart has two distinct types of cells. There are electrical (***conductive***) cells, which initiate electrical activity and conduct it through the heart, and there are mechanical (***contracting***) cells, which respond to the electrical stimulus and contract to pump blood. After the ____________________ cells initiate electrical the impulse and conduct it through the heart, the ____________ cells respond by contracting and pumping blood. mechanical

2. The heart will respond with contraction only if it is stimulated by electrical activity. Thus, you cannot have a mechanical response if there is no ____________ stimulus. electrical

3. After the electrical cells have discharged their stimuli, the mechanical cells are expected to respond by ____________. contracting

4. Without ____________ stimulus, the mechanical cells can't be expected to contract. electrical

5. Since it is not practical to see inside a living patient's heart, we must rely on external evidence to evaluate the status of both electrical and mechanical cardiac function. For a complete assessment of cardiac status, we must evaluate both ____________ and ____________ functions. electrical; mechanical

6. As part of our assessment of mechanical function, we use blood pressure, pulses, and other perfusion parameters to determine whether the heart is pumping adequately. We must also look for external evidence to evaluate the heart's electrical activity. The best way to do this is to monitor the *electrocardiogram* (EKG). An EKG tracing is used to evaluate the ____________ activity of the heart, while the mechanical activity is evaluated by assessing ____________ and ____________. electrical pulses blood pressure

7. You might occasionally encounter a situation in which the heart muscle is not able to contract in response to the electrical stimulus. In this case, you could have electrical activity but no ____________ response. If you had a functioning electrical system but a failing heart muscle, you could very likely see a viable tracing, but the patient might not have palpable ____________ or blood pressure. mechanical pulses

8. To evaluate a patient's cardiac function, you must assess the mechanical function by examining ____________ and ____________ and evaluate the electrical function by analyzing the ____________ tracing. pulses; blood pressure EKG

9. An EKG tracing is designed to give a graphic display of the electrical activity in the heart. The pattern displayed on the EKG is called the heart **rhythm**. Technically, the word **arrhythmia** refers to an abnormal heart rhythm, although the term is also used more generally to refer to all cardiac electrical patterns. The term **dysrhythmia** is synonymous with *arrhythmia*; both are used to refer to patterns of ____________ activity within the heart. All three terms are used loosely (and often interchangeably) to refer to the heart's ____________ activity. electrical electrical

10. An EKG can't tell you about the heart's mechanical activity—you have to assess the patient's pulse and blood pressure to determine that. But an EKG can tell you about the ____________ activity, which can be a vital part of your patient assessment. This data is provided in the form of recognizable patterns, called *arrhythmias.* Arrhythmias are graphic representations of the heart's ____________ activity. electrical electrical

11. To understand and interpret arrhythmias, it is necessary to understand the electrical activity that is occurring within the heart. This is because all arrhythmias are actually graphic displays of electrical activity. The term *electrocardiography* is given to the study of arrhythmias because arrhythmias are manifestations of ____________ activity within the heart. electrical

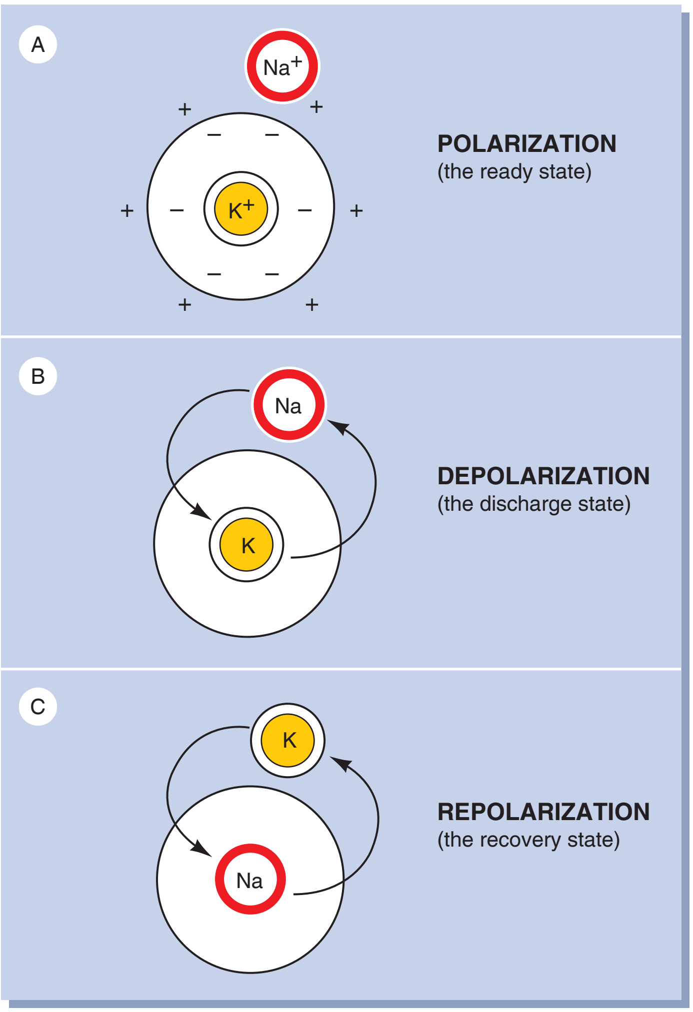
12. To help you understand and eventually be able to interpret individual arrhythmia patterns, you might want to know a little bit about the electrical processes that take place in the heart to produce the arrhythmia. To do this, we'll consider the electrical component independent of the mechanical component. For now, we are discussing only the __________ activity in the heart. electrical

Impulse Formation

13. The electrical (pacemaking) cells in the heart are distinctive in that they can create their own electrical impulses without an outside stimulus. On the cellular level, they create a change in electrical balance in the cell, causing an electrical current to form. This ability of cardiac cells to initiate electrical impulses on their own is called **automaticity**. Automaticity is the ability of cardiac cells to create their own impulses __________ an outside stimulus. It is not the whole heart that creates the charge, it's the individual pacemaking __________ within the heart's electrical system. without cells

14. The creation of an electrical impulse is a function of electrolytes within cardiac cells, or more accurately, the way those electrolytes move across cell walls. The primary electrolytes involved in creating the heart's electrical stimulus are sodium (Na^+) and potassium (K^+). Sodium and __________ are the primary electrolytes that allow the heart to initiate impulses. Both carry a positive electrical charge, but they are not present in equal quantities. The sodium "outweighs" the potassium, making the potassium *relatively* negative to the sodium. It is the *difference* in that potential that allows electrolytes to move through cell membranes. Movement of electrolytes through the cell __________ is what creates the electrical impulse. potassium membrane

Figure 1 The Sodium Pump: Chemical Basis for Impulse Formation



15. In a resting cell, the potassium is on the inside and the sodium is on the outside. The outside of the cell is positive, and the inside is *relatively* negative. The charges are balanced so no electricity flows (Figure 1A). As the sodium enters the cell, and the potassium leaves, an electrical charge is created (Figure 1B). The sodium then returns to the outside of the cell and the potassium goes back in (Figure 1C). This phenomenon is commonly referred to as the **sodium pump**. The cycle is repeated for every heartbeat. The term __________ refers to the movement of electrolytes in and out of the cell to create an electrical stimulus. When the positive and negative charges are __________, no electricity flows. When the positive and negative charges exchange places, an __________ impulse is formed.

sodium pump
balanced
electrical

16. For an electrical current to form, there must be a difference between the electrical charges. In the resting cell, the charges are balanced; hence no electricity flows. This is called the ***polarized*** state; the cell charges are __________ and ready for action. Polarization refers to a ready state where the electrical charges are __________ and no __________ current flows. When the cell is in its ready state, it is said to be __________. When the charges exchange places in the cell, the result is formation of an __________ current. Once the pacemaker cells provide the stimulation, the flow is passed from cell to cell along the conduction pathways until the cardiac __________ cells are stimulated to contract.

balanced
balanced
electrical
polarized
electrical
muscle

Polarization and Depolarization

17. The polarized state is considered a "ready for action" phase. When the two chemical charges (sodium and potassium) trade places, the electricity flows in a wave-like motion throughout the heart. This wave of electrical flow is called **depolarization** and is how the electrical stimulus travels through the heart (Figure 1B). Polarization refers to the "ready" state, while __________ refers to the process of electrical discharge and flow of electrical activity. Depolarization does not mean that the heart muscle contracted. Depolarization is an __________ function. Contraction is __________, and is expected to follow depolarization.

depolarization
electrical
mechanical

18. After the cell depolarizes, the positive and negative electrical charges will again return to their original positions around the cell, and the cell will prepare itself for another discharge (Figure 1C). The process that follows depolarization, when the cell charges are returning to their original state, is called **repolarization**. Repolarization refers to the return of the electrical charges to their __________ position. Repolarization occurs __________ depolarization.

original
after

19. If each of the positive charges on the outside of the cell is balanced by a negative charge on the inside of the cell, the electrical charges will be balanced, and there will be no movement of electricity. This state is called __________ and can be considered a "ready" state.

polarization

20. The wave of electrical activity that takes place when the electrical charges surrounding the cell trade places is called __________, and the return of the electrical charges to their original state is called __________.

depolarization
repolarization

21. If polarization is considered the *ready* state, and __________ is considered the *discharge* state, then __________ would be considered the *recovery* state.

depolarization
repolarization

22. Now let's relate this cellular activity to what is actually happening in the heart. All of the sequences described in the preceding frames are happening to single cells within the heart, but they do it in a __________ -like movement, resulting in the entire heart responding electrically to the same stimuli.

wave

Conduction System

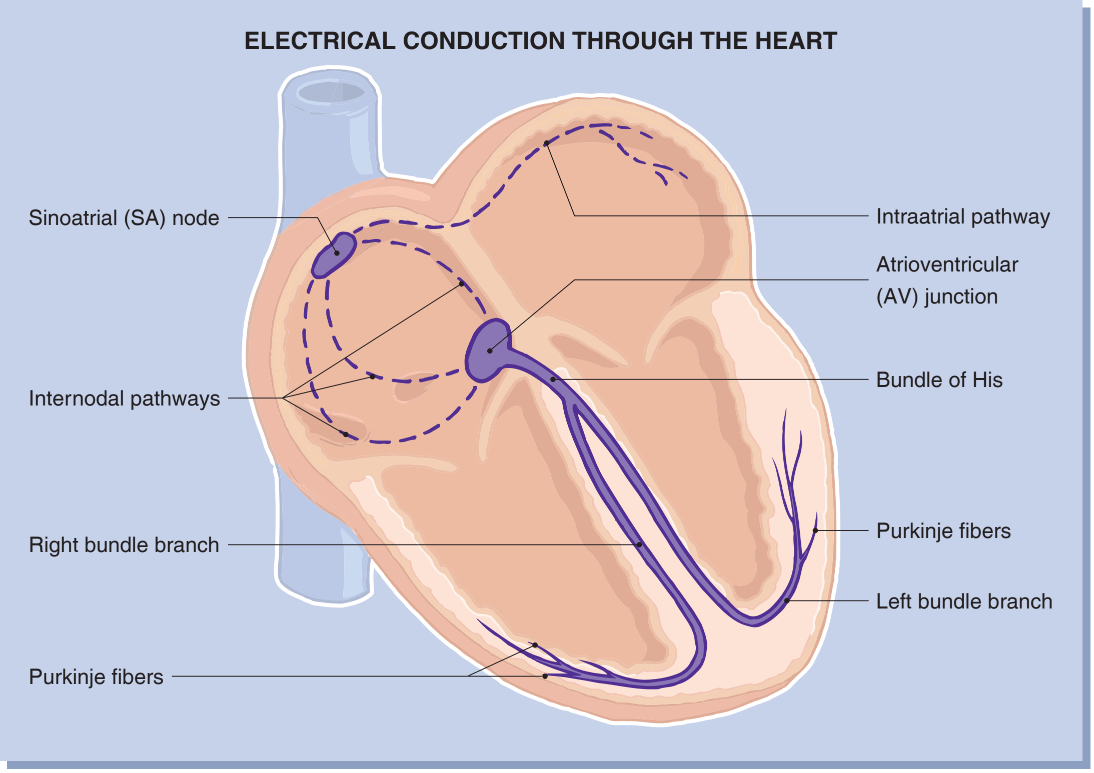
23. The electrical cells in the heart are all arranged in a system of pathways called the **conduction system**. The physical layout of the conduction system is shown in Figure 2. This information is an essential part of arrhythmia interpretation and should therefore be memorized now. Normally, the electrical impulse originates in the SA node and travels to the ventricles by way of the AV node. Look at Figure 2 and trace a normal electrical impulse. Where would the impulse go after it left the AV node and the Bundle of His? ______________________________

down the left and right bundle branches and then to the Purkinje fibers

24. In the normal heart, the first impulse that starts the flow of electrical current through the heart comes from the SA node. The impulse travels through the atria by way of the intraatrial pathways and to the AV node by way of the internodal pathways. If you look microscopically at the cells along these pathways, you would not see any physical difference between them and the cells in other areas of the atria, so researchers have questioned whether they actually exist. However, current electrophysiologic studies support the concept that these pathways do exist, if only as a preferred route by which impulses travel to the AV node. As it leaves the SA node, where does the current go? ______________________________

down the internodal and intraatrial pathways

Figure 2 Conduction System



25. The next area of conductive tissue along the conduction pathway is at the site of the AV node. The AV node is unique in that it does have conductive tissue, but it does not have any pacemaker cells like other areas of the conduction system. The pacemaking cells are actually located at the junction between the AV node and the atria, in an area called the **AV junction**. Thus, the term *AV node* can be used when talking about conduction, but the term *AV junction* is more accurate if you are referring to formation of impulses. Let this confuse you. It is simply an explanation of what might otherwise appear to be indiscriminate use of the two phrases. We will use the term *AV node* if talking only about ____________, but if we're specifically discussing pacemaking capabilities, we will call it the AV ____________.

conduction

junction

26. After leaving the area of the AV node, the impulses go through the ____________ to reach the right and left bundle branches. These branches are located within the right and left ventricles, respectively.

Bundle of His

27. At the terminal ends of the bundle branches, smaller fibers distribute the electrical impulses to the muscle cells to stimulate contraction. These terminal fibers are called ____________ fibers.

Purkinje

28. Are the muscle cells themselves part of the electrical conduction system?

____

____

No, they are made up of mechanical cells, not electrical cells.

29. Rearrange the following parts of the conduction system to place them in the actual order of conduction:

(1) ____________	(a) Bundle of His	1. b
(2) ____________	(b) SA node	2. f
(3) ____________	(c) Purkinje fibers	3. e
(4) ____________	(d) left and right bundle branches	4. a
(5) ____________	(e) AV node	5. d
(6) ____________	(f) intraatrial pathways	6. c

Inherent Rates

30. Each of the three major areas of the conduction system has its own preferred rate, called an **inherent rate**, at which it initiates impulses. An inherent rate means simply that each site has a rate range at which it usually produces impulses. A site can exceed or fall below its inherent rate, indicating that these rates are not concrete rules. But generally speaking, the sites will produce impulses at a rate within their own ____________ rate ranges.

inherent

31. The inherent rate ranges of the major sites are as follows:

SA node	60–100 beats per minute
AV junction	40–60 beats per minute
Ventricles	20–40 beats per minute

This information would give you a clue that if an rate was between 20 and 40 beats per minute (bpm), the electrical impulse that stimulated the rhythm probably originated in the ______________. If the rate was between 40 and 60 bpm, the impulse probably came from the ______________, and it most likely came from the ______________ if the rate was between 60 and 100 bpm.

ventricle
AV junction
SA node

32. These rates are often helpful clues to be used in interpreting arrhythmias, but they can be misleading unless they are understood to be mere guidelines and not concrete ______________.

rules

33. Generally speaking, the fastest inherent rate will become the pacemaker of the heart and override all other stimuli. The inherent rate of the SA node is the fastest and therefore keeps the heart at a rate between ______________ and ______________ bpm. Thus, the normal is "sinus" in origin. The SA node is the normal pacemaker for the heart because the rate of the SA node is ______________ than the other conduction sites.

60
100
faster

Irritability and Escape

34. If, however, a site becomes irritable and begins to discharge impulses at a faster-than-normal rate, it can override the SA node and take over the pacemaking function for the heart. If the SA node is discharging at a rate of 72 and the AV junction begins to fire at a rate of 95, the ______________ will become the pacemaker.

AV junction

35. This mechanism of an irritable site speeding up and taking over as pacemaker is called **irritability**. It is usually an undesirable occurrence, since it overrides the normal pacemaker and causes the heart to beat faster than it otherwise would. Irritability occurs when a site below the SA node ______________ and takes over the pacemaking role.

speeds up

36. Something very different happens if the normal pacemaker slows down for some reason. If the SA node drops below its inherent rate, or if it fails entirely, the site with the next highest inherent rate will usually take over the pacemaking role. The next highest site is within the ______________, so that site would become the pacemaker if the SA node should fail. This mechanism is called **escape** and is a safety feature that is built into the heart to protect it in case the normal ______________ fails.

AV junction
pacemaker

37. Escape mechanism, unlike irritability, is a safety feature to protect the heart. Would you expect an irritable rhythm to be faster or slower than an escape rhythm? ______________

faster

38. The inherent rate of different areas of the conduction system refers to the rate at which that site ______________.

initiates impulses

39. The SA node has an inherent rate of ______________ to ______________ bpm. This means that the normal rate of the heart will usually be within that range.

60
100

40. If the rate of an EKG is between 40 and 60, the impulse for that rhythm is probably coming from the ______________.

AV junction

41. What is the inherent rate of the ventricular conductive tissues? ______________

20–40 bpm

42. Because these rates cannot be relied upon as firm rules, they should be viewed only as ________________. If they are used as clues, the rates will be helpful in interpreting arrhythmias, but if they are considered inflexible, they will simply confuse the learner.

guidelines

43. A rule regarding the pacemaker function of the heart states that the site that initiates impulses at the ________________ rate will usually become the pacemaker.

fastest

44. In the normal heart, the ________________ initiates impulses at the fastest rate and therefore becomes the ________________.

SA node
pacemaker

45. If the AV junction or the ventricle became irritable, either could become the pacemaker if it were able to accelerate until it ________________________________

____

____

became faster than the SA node

46. The process described in the preceding frame is called ________________.

irritability

47. If the SA node failed as pacemaker, or if its rate dropped below its normal range, the ________________ would probably take over as pacemaker.

AV junction

48. The safety mechanism described in the preceding frame is called ________________.

escape

Nervous System Influence

49. In addition to the inherent rates, the heart can be influenced by the autonomic nervous system. The two branches of this nervous system oppose each other and thus keep the heart in a relative state of balance. The *sympathetic branch* influences both the atria (i.e., the SA node, the intraatrial and internodal pathways, and the AV junction) and the ventricles. If the sympathetic branch is stimulated, it will cause both the atria and ventricles to react in these ways:

- Increased rate
- Increased conduction through the AV node
- Increased irritability

The *parasympathetic branch* has the opposite effects, but it influences only the atria; it has little or no effect on the ventricles. While stimulation of the parasympathetic branch causes the atria to slow down, as well as decreasing irritability and slowing conduction through the AV node, stimulation of the sympathetic branch would cause what three effects on the atria and ventricles? ________________________________

____

____

increased heart rate;
increased AV conduction;
increased irritability

These nervous influences are outlined in Figure 3.

50. If the vagus nerve (which is part of the parasympathetic branch) is stimulated, you would expect the heart rate to ________________. On the other hand, if both the sympathetic and the parasympathetic branches are balanced, the heart rate would remain normal. What would you expect if you blocked the normal influence of the vagus nerve? ________________________________

____

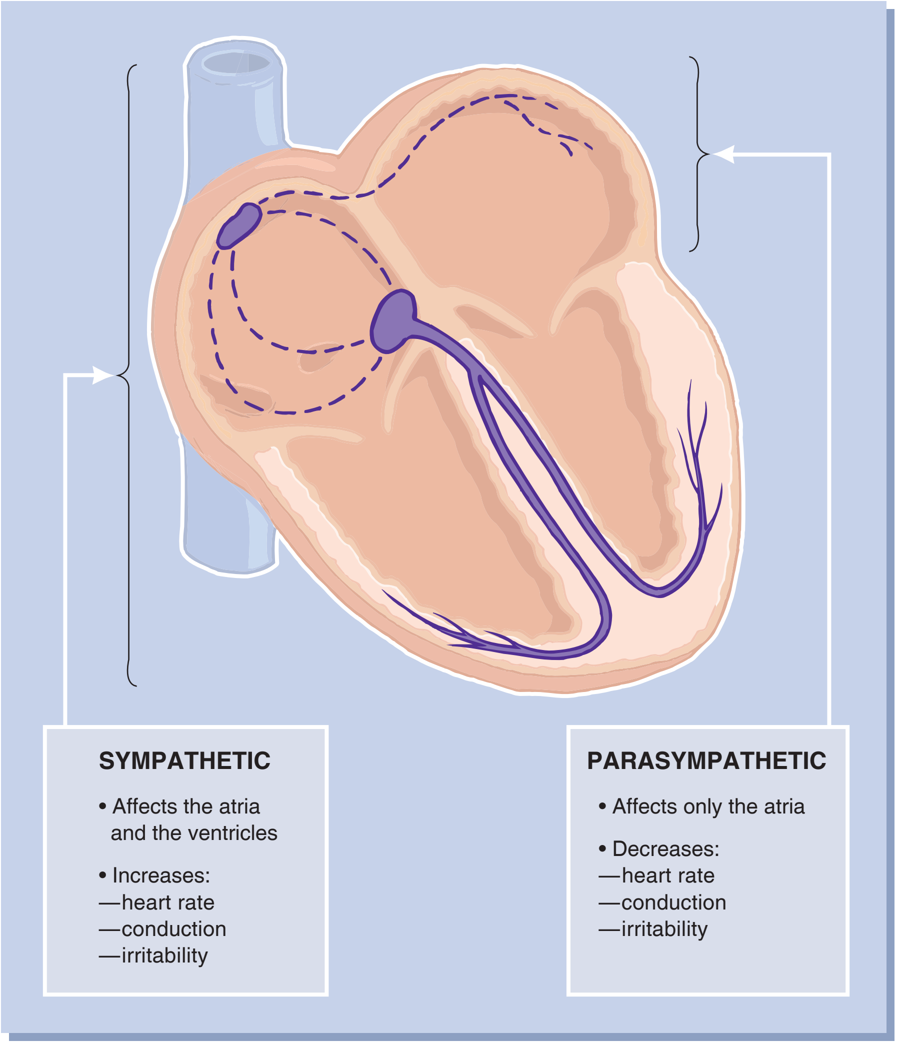
____

____

heart rate would decrease

You would get a response similar to stimulation of the sympathetic branch: heart rate would increase as well as irritability and AV conduction.

Figure 3 Innervation of the Heart by the Autonomic Nervous System



51. If a patient had a heart rate that was too slow, you might try to speed it up by giving a drug that would either stimulate the sympathetic branch or ______________________________________. block the parasympathetic branch

52. The two branches of the autonomic nervous system that influence heart rate are the ____________ branch and the ____________ branch. sympathetic parasympathetic

53. Which of these branches, when stimulated, will produce an increase in heart rate, AV conduction, and irritability? ____________ sympathetic

54. One of the branches has control over the atria and the ventricles, while the other influences only the atria. Which one affects both the atria and the ventricles? ____________ sympathetic

55. If both branches are exerting equal influence over the heart, what will happen to the rates? ____________ They will stay within the ranges of the normal inherent rates.

56. What will happen if one of the branches of the autonomic nervous system is blocked? ____________ The heart will respond to the influence of the opposing branch.

57. Using the reasoning described in the preceding frame, explain what would happen to the heart rate if the parasympathetic branch were blocked. ____________ It would increase.

58. The vagus nerve is part of the ____________ branch of the autonomic nervous system. Therefore, stimulation of the vagus nerve would cause the heart rate to ____________, and blocking of the vagus nerve would cause the heart rate to ____________. parasympathetic decrease increase

59. All of this discussion is about ____________ activity and does not yet connect with mechanical activity. In order to discuss the heart contracting and producing a pulse, we must connect the electrical activity with ____________ activity. electrical mechanical

60. If the muscle cells receive an electrical stimulus, they will respond to it by contracting. Sometimes, however, the muscle itself contract because it is injured or chemically imbalanced. In these cases, the electrical component is all right, but the ____________ component needs attention. In such a patient you would expect to find the essentially normal, but the ____________ would be absent or diminished. mechanical pulse

61. The opposite situation is more common and is the reason you are reading this book. This is when the heart muscle is able to respond but the electrical activity is erratic. Sometimes the electrical stimuli will make the ventricles contract before the atria do, or maybe there will just be too many electrical stimuli, so that the heart is not able to respond effectively to any of them. And sometimes the electrical impulse will discharge before the ventricles have time to fill with blood, thereby causing the ventricles to contract early, and eject insufficient blood for an adequate pulse. In all of these conditions, the erratic electrical activity will be seen on the as an ____________. arrhythmia

KEY POINTS

- The heart has two types of cells:
  - Electrical cells, which initiate and conduct impulses
  - Mechanical cells, which contract in response to stimulation
- Arrhythmias are graphic representations of electrical activity.
- Electrical activity precedes mechanical activity.
- Electrical activity can occur without mechanical response (pulse).
- If the electrical impulse stimulates the mechanical cells to contract, the heart is expected to contract and pump blood, thus producing a pulse.
- Polarization is when the electrical charges are balanced and ready for discharge.
- Depolarization is the discharge of energy that accompanies the transfer of electrical charges across the cell membrane.
- Repolarization is the return of electrical charges to their original state of readiness.
- Depolarization differs from contraction in that depolarization is an electrical phenomenon, whereas contraction is mechanical and is expected to follow depolarization.
- As shown in Figure 2, electrical flow in the normal heart originates in the SA node, then travels via the intraatrial and internodal pathways to the AV node, then through the Bundle of His to the left and right bundle branches, and finally to the Purkinje fibers, where the mechanical cells are stimulated.
- The inherent rates of the conduction system are as follows:

SA Node	60–100 bpm
AV Junction	40–60 bpm
Ventricles	20–40 bpm

- The site with the fastest rate will be the pacemaker.
- The SA node is the normal pacemaker of the heart.
- Irritability is when a site speeds up and takes over as pacemaker.
- Escape is when the normal pacemaker slows down or fails and a lower site assumes pacemaking responsibility.
- The influence of the autonomic nervous system can also affect the heart:
  - *Sympathetic* stimulation causes:

    Increased heart rate
    Increased AV conduction
    Increased irritability
  - *Parasympathetic* stimulation causes:

    Decreased heart rate
    Decreased AV conduction
    Decreased irritability
- The sympathetic branch influences both the atria (i.e., the SA node, the intraatrial and internodal pathways, and the AV junction) and the ventricles; the parasympathetic branch influences only the atria.
- If one branch of the autonomic nervous system is blocked, the effects of the opposing branch will prevail.

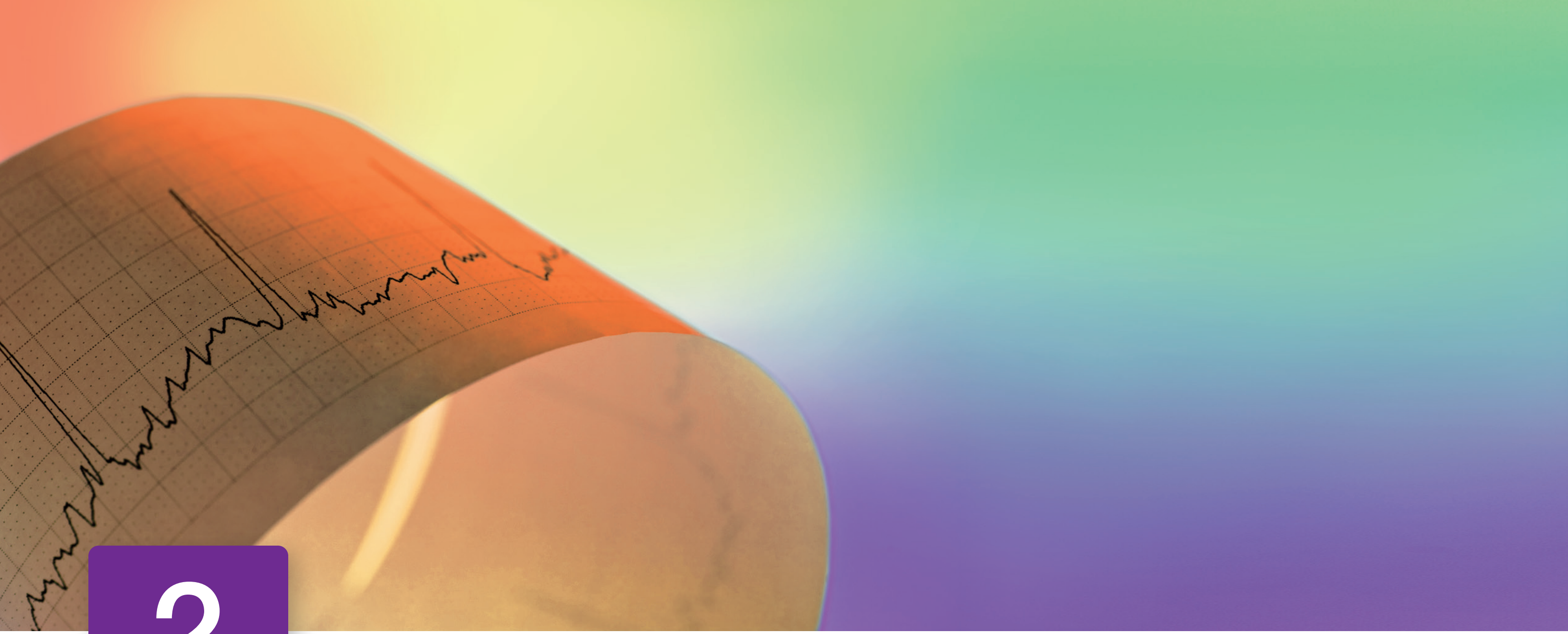
SELF-TEST

Directions: Complete this self-evaluation of the information you have learned from this chapter. If your answers are all correct and you feel comfortable with your understanding of the material, proceed to the next chapter. However, if you miss any of the questions, you should review the referenced frames before proceeding. If you feel unsure of any of the underlying principles, invest the time now to go back over the entire chapter. **Do not proceed with the next chapter until you are very comfortable with the material in this chapter.**

Questions	Referenced Frames	Answers
1. Name the two types of cardiac cells and tell what type of activity each is responsible for.	1, 2, 3, 4	electrical: conduction; mechanical: contraction
2. How do these two types of cells work together to produce cardiac activity?	1, 2, 3, 4	Electrical cells stimulate muscle cells to contract.
3. What physical signs are used to reflect the mechanical function of the heart?	5, 6, 7, 8	pulses, blood pressure, and other perfusion parameters

Questions	Referenced Frames	Answers
4. How do you assess electrical activity in the heart?	5, 6, 7, 8, 10	Analyze the EKG.
5. Arrhythmias are manifestations of which type of cardiac activity?	9, 10, 11, 12	electrical
6. What happens when the positive and negative electrical charges exchange places across the cell membrane of a cardiac cell?	13, 14, 15, 16, 17	It initiates the flow of electrical current.
7. Explain the polarized state.	14, 15, 16, 17, 19, 21	when electrical charges are balanced and in a state of readiness for discharge
8. Explain depolarization.	16, 17, 20, 22	the discharge of electrical energy that accompanies the transfer of electrical charges across the cell membrane
9. Is depolarization the same as contraction?	17	No, depolarization is an electrical phenomenon. Contraction is mechanical and is expected to follow depolarization.
10. What is repolarization?	18, 20, 21	the return of the electrical charges to their original state of readiness
11. List the areas of the conduction system in the order in which the impulses travel through the heart.	23, 24, 25, 26, 27, 29	1. SA Node 2. Intraatrial and Internodal Pathways 3. AV Node 4. Bundle of His 5. Bundle Branches 6. Purkinje Fibers
12. Which site is normally the pacemaker of the heart, and why?	24, 33, 34, 43, 44	The SA node, because it has the fastest inherent rate.
13. Give the inherent rates for each of the following sites: Sinus Node ____________ AV Junction ____________ Ventricles ____________	30, 31, 32, 38, 39, 40, 41, 42	60–100 times per minute 40–60 times per minute 20–40 times per minute
14. What process is responsible for a site speeding up and overriding a higher site, thus taking over as pacemaker?	33, 34, 35, 45, 46	irritability
15. What mechanism is in play if a lower site takes over responsibility for the pacemaking function following failure of a higher site?	33, 36, 37, 47, 48	escape
16. Which nervous system has two branches that control the activities of the heart?	49	autonomic
17. Name the two branches of the nervous system identified in the preceding question.	49, 52	sympathetic; parasympathetic
18. List three things that will happen to the heart if the sympathetic branch is stimulated.	49, 50, 51, 53	increased rate, increased AV conduction, increased irritability
19. List three things that will happen to the heart if the parasympathetic branch is stimulated.	49, 50, 51, 58	decreased rate, decreased AV conduction, decreased irritability

Questions	Referenced Frames	Answers
20. What part of the heart does the sympathetic branch innervate?	49, 54	the atria and ventricles
21. What part of the heart does the parasympathetic branch innervate?	49, 54	only the atria
22. What happens if one branch is blocked?	50, 51, 55, 56, 57, 58	The influence of the opposing branch will control the heart.



2

Waves and Measurements

Overview

IN THIS CHAPTER, you will learn how cardiac electrical activity is transferred to graph paper so that it can be seen and analyzed for arrhythmia interpretation. You will learn about the equipment used for monitoring, and you will learn all the specifics of the graph paper upon which EKG images are typically drawn. You will learn the difference between a single cardiac cycle and an EKG rhythm strip. You will find out about the different components that make up a single cardiac cycle on the EKG, and you will learn to identify each component and know what it suggests is happening within the heart.

Introduction

1. In Chapter 1, you learned that arrhythmias are manifestations of the heart's ____________________ activity. And you learned that the study of arrhythmias is called ____________________. To study arrhythmias, we have to transform the electrical activity into a format that can be seen.

electrical
electrocardiography

Electrodes

2. The electrical patterns of the heart can be picked up from the surface of the skin by attaching an **electrode** to the skin and connecting it to a machine that will display the electrical activity on graph paper. An electrode is a small item attached to the patient's ____________ and then connected by wire to a machine capable of inscribing the patterns on graph ____________.

skin
paper

3. The electrical activity is displayed best if you can ensure good contact between the electrode and the skin. This can be done in several ways:

- By abrading the skin slightly
- By removing any obstacles, such as dirt or hair
- By using a contact medium, such as saline or a commercial gel

All of these measures are intended to improve ____________ between the electrode and the skin.

contact

4. An ____________ placed on the skin can pick up electrical activity from within the heart and display it on graph paper using an EKG machine. To ensure a good tracing, you must provide good contact between the ____________ and the ____________.

electrode
skin; electrode

5. Contact between the skin and the electrode can be improved by lightly ____________ the skin, by wiping off excess ____________, or possibly by ____________ excess hair. An important way to ensure good contact is to use some type of contact medium, such as ____________ or a commercial ____________.

abrading; dirt
shaving
saline
gel

6. When an EKG machine is turned on but isn't yet connected to the patient's electrodes, the writing point (stylus) of the machine will simply produce a straight line on the paper. This line is called the **isoelectric line** because all of the electrical forces are equal; no current is flowing. Once the machine is connected to the patient's electrodes, the needle will move up or down on the paper (above or below the isoelectric line) in response to the electrical forces it receives. If no current is flowing, or if the forces balance each other out, the graph paper will show a ____________. If the machine receives a flow of electricity, the needle will move ____________ or ____________ in response to the current.

straight line
up
down

Rule of Electrical Flow

7. A very basic rule of electrocardiography refers to the flow of electricity through the heart and out to the electrodes. This rule states that if the electricity flows *toward* the *positive* electrode, the patterns produced on the graph paper will be *upright*. The converse of this rule is also true: if the electricity flows *away* from the *positive* electrode (or *toward* the *negative* electrode), the pattern will be a *downward* deflection. If the flow of electricity is toward the positive electrode, the machine will produce an ____________ deflection on the graph paper (Figure 4).

upright

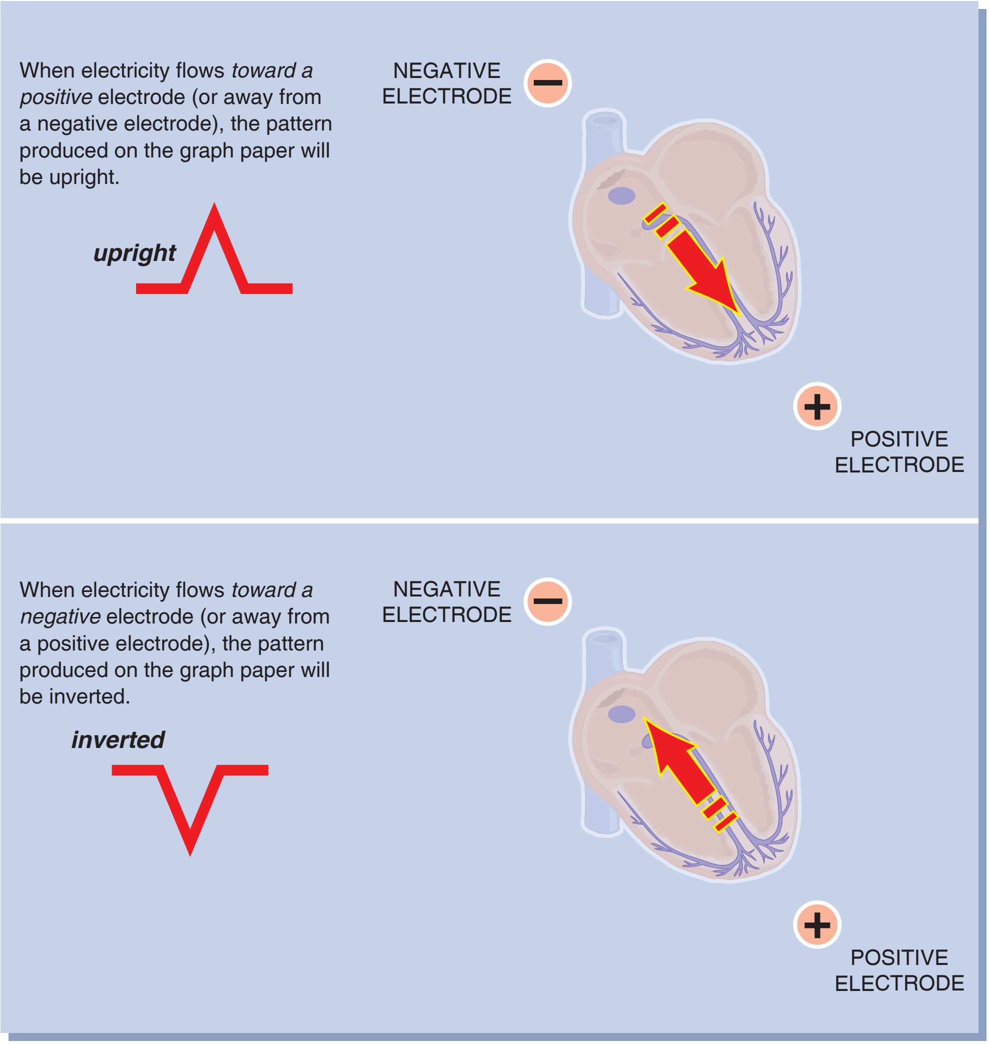
8. Look at Figure 4. If the electrical flow is toward the negative electrode, would you expect the graph paper to show a positive or a negative deflection? ____________

negative

9. If the graph paper shows a positive deflection, you would assume that the electrical activity is flowing primarily toward the ____________ electrode.

positive

Figure 4 Rule of Electrical Flow



10. If the deflection on the graph paper is negative, you would assume that the electrical flow is toward the ________________ electrode and away from the ________________ electrode.

negative
positive

11. Thus, we can determine the direction of electrical flow by the type of deflection made on the EKG paper. But to draw any conclusions based on this information, we must be sure that the electrodes are always in the same place on the patient so that the information is not misleading. The placement of the electrodes on patients is always ________________ to avoid confusion or misinterpretation of information.

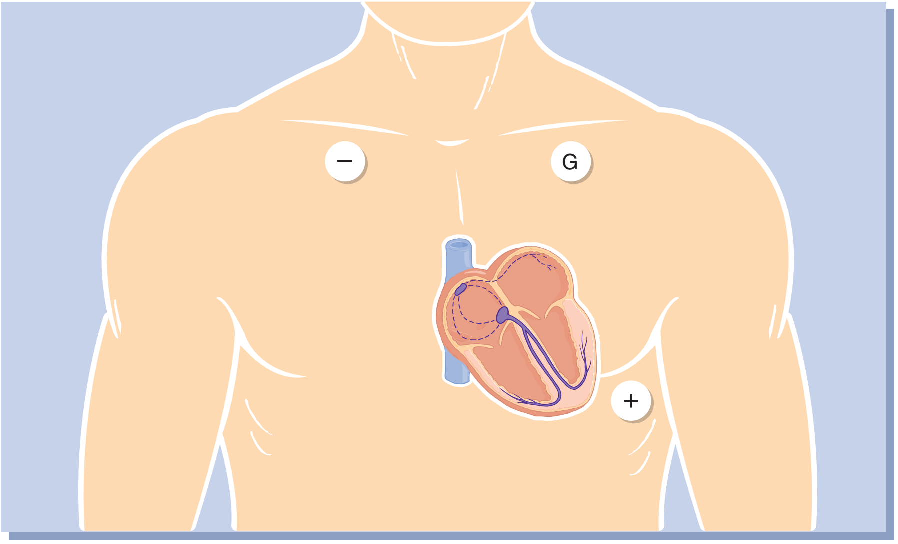
the same (standardized)

Monitoring Leads

12. The positioning of electrodes for monitoring the EKG allows you to see a single view of the heart's electrical pattern. By rearranging electrodes, many such views are possible. (This concept can be compared to a camera that can photograph the heart from many angles, each one giving additional depth to the overall visualization of the heart itself.) Each view of the heart is called a **lead**. Leads can be changed by a knob on the machine that diverts the flow of electricity through different electrodes. For sophisticated EKG interpretation, many leads are inspected to visualize the entire heart. However, for basic arrhythmia interpretation, it is necessary to monitor only a single lead. A monitoring lead shows only one ________________ of the heart's electrical activity.

view

Figure 5 Electrode Placement for Monitoring Lead II



13. When monitoring a patient for patterns of electrical activity such as arrhythmias, a lead is selected to give a clear picture of the basic wave forms. Single leads that give good pictures of the basic waves are called monitoring leads because they are used to ________________ patterns such as arrhythmias. The first widely used monitoring lead was Lead II, but now it is common to use other leads as well, especially variations of the chest leads (such as MCL_1). The modified chest leads often give a better view of the heart's atrial activity, which is sometimes needed to differentiate complex arrhythmias. The examples in this book all happen to be Lead II. This does not mean that Lead II is better than MCL_1, nor does it mean that you must always use Lead II for monitoring arrhythmias. The same *patterns* apply whether you view them in Lead II, MCL_1, or any other monitoring lead. Regardless of which lead is used, the ________________ remain the same, so it doesn't matter which lead you use to learn basic arrhythmias. Just because the examples in this book are Lead II doesn't mean that it is the only monitoring lead, or even the best. You will encounter other monitoring leads as you learn more about EKGs, but for now you can assume that the information in this book refers to ________________ unless otherwise specified.

monitor

patterns

Lead II

14. Figure 5 shows the placement of electrodes to monitor Lead II. Note that the positive electrode is at the apex of the heart, and the negative electrode is below the right clavicle. The third electrode is a ground electrode and does not measure electrical flow in this lead. Since the pacemaker is normally in the ________________ and the electrical current flows toward the ventricles, the primary thrust of electrical flow in the heart will be toward the positive electrode in Lead II. Thus, the primary deflections in Lead II will be ________________.

SA node

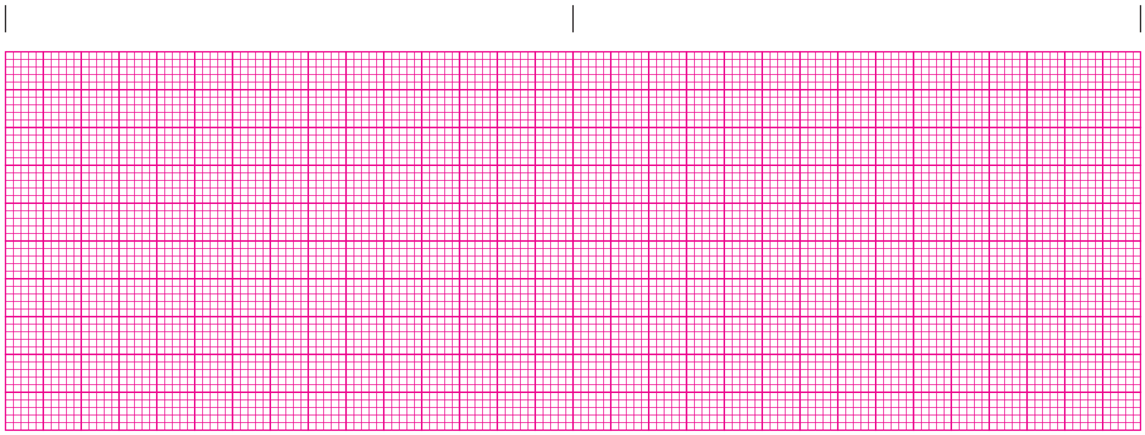
upright

Graph Paper

15. All EKG interpretation relies on the use of standardized, uniform graph paper. The size of the graph on the paper and the speed at which the paper travels through the EKG machine are both kept constant; all EKG paper is the same, and all EKG machines operate at the same speed. By keeping the paper and the speed standardized, we can look at the patterns created by an individual's heart activity and compare them to what has been established as "normal" activity. If the graph paper was not ________________, we would not be able to compare one person's EKG to

standardized

Figure 6 Sample EKG Graph Paper



The three vertical lines in the upper margin are measures of time standard to all EKG graph paper. The distance between two "tic" marks is 3 seconds; thus, this strip measures 6 seconds in duration.

any other EKG, nor would we be able to compare several EKGs taken on one person at different times. Similarly, if all EKG machines ran at different ________, we would not have a constant "norm" for comparing individual EKGs.

speeds

16. Since all graph paper has ________ markings, we must learn what these markings mean so that we will be able to interpret the EKG tracings that are superimposed on the graph paper. Look at the sample graph paper shown in Figure 6. You will notice that there are lines going up and down (vertical) and lines going across (horizontal). Also notice that every fifth line is heavier than the other lighter lines. How many light lines are there between two heavy ones? ________

standardized

four

17. The lines on the graph paper can help determine both the direction and the magnitude of deflections. When all electrical forces are equal, there is neither an upright nor a downward deflection; an isoelectric line is created. If the electrical force is toward the positive electrode, the stylus will draw an ________ wave. If the force travels primarily toward the negative electrode, the wave will be ________. If no current is present, or if positive and negative forces are equal, the graph paper will show a ________ line, called an isoelectric line.

upright

downward (inverted)

straight

Voltage Measurements

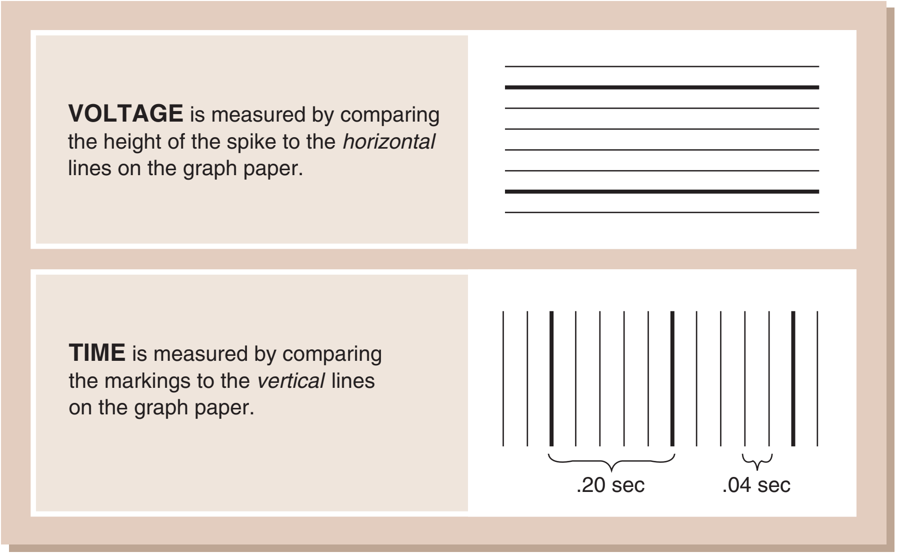
18. It is the strength of the current, or its voltage, that will determine the magnitude of the deflection. If it is a very strong positive wave, it will create a high spike above the isoelectric line. If it is a very weak positive charge, the deflection will go only slightly above the isoelectric line in response to the amplitude of the charge. Therefore, the height of the deflection will indicate the ________ of the electrical charge that produced the deflection. The same principle holds for negative deflections: the stronger the charge, the deeper the wave will go below the isoelectric line.

voltage (or amplitude)

19. Since voltage produces either an upright or a downward deflection on the EKG, the magnitude of the current can be measured by comparing the height of the spike against the horizontal lines on the graph paper (Figure 7). Voltage can be measured quantitatively (in millivolts), but you need not concern yourself with these figures for basic arrhythmia interpretation. On the graph paper, the horizontal lines measure ________.

voltage

Figure 7 Using Graph Paper Markings to Measure Voltage and Time



Time Measurements

20. The second, and more important, thing that the graph paper can provide is a determination of time. The vertical lines can tell you just how much time it took for the electrical current within the heart to travel from one area to another. The vertical lines are the most important markings for simple arrhythmia identification because they can tell you about the ____________ it takes for the current to travel about within the heart. time

21. The standard rate at which the EKG machine runs paper past the stylus is 25 millimeters per second. At this standard rate, we know that it takes 0.20 second to get from one *heavy* vertical line to the next *heavy* vertical line. Therefore, if a deflection began on one heavy line and ended on the next heavy line, we would know that the electrical current within the heart that caused the deflection lasted ____________ second. 0.20
This is an essential figure to remember because it is the basis for many of the rates, rules, and normal values you will learn in later sections. The distance (in time) between two heavy vertical lines on the EKG graph paper is ____________ second. 0.20

22. If the time frame between two heavy vertical lines is 0.20 second and there are five small squares within this same area, it would follow that each of these small squares is equivalent to one-fifth of 0.20 second, or 0.04 second each. The distance (in time) between two light vertical lines, or across one small square, is ____________ second. 0.04

23. You now can see that graph paper can be used to measure ____________ voltage
and ____________. time

Cardiac Cycle

24. As you know, the heart has four chambers. The upper two are the atria and the lower two are the ventricles. In most cases the atria function as a team and contract together, and the ventricles also operate as a single unit. So for nearly all of our discussions we will consider the atria as a single unit and the ventricles as a single unit, even though we realize that they are actually the ____________ separate chambers four
that make up the heart.

25. The upper chambers of the heart are called the ________________, and they will be considered a single ________________. Likewise, the ________________ are the lower chambers and will be considered a ________________ unit.

atria
unit
ventricles
single

26. In the normal heart, blood enters both atria simultaneously and then is forced into both ventricles simultaneously as the atria contract. All of this is coordinated so that the atria fill while the ventricles contract, and when the ventricles are filling, the atria contract. In considering a cardiac cycle, we would expect the ________________ to contract first.

atria

27. Before the atria can contract, they must first receive an electrical stimulus to initiate the muscle cells response. In fact, for any myocardial cell to contract, it must first receive an ________________ stimulus. We know that the ________________ cells have the ability to initiate an impulse. And we know that the same electrical impulses that eventually produce contraction of the heart can also produce deflections on the EKG graph paper. It is by careful scrutiny of these wave patterns that we are able to determine the ________________ activity that is present in the heart, and sometimes we can even speculate on the type of ________________ activity that could be expected. But to make these determinations, we must first investigate the ________________ patterns produced by the heart's electrical activity.

electrical; electrical
electrical
mechanical
wave

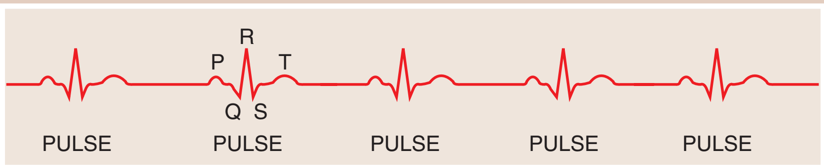
28. During each phase of the cardiac electrical cycle, a distinct pattern is produced on the EKG ________________ paper. By learning to recognize these wave patterns and the cardiac activity each represents, we can study the relationships between the different areas of the heart and begin to understand what is taking place within the heart at any given time. For each pacemaker impulse, the electrical flow travels down the ________________ pathways, depolarizing the atria and then the ventricles as it goes. Following this, the pattern begins again with another impulse from the pacemaker. Each cardiac cycle includes all of the electrical activity that would normally be expected to produce a single heart beat. The cardiac cycle begins with the initiating impulse from the pacemaker and encompasses all phases until the ventricles are repolarized. On the EKG graph paper, the cardiac cycle includes all of the wave patterns produced by electrical activity, beginning with the ________________ impulse and including ventricular ________________.

graph
conduction
pacemaker
repolarization

29. On the EKG, each of these phases is displayed by a specific wave pattern. Figure 8 shows a series of cardiac electrical cycles that makes up a typical EKG rhythm strip. In Figure 9, a single cardiac cycle has been enlarged so that we can see each of the individual patterns more closely. A single cardiac cycle is expected to produce one ________________ beat. An EKG rhythm strip is composed of more than one ________________ cycle.

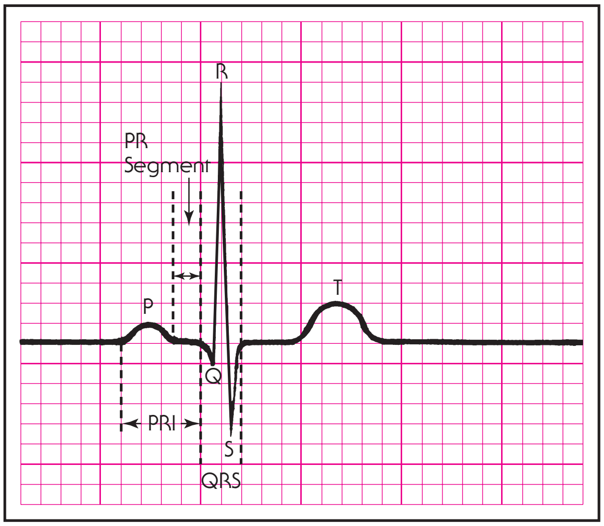
heart
cardiac

Figure 8 A Typical EKG Rhythm Strip



In a healthy heart, each cardiac cycle would be expected to correlate with the patient's individual pulse beats.

Figure 9 The EKG Complex



Waves, Intervals, Segments

30. In labeling the activity on the graph paper, the deflections above or below the isoelectric line are called *waves.* In a single cardiac cycle there are five prominent waves, and each is labeled with a letter. Look at Figure 9 and find the P, Q, R, S, and T waves. An **interval** refers to the area between (and possibly including) waves, and a **segment** identifies a straight line or area of electrical inactivity between waves. Find the PR segment and the PR interval (PRI) on Figure 9. Does the PR segment include any waves? ____________ Does the PR interval include any waves? ____________

No.

Yes. The PRI includes the P wave and the PR segment.

P Wave and PRI

31. The first wave you see on the cardiac cycle is the P wave. Locate it in Figure 9. The P wave starts with the first deflection from the isoelectric line. The ____________ wave is indicative of atrial depolarization.

P

32. When you see a P wave on the EKG, does that mean that the atria contracted? ____________

No, not necessarily. It means the atria were depolarized, but it is possible that the muscle cells did not contract in response. It is impossible to tell whether or not the atria contracted simply by looking at the EKG.

33. As the impulse leaves the atria and travels to the AV node, it encounters a slight delay. The tissues of the node do not conduct impulses as fast as other cardiac electrical tissues. This means that the wave of depolarization will take a longer time to get through the AV node than it would in other parts of the heart. On the EKG, this is translated into a short period of electrical inactivity called the **PR segment**. This is the straight line between the P wave and the next wave. Locate the PR segment on Figure 9. The PR segment is indicative of the delay in the ____________.

AV node

34. The AV node is the area of the heart with the slowest conduction speed. That is, the conductive tissues of the sinus node, the atria, and the ventricles all conduct impulses faster than the AV node does. This is necessary to allow time for atrial contraction and complete filling of the ventricles. On the EKG tracing, this delay at the AV ______________ is seen as a short isoelectric segment between the ______________ wave and the next wave. This segment is called the ______________ segment.

node
P
PR

35. If you wished to refer to all of the electrical activity in the heart before the impulse reached the ventricles, you would look at the PR interval. This includes both the P wave and the PR segment. The P wave displays ______________ depolarization, and the PR segment is caused by the ______________ in the AV node. Therefore, the PR ______________ includes all atrial and nodal activity.

atrial
delay
interval

QRS Complex

36. By definition, the PR interval begins at the first sign of the P wave and ends at the first deflection of the next wave, called the **QRS complex**. The PR interval includes all ______________ and all ______________ activity but does not include ventricular activity.

atrial; nodal

37. Ventricular depolarization is shown on the EKG by a large complex of three waves: the Q, the R, and the S. Collectively, these are called the QRS complex. This complex is significantly larger than the P wave because ventricular depolarization involves a greater muscle mass than atrial depolarization. The QRS complex starts with the Q wave. The Q wave is defined as the first negative deflection following the P wave but before the R wave. Locate the Q wave on Figure 9. The Q wave flows immediately into the R wave, which is the first positive deflection following the P wave. Next comes the S wave, which is defined as the second negative deflection following the P wave, or the first negative deflection after the R wave. Collectively, the QRS complex signifies ______________ depolarization.

ventricular

38. The QRS complex is larger and more complicated than the P wave, primarily because it involves a larger part of the heart. Very often, the QRS complex looks different from the complex shown in Figure 9, but it is still called the QRS complex. Several different configurations of the QRS complex are shown in Figure 10. Regardless of appearance, these still indicate depolarization of the ______________.

ventricles

39. After the ventricles depolarize, they begin their repolarization phase, which results in another wave on the EKG. The T wave is indicative of ventricular repolarization. The atria also repolarize, but their repolarization is not significant enough to show up on the EKG, so you do not see an atrial equivalent of the T wave. Ventricular repolarization is much more prominent and is seen on the EKG as the ______________ wave.

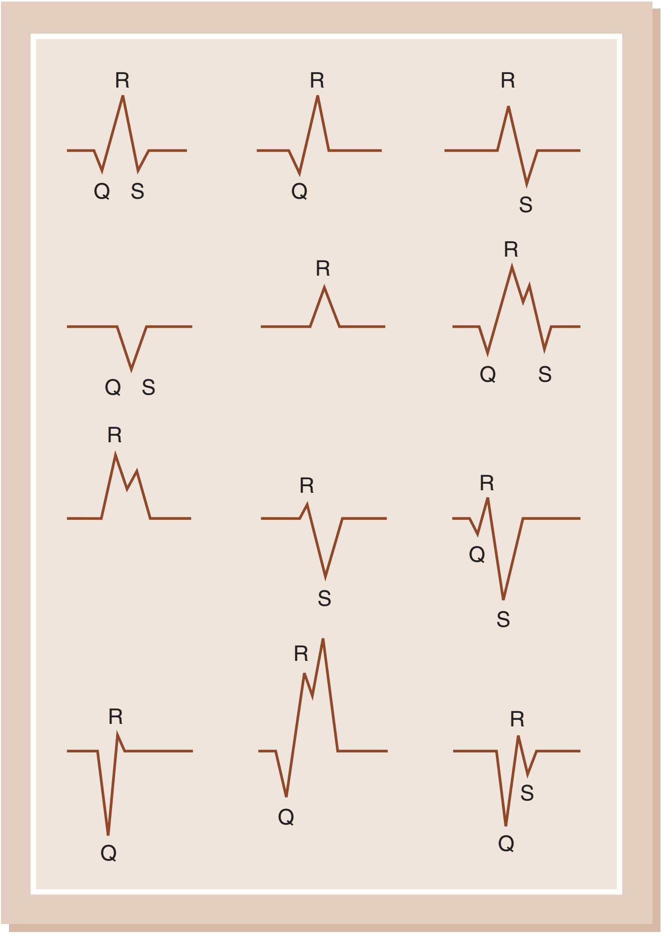
T

40. Now that you have learned the definitions of all of the waves on the EKG and what each one means, turn to the Practice Strips at the end of this chapter and label each wave on each practice strip in Part I (strips 2.1–2.12). Be sure to recall what each wave means as you mark it on the EKG. When you finish marking the waves, go back and identify the PR interval, the PR segment, and the QRS complex for each strip.

Practice Strips (Part I)

41. To interpret arrhythmias you must be able to measure the duration of both the PR interval and the QRS complex. The grid markings on the graph paper are used to determine just how many seconds it took for the impulse to create those intervals.

Figure 10 Various QRS Configurations



To make these measurements, you will use EKG calipers. Let's measure the PRI first. You can use Figure 9 for practice. Place one point of the calipers on the very first deflection that marks the beginning of the P wave. Then place the other point of the calipers on the final point of the PR interval, which you will recall is actually the very beginning of the ______________ complex. Make sure you don't have any part of the QRS complex included in your measurement. Now, count the number of small boxes within your caliper points, and multiply that number by ______________ second, which is the amount of time allotted to each small box. What is your measurement? ______________ second.

QRS
0.04
0.16

42. For the PR interval to be considered normal, it must be between 0.12 and 0.20 second. If it is less than 0.12 second, it is considered a short PRI, and if it is greater than 0.20 second, it is said to be prolonged. The P wave itself does not contribute to a long PRI; it is actually the delay in the AV node, or the PR ______________, that varies according to how long the node held the impulse before transmitting it. The normal PRI should be ______________ second; a long PRI would suggest a ______________ in the ______________.

segment
0.12–0.20
delay; AV node

43. Is the PRI measurement you determined for the complex shown in Figure 9 considered to be normal? ______________

Yes. It is 0.16 second, which is within the normal range of 0.12–0.20 second.

ST Segment and T Wave

44. You measure the QRS complex in the same way as the PR interval. Just make sure your caliper points are exactly where the definitions tell you they should be. Starting with the Q wave, measure where the deflection first begins to go below the isoelectric line. This part usually isn't so hard. The S wave is more difficult. Between the S wave and the T wave is a section called the **ST segment**. Although segments are supposed to be straight lines, the ST segment often gets caught up in the transition between the QRS complex and the T wave and is very rarely a cut-and-dried configuration. So you must look for some clue that indicates to you where the S wave stops and the ________ wave begins. If such an indication is present, it will usually be a very small notch or other movement suggesting an alteration of electrical flow. Use this point as the outside measurement of the QRS complex. Include in your measurement the entire S wave, but don't let it overlap into the ST segment or the T wave. The QRS measurement should include the beginning of the ________ wave and the end of the ________ wave.

T

Q

S

Measurements

45. For practice, measure the QRS complex shown in Figure 9. What is your measurement? ________ second.

0.08

46. People very rarely agree on what a normal time range is for the QRS measurement. It is usually considered to be between 0.06 and 0.11 second. For simplicity, we'll define the normal QRS complex measurement as anything less than 0.12 second. This means that the ventricles took a normal amount of time to depolarize if they did it in less than ________ second.

0.12

47. Is the QRS measurement shown in Figure 9 considered to be normal?

____

____

____

Yes. It measures 0.08 second, which is less than 0.12 second.

Practice

48. Now that you know how to measure PRIs and QRSs, the rest is up to you. All it takes is practice, practice, and more practice. It is particularly helpful if you can get someone to check your measurements in the beginning so you don't develop bad habits. You can start by measuring PRI and QRS intervals on each of the strips in Part II of the Practice Strips at the end of the chapter (strips 2.13–2.30). The answer key shows you where the calipers were placed to obtain the answers, so if your measurements differ from those given, look to see where the complex was measured to arrive at the answer shown.

Practice Strips (Part II)

Artifact, Interference

49. The complexes on an EKG tracing are created by electrical activity within the heart. But it is possible for things other than cardiac activity to interfere with the tracing you are trying to analyze. Some common causes of interference, or artifact, are:

- Muscle tremors, shivering
- Patient movement

- Loose electrodes
- The effect of other electrical equipment in the room (called 60-cycle interference)

Each of these situations can cause ____________ on the EKG tracing, which may interfere with your interpretation of the arrhythmia. When such external factors cause deflections on an EKG strip, those deflections are considered to be artifact and are important to recognize because they can ____________ with your interpretation of the arrhythmia.

artifact

interfere

50. Figure 11 shows you what each of these types of interference can look like on an EKG tracing. As you can see, ____________ can often confuse you and lead you to believe that the deflection was caused by cardiac activity when it was not. As you practice identifying the P waves and QRS complexes, you will become more and more familiar with the normal configurations of these wave forms and will be more apt to distinguish them from artifact. When trying to determine whether or not a deflection was caused by artifact, you should try to identify the ____________ waves and ____________ complexes of the underlying rhythm and compare these configurations with the questionable deflections.

artifact

P; QRS

Figure 11 Types of Interference

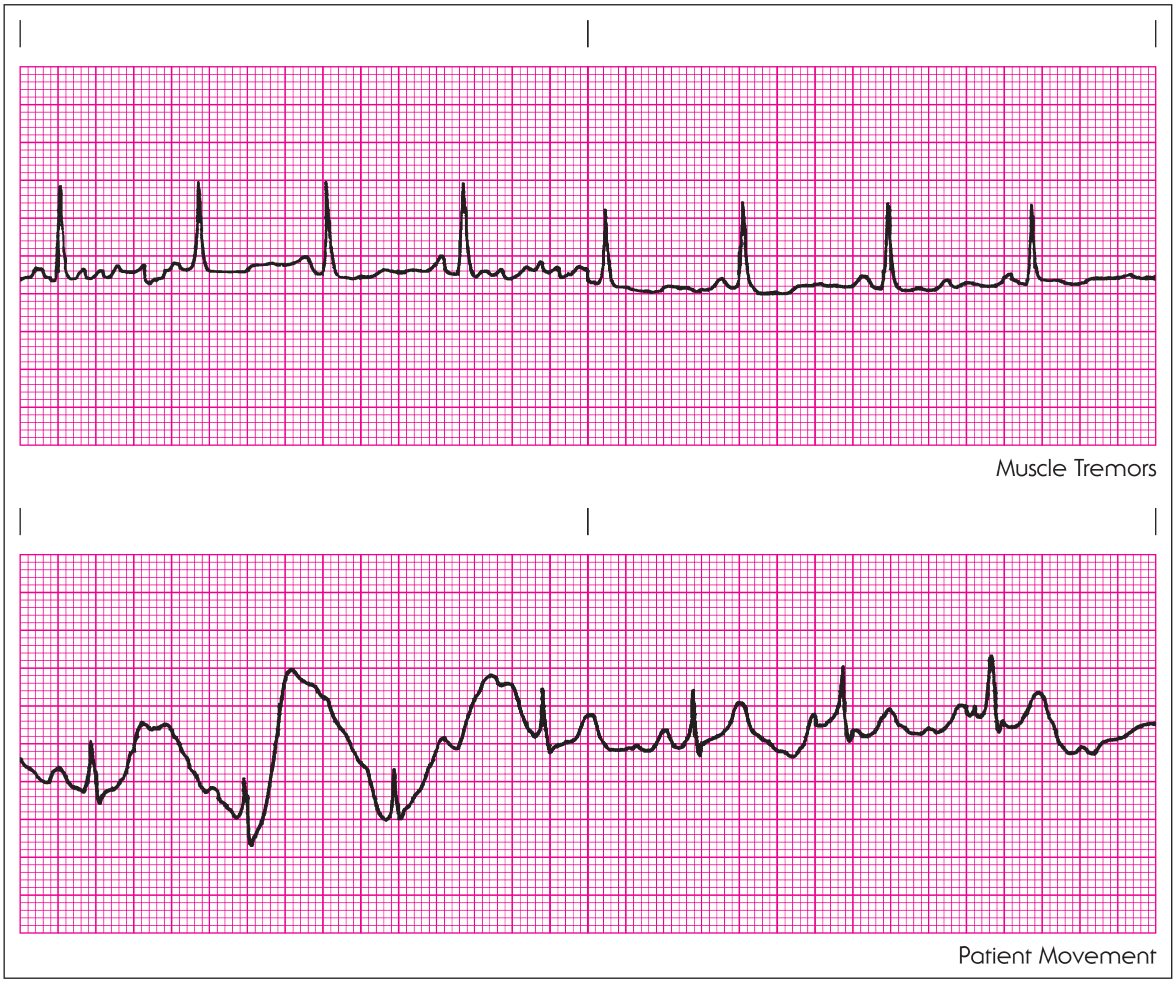


Figure 11 (*Continued*)

Refractory Periods

51. Let's go back to electrophysiology to make one final point. Since depolarization takes place when the electrical charges begin their wave of movement by exchanging places across the cell membrane, it would follow that this process cannot take place unless the charges are in their original position. This means that the cell cannot depolarize until the ________ process is complete. For depolarization to take place, repolarization must be ________.

repolarization
complete

52. When the charges are depolarized and have not yet returned to their polarized state, the cell is said to be electrically "refractory" because it cannot yet accept another impulse. If a cell is ________, it cannot accept an impulse because it isn't yet ________.

refractory
repolarized

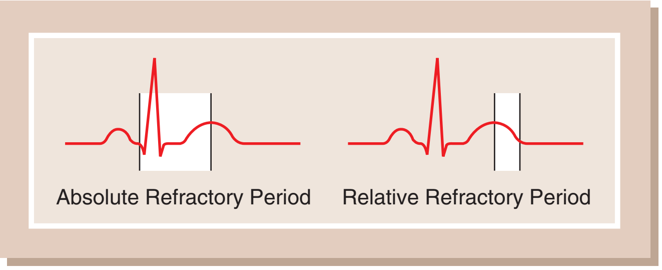
53. On the EKG, the refractory period of the ventricles is when they are depolarizing or repolarizing. Thus, the QRS and the T wave on the EKG would be considered the ________ period of the cardiac cycle, since it signifies a period when the heart would be unable to respond to an impulse.

refractory

54. Sometimes an electrical impulse will try to discharge the cell before repolarization is fully complete. In most cases nothing will happen because the cells aren't back to their original position and therefore can't ________. But once in a while, if the stimulus is strong enough, an impulse might find several of the charges

depolarize

Figure 12 Refractory Periods



in the right position and thus discharge them before the rest of the cell is ready. This results in abnormal depolarization and hence is an undesirable occurrence. This premature depolarization can occur only if most of the cell charges are back to their ________________ positions. Thus, there is a small part of the refractory period that is not absolutely refractory. This small section is called the *relative* refractory period because some of the charges are polarized and thus can be ________________ if the impulse is strong enough.

original

depolarized

55. So there are actually two refractory periods: an *absolute* refractory period, when no impulse can cause depolarization, and a *relative* refractory period, when a strong impulse can cause a premature, abnormal discharge. The ________________ refractory period would allow depolarization if the impulse were strong enough, while the ________________ refractory period would not allow any response at all.

relative

absolute

56. Figure 12 shows you where these refractory periods are located on the EKG. Notice that while all of the T wave is considered a refractory period, the downslope of the T wave is only relatively refractory. This means that if a strong impulse fell on the downslope of the T wave, it could result in ventricular ________________. This fact will become more important to you when we begin to look at specific arrhythmias.

depolarization

57. You now have all of the information you need to begin analyzing EKG rhythm strips. You can identify all of the different waves that make up a cardiac cycle, and you can measure the PRI and the QRS complex. You are now ready to turn to Chapter 3 and learn how to apply this knowledge as you develop a technique for analyzing EKG rhythm strips.

KEY POINTS

- Electrodes are devices that are applied to the skin to detect electrical activity and convey it to a machine for display.
- Electrode contact can be improved by:
  - Abrading the skin
  - Cleaning or drying the skin
  - Using a contact medium
- If electricity flows toward the positive electrode, the patterns produced on the graph paper will be upright; if the electrical flow is toward the negative electrode, the patterns will be inverted.
- Electrode placement is standardized to avoid confusion in EKG interpretation (Figure 5).
- A lead is a single view of the heart, often produced by a combination of information from several electrodes.
- A monitoring lead is one that clearly shows individual waves and their relationship to other waves. All the examples in this book are Lead II (although this is only one of many monitoring leads).
- Graph paper is standardized to allow comparative analysis of EKG wave patterns.
- The isoelectric line is the straight line made on the EKG when no electrical current is flowing.
- Vertical lines on the graph paper measure time; horizontal lines measure voltage (Figure 7).
- A small square on the graph paper (the distance between two light vertical lines) is 0.04 second.
- A large square on the graph paper (the distance between two heavy vertical lines) is 0.20 second.
- The atria normally contract before the ventricles do.
- A single cardiac cycle on the EKG includes everything from depolarization of the atria up to and including repolarization of the ventricles.
- A single cardiac cycle is expected to produce a single heart beat (a pulse).
- The P wave represents atrial depolarization.
- The PR segment represents delay in the AV node.
- The PR interval includes the P wave and the PR segment and represents both atrial depolarization and delay in the AV node.
- The PRI is measured from the beginning of the P wave to the beginning of the QRS complex.
- The PRI is normally between 0.12 and 0.20 second.
- The QRS complex represents ventricular depolarization.
- The QRS interval is measured from the beginning of the Q wave to the end of the S wave.
- The Q wave is the first negative deflection following the P wave but before the R wave.
- The R wave is the first positive wave following the P wave, or the first positive wave of the QRS complex.
- The S wave is the second negative deflection following the P wave, or the first negative deflection following the R wave.
- The QRS interval is normally less than 0.12 second.
- External factors capable of producing artifact on the EKG tracing include muscle tremors, shivering, patient movement, loose electrodes, and 60-cycle electrical current.
- A cell is electrically refractory when it has not yet repolarized and thus cannot accept and respond to another stimulus.
- The absolute refractory period occurs when the cells cannot respond to any stimulus at all.
- The relative refractory period occurs when some of the cells are capable of responding if the stimulus is strong enough.
- If an impulse falls during the relative refractory period, the heart might be depolarized, but in an abnormal way.
- The absolute refractory period encompasses the QRS and the first part of the T wave.
- The relative refractory period is the downslope of the T wave.

SELF-TEST

Directions: Complete this self-evaluation of the information you have learned from this chapter. If your answers are all correct and you feel comfortable with your understanding of the material, proceed to the next chapter. However, if you missed any of the questions, you should review the referenced frames before proceeding. If you feel unsure of any of the underlying principles, invest the time now to go back over the entire chapter. **Do not proceed with the next chapter until you are very comfortable with the material in this chapter.**

Questions	Referenced Frames	Answers
1. What is an electrode used for?	1, 2, 4	to pick up electrical activity from the skin surface
2. List three ways to improve contact between the electrode and the skin.	2, 3, 4, 5	abrade skin; clean skin; use contact medium
3. If the electrical current flows toward the positive electrode, will the deflection on the graph paper be upright or downward?	6, 7, 8, 9, 10, 17	upright
4. Why is it important to standardize electrode placement?	11, 12	to avoid confusion when interpreting EKG patterns
5. What is a lead, and how does it differ from an electrode?	12, 13	A lead is a single view of the heart, often produced by a combination of information from several electrodes.
6. How many leads do you need to know to interpret arrhythmias?	12, 13	one; only a monitoring lead
7. Which lead will be discussed throughout this book?	13	Lead II
8. What are the electrode positions for the lead identified in the preceding question?	14	negative electrode below right clavicle; positive electrode at the apex; ground electrode below the left clavicle.
9. What features are important for a good monitoring lead?	12, 13	clear visualization of the basic waves
10. In Lead II, will the primary deflections be upright or downward on the EKG?	14	Upright, because the current is flowing toward the positive electrode.
11. Why is it important to use standardized EKG graph paper?	15, 16	Standardized markings enable you to measure the EKG and compare it to “normal.”
12. What is an isoelectric line?	17	It is the straight line on the EKG made when no electrical current is flowing.
13. What do the vertical lines on the graph paper tell you?	16, 17, 20, 21, 22, 23	time
14. What do the horizontal lines on the graph paper tell you?	16, 17, 18, 19, 23	voltage
15. How much time is involved between two heavy lines on the graph paper?	16, 21, 22	0.20 second
16. How much time is involved in one small square on the graph paper?	16, 21, 22	0.04 second
17. Which chambers contract first in a single cardiac cycle?	24, 25, 26	the atria
18. What must occur for the heart to contract?	27	The muscle cells must receive an electrical stimulus.
19. What cardiac activity is included in a single cardiac cycle on the EKG?	28	everything from depolarization of the atria up to and including repolarization of the ventricles

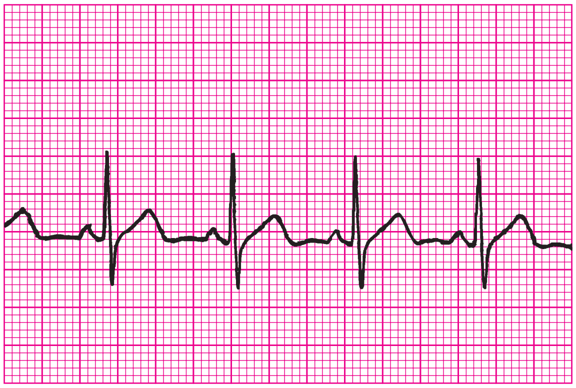
Questions	Referenced Frames	Answers
20. How many heart beats would you expect a single cardiac cycle to produce?	28, 29	one
21. What are the five waves found in a single cardiac cycle on the EKG?	30, 40	P, Q, R, S, and T
22. Differentiate between waves, segments, and intervals.	30	Waves are deflections, segments are straight lines, and intervals include both waves and segments.
23. What does the P wave represent, and how is it found on the EKG?	31	atrial depolarization; it is measured from the first deflection on the cardiac cycle until the deflection returns to the isoelectric line
24. What does the PR segment represent?	33, 34	delay in the AV node
25. What is the PR interval, how is it measured, and what is its normal duration?	35, 36, 41, 42, 43, 48	The PRI includes the P wave and the PR segment. It is measured from the beginning of the P wave to the very beginning of the QRS complex. It is normally 0.12–0.20 second.
26. What does the QRS represent, how is it measured, and what is its normal duration?	37, 38, 44, 45, 46, 47, 48	ventricular depolarization; measure from the beginning of the Q wave to the end of the S wave; normally less than 0.12 second
27. What does the T wave represent?	39	ventricular repolarization
28. List four external factors capable of producing artifact on the EKG tracing.	49, 50	muscle tremors, shivering; patient movement; loose electrodes; 60-cycle electrical current
29. What is meant by *electrical refractoriness?*	51, 52, 53	The cells are not yet repolarized and thus cannot accept and respond to another stimulus.
30. Differentiate between absolute refractory period and relative refractory period.	54, 55, 56	Absolute refractory period means that the heart cannot accept any stimulus at all. Relative refractory period means that some of the cells are capable of responding to a strong stimulus.
31. What is so important about the relative refractory period?	54, 55, 56	If an impulse hits on the relative refractory period, the heart can be discharged in an abnormal way.
32. What part of the EKG complex signifies the relative refractory period?	56	the downslope of the T wave

PRACTICE STRIPS (answers can be found in the Answer Key on page 551)

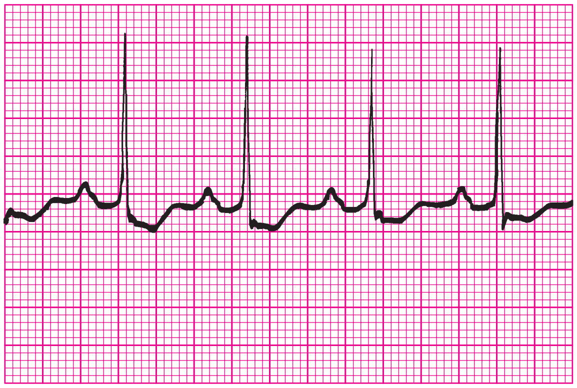
PART I: LABELING WAVES

Directions: For each of the following rhythm strips, label the P, Q, R, S, and T waves of a single cardiac cycle. (Some of the tracings may not have all of these waves.) As you finish each strip, check your answers. They start on page 551.

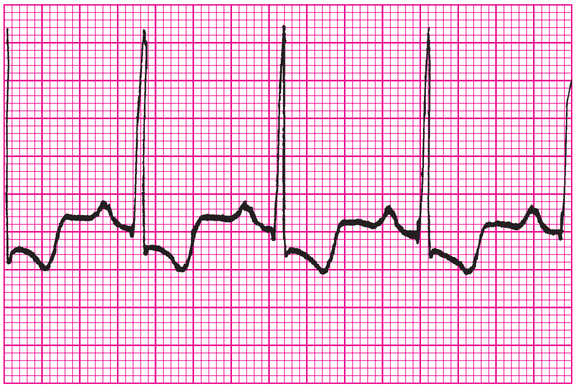
2.1



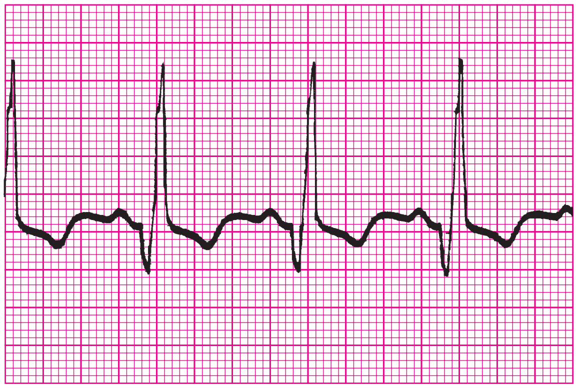
2.2



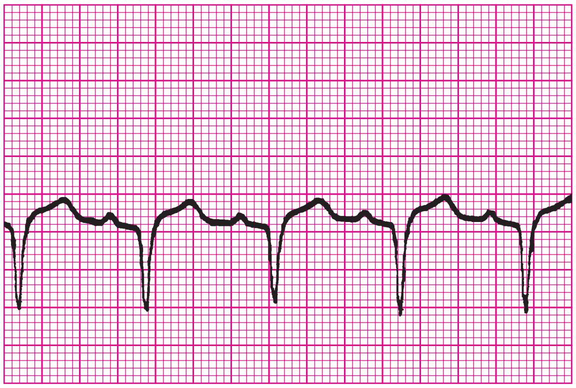
2.3



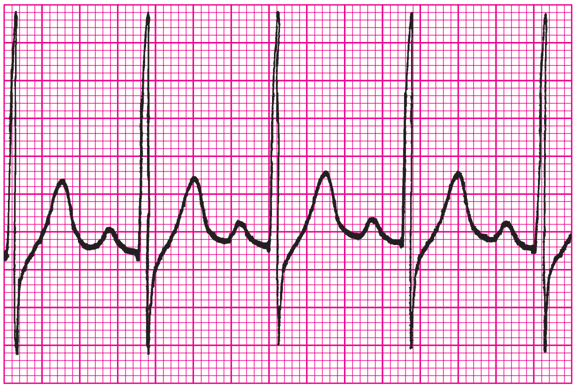
2.4



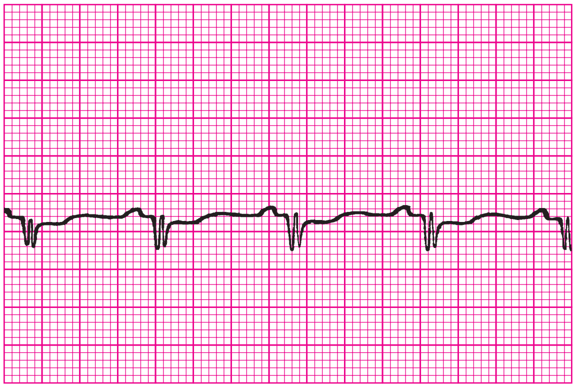
2.5



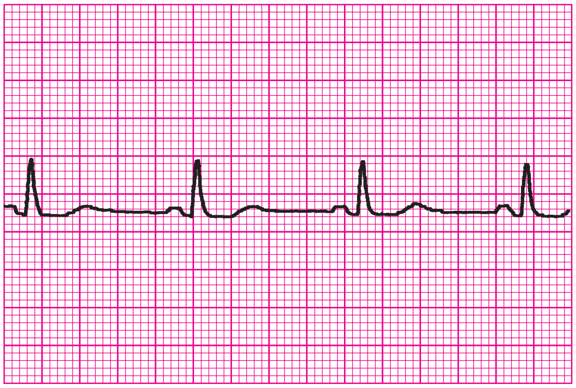
2.6



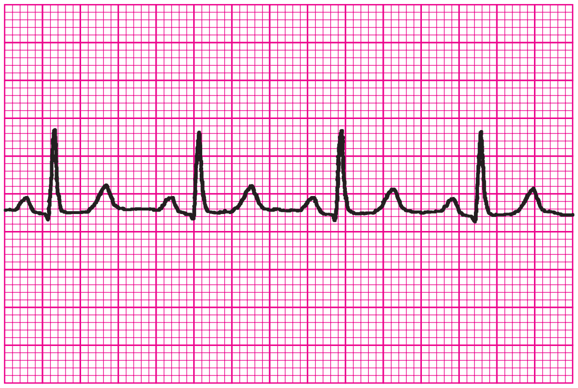
2.7



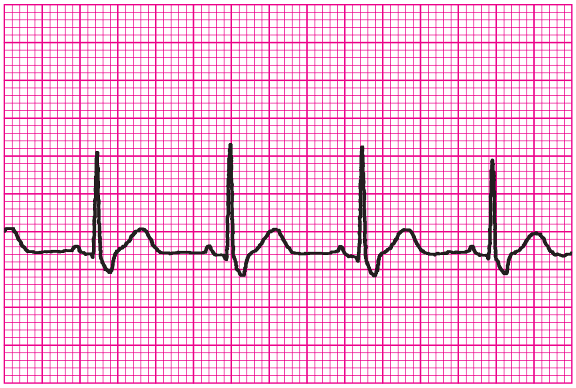
2.8



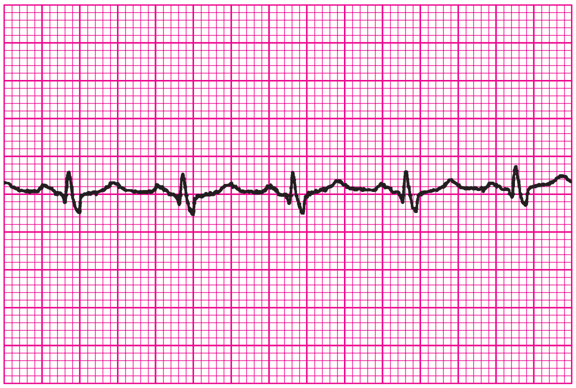
2.9



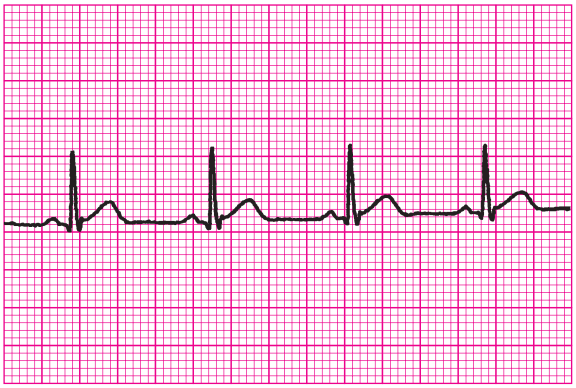
2.10



2.11



2.12

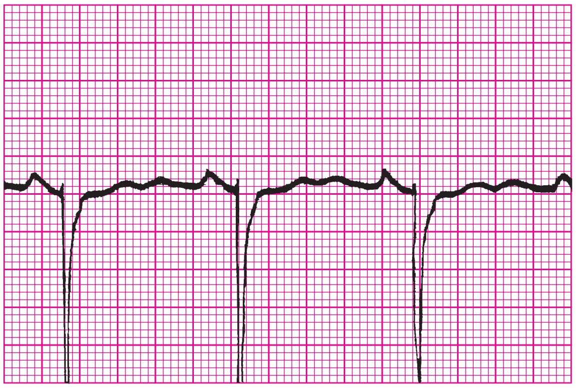


When you have completed this exercise, check your answers. They start on page 552. Then return to Frame 41 in this chapter (page 23).

PART II: MEASURING INTERVALS

Directions: For each of the following rhythm strips, measure the PR interval and the QRS complex. As you do each strip, check your answers. They start on page 39.

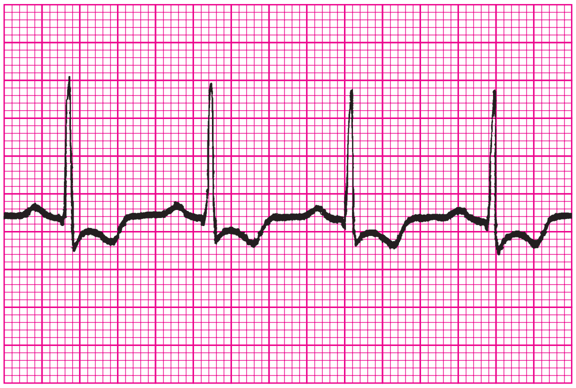
2.13



PRI: ______________ **second**

QRS: ______________ **second**

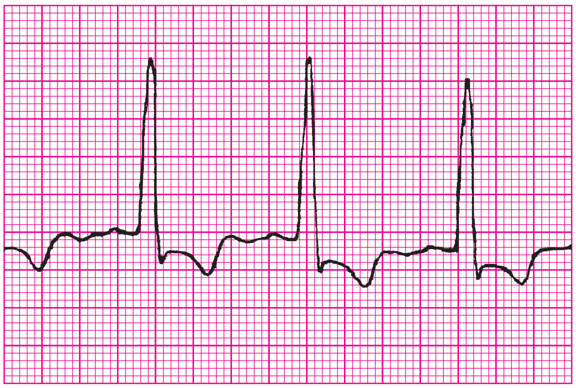
2.14



PRI: ______________ **second**

QRS: ______________ **second**

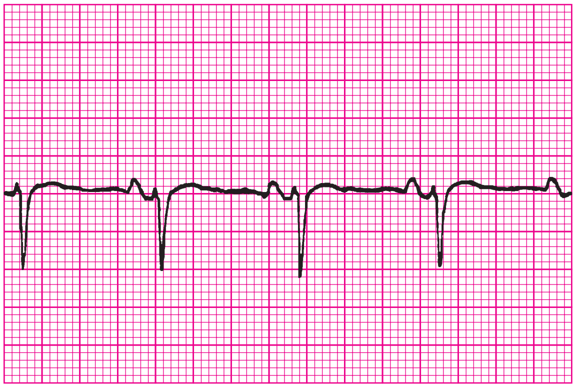
2.15



PRI: ______________ **second**

QRS: ______________ **second**

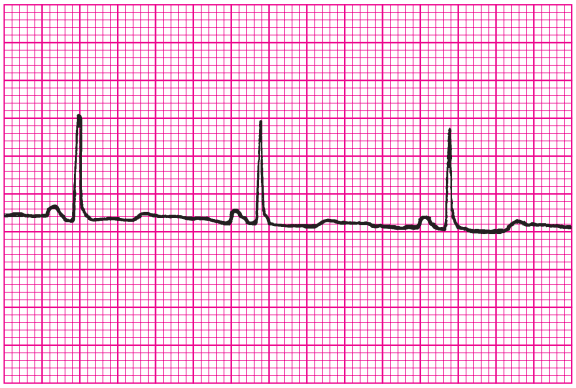
2.16



PRI: ______________ second

QRS: ______________ second

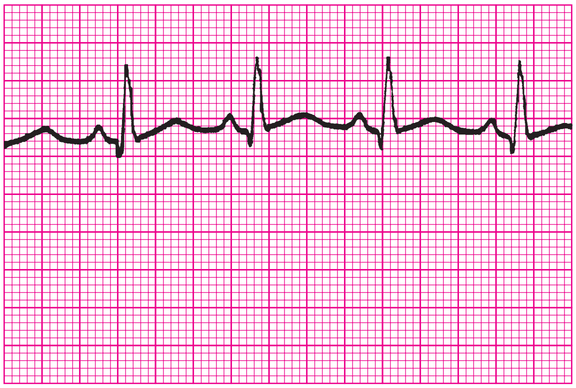
2.17



PRI: ______________ second

QRS: ______________ second

2.18



PRI: ______________ second

QRS: ______________ second