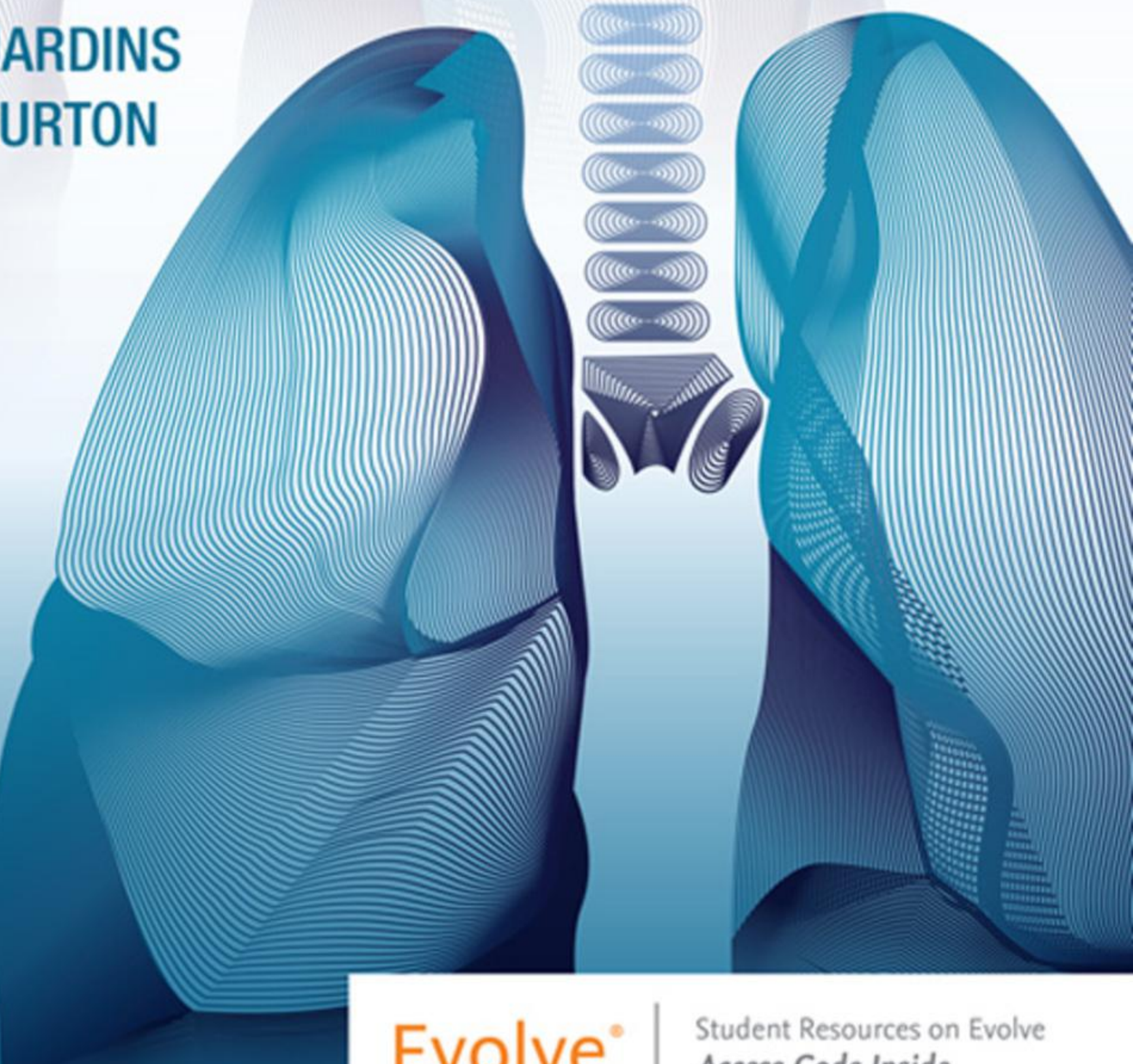
EIGHTH EDITION

Clinical Manifestations and Assessment of Respiratory Disease

TERRY DES JARDINS
GEORGE G. BURTON



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CLINICAL MANIFESTATIONS AND ASSESSMENT OF RESPIRATORY DISEASE, EIGHTH EDITION

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In Memory of Robert Cohn, MD

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There is a manpower shortage of health care providers who care for the critically ill. This is one of the most pressing issues affecting the future of our aging population and American medicine. … It has been generally acknowledged … that the shortages in nursing, respiratory care practitioners, and pharmacists have already reached crisis levels. … A severe shortage of (pulmonary/critical care physicians) can be expected in the very near future.[1]

> *Respiratory therapists are important for patient outcomes and their roles might even be expanded beyond traditional boundaries. More research is needed to define the ICU multidisciplinary staffing that matches patient needs and optimizes patient outcomes.*[2]

Shortfalls in the pulmonary and critical care physician workforce are estimated to be at least 38% and 22%, respectively, by 2020. Advanced Practice Registered Nurses (APRNs) and Physician Assistants (PAs) are now so entrenched in the medical services they are allowed to act as primary care providers (PCPs), managing everything from diabetes mellitus to heart failure. However, at the time of this writing, the respiratory care profession is in the process of developing a worker with credentials and practice privileges similar to those of the APRN and PA who will be designated as an Advanced Practice Respiratory Therapist (APRT). In the final analysis, respiratory therapists (RTs) are the only ancillary medical professionals with comprehensive training in all aspects of pulmonary medicine, including education and management of patients with chronic lung disease.[3,4]

Three issues will drive the growth of the respiratory care profession into the 21st century: an aging population with complex health care issues, ever more complex and expensive respiratory care technologies, and concern to find the most cost-effective way to face these challenges. It will become increasing clear to respiratory therapy professionals at all levels that pathophysiology drives intelligent therapy—in a very dynamic fashion! What an exciting time for the profession!

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Preface

The use of **therapist-driven protocols** (**TDPs**)—now often called simply **respiratory protocols** is an integral part of respiratory health services. TDPs provide much-needed flexibility to respiratory care practitioners and increase the quality of health care. This is because the respiratory therapy care program can be modified easily and efficiently according to the needs of the patient.

Essential cornerstones to the success of a TDP program are (1) the quality of the respiratory therapist's assessment skills at the bedside and (2) the ability to transfer objective clinical data into a treatment plan that follows agreed-upon guidelines. This textbook is designed to provide the student with the fundamental knowledge and understanding necessary to assess and treat patients with respiratory diseases in order to meet these objectives.

Part I of the textbook, *Assessment of Cardiopulmonary Disease,* contains three sections:

Section I, *Bedside Diagnosis,* consists of three chapters. Chapter 1 describes the knowledge and skills involved in the patient interview. Chapter 2 provides the knowledge and skills needed for the physical examination. Chapter 3 presents a more in-depth discussion of the pathophysiologic basis for commonly observed clinical manifestations of respiratory diseases.

Section II, *Clinical Data Obtained From Laboratory Tests and Special Procedures,* is composed of Chapters 4 through 9. Collectively, these chapters provide the reader with the essential knowledge and understanding base for the assessment of pulmonary function studies, arterial blood gases, oxygenation, the cardiovascular system (including hemodynamic monitoring), radiologic examination of the chest, and other important laboratory tests and procedures.

Section III, *The Therapist-Driven Protocol Program—The Essentials,* consists of Chapters 10, 11, and 12.

Chapter 10, "The Therapist-Driven Protocol Program," provides the reader with the essential knowledge base and step-by-step process needed to assess and implement protocols in the clinical setting. The student is provided with the basic knowledge and helpful tools to (1) gather clinical data systematically, (2) formulate an assessment (i.e., the cause and severity of the patient's condition), (3) select an appropriate and cost-effective treatment plan, and (4) document these essential steps clearly and precisely. At the end of each respiratory disorder chapter, one or more representative case studies demonstrate appropriate TDP assessment, treatment, and charting strategies. Chapter 10 is a cornerstone chapter to the fundamentals necessary for good assessment and critical-thinking skills. The case studies presented at the end of each respiratory disorder chapter often direct the reader back to Chapter 10.

Chapter 11, "Respiratory Insufficiency, Respiratory Failure, and Ventilatory Management Protocols," is a fully up-dated chapter in this eighth edition. This chapter describes how respiratory failure can be classified as (1) hypoxemic (type I) respiratory failure, (2) hypercapnic (type II) respiratory failure, or (3) a combination of both. These categories reflect the pathophysiologic basis of respiratory failure. In addition, this chapter provides the components of mechanical ventilation protocols, including the standard criteria for mechanical ventilation, the clinical indicators for both hypercapnic and hypoxemic respiratory failure, ventilatory support strategies for noninvasive and invasive mechanical ventilation, a mechanical ventilator management protocol, and a mechanical ventilation weaning protocol.

Chapter 12, "Recording Skills and Intraprofessional Communication," provides the basic foundation needed to collect and record respiratory assessments and treatment plans.

Parts II through **XIV** (Chapters 13 through 45) provide the reader with essential information regarding **common respiratory diseases**. Each chapter adheres to the following format: a description of the anatomic alterations of the lungs, etiology of the disease process, an overview of the cardiopulmonary clinical manifestations associated with the disorder, management of the respiratory disorder, one or more case studies, and a brief set of self-assessment questions. A further description of this format follows.

Anatomic Alterations of the Lungs

Each respiratory disease chapter begins with a detailed, color illustration showing the major anatomic alterations of the lungs associated with the disorder. Although a serious effort has been made to illustrate each disorder accurately at the beginning of each chapter, artistic license ("cartooning") has been taken to emphasize certain anatomic points and pathologic processes. The material that follows this section in each respiratory disorder chapter discusses the disease in terms of the following:

1. The common pathophysiologic mechanisms activated throughout the respiratory system as a result of the anatomic alterations
2. The clinical manifestations that develop as a result of the pathophysiologic mechanisms
3. The basic respiratory therapy modalities used to improve the anatomic alterations and pathophysiologic mechanisms caused by the disease

When the anatomic alterations and pathophysiologic mechanisms caused by the disorder are improved, the clinical manifestations also should improve.

Etiology

A discussion of the etiology of the disease follows the presentation of anatomic alterations of the lungs. Various causes, predisposing conditions, and common comorbidities are described.

Overview of the Cardiopulmonary Clinical Manifestations Associated With the Disorder

This section comprises the central theme of the text. The reader is provided with the clinical manifestations commonly associated with the disease under discussion. In essence, the student is given a general "overview" of the signs and symptoms commonly demonstrated by the patient. By having a working knowledge—and therefore a predetermined expectation—of the clinical manifestations associated with a specific respiratory disorder, the respiratory therapist is in a better position to:

1. Gather clinical data relevant to the patient's respiratory status
2. Formulate an objective—and measurable—respiratory assessment
3. Develop an effective and safe treatment plan that is based on a valid assessment

If the appropriate data are not gathered and assessed correctly, the ability to treat the patient effectively is lost. As mentioned earlier, the case studies presented at the end of each respiratory disorder chapter frequently refer the reader back to Chapter 10 for a broader discussion of the signs and symptoms commonly associated with the disease under discussion—the "clinical scenario." When a particular clinical manifestation is unique to the respiratory disorder, however, a discussion of the pathophysiologic mechanisms responsible for the signs and symptoms is presented in the respective chapter.

Because of the dynamic nature of many respiratory disorders, the reader should note the following regarding this section:

- Because the severity of the disease is influenced by a number of factors (e.g., the extent of the disease, age, the general health of the patient), the clinical manifestations may vary considerably from one patient to another. In fact, they may vary in the same patient from one *time* to another. Therefore the practitioner should understand that the patient may demonstrate *all* the clinical manifestations presented or just a *few.*

  For example, many of the clinical manifestations associated with a respiratory disorder may never appear in some patients (e.g., digital clubbing, cor pulmonale, increased hemoglobin level). As a general rule, however, the prototypical patient usually demonstrates most of the manifestations presented during the advanced stages of the disease.
- For a variety of practical reasons, some of the clinical manifestations presented in each chapter may not actually be measured (or measurable) in the clinical setting (e.g., age, mental status, severity of the disorder). They are nevertheless conceptually important and therefore are presented here through extrapolation. For example, the newborn with severe respiratory distress syndrome, who obviously has a restrictive lung disorder as a result of the anatomic alterations associated with the disease, cannot actually perform the maneuvers necessary for a pulmonary function study.
- It should be noted that the clinical manifestations presented in each chapter are based only on the *one respiratory disorder under discussion*. In the clinical setting, however, the patient often has a combination of respiratory problems (e.g., emphysema compromised by pneumonia) and may have manifestations related to each of the pulmonary disorders.

This section does not attempt to present the "absolute" pathophysiologic bases for the development of a particular clinical manifestation. Because of the dynamic nature of many respiratory diseases, the precise cause of some of the manifestations presented by the patient is not always clear. In most cases, however, the primary pathophysiologic mechanisms responsible for the various signs and symptoms are known and understood and are described herein.

Management of the Disease

Each chapter provides a general overview of the current more common therapeutic modalities (treatment protocols) used to offset the anatomic alterations and pathophysiologic mechanisms activated by a particular disorder.

Although several respiratory therapy modalities may be safe and effective in treating a respiratory disorder, the respiratory therapist must have a clear conception of the following:

1. How the therapies work to offset the anatomic alterations of the lungs caused by the disease
2. How the correction of the anatomic alterations of the lungs work to offset the pathophysiologic mechanisms
3. How the correction of the pathophysiologic mechanisms works to offset the clinical manifestations demonstrated by the patient

Without this understanding, the practitioner merely goes through the motions of performing therapeutic tasks without any expected or measurable outcomes.*

Case Study

The case study at the end of each respiratory disease chapter provides the reader with a realistic example of (1) the manner in which the patient may arrive in the hospital with the disorder under discussion; (2) the various clinical manifestations commonly associated with the disease; (3) the way the clinical manifestations can be gathered, organized, and documented; (4) the way an assessment of the patient's respiratory status is formulated from the clinical manifestations; and (5) the way a comprehensive treatment plan is developed from the assessment.

*The reader should understand that this book is not a respiratory pharmacology text. Its emphasis is on the appropriate modalities to be used rather than specific pharmacologic agents.

In essence, the case study provides the reader with a good example of the way in which the respiratory therapist would gather clinical data, make an assessment, and treat a patient with the disorder under discussion. In addition, many of the case studies presented in the text describe a respiratory therapist assessing and treating the patient several times—demonstrating the importance of serial assessment and the way therapy is often up-regulated or down-regulated on a moment-to-moment basis in the clinical setting.

Self-Assessment Questions

Each disease chapter concludes with a set of self-assessment questions. Answers appear at the end of the book.

Appendices and Glossary

The appendices and the glossary can be found on the Evolve website for students (http://evolve.elsevier.com/DesJardins/respiratory). The appendices that are on Evolve are as follows:

Appendix I: Symbols and Abbreviations Commonly Used in Respiratory Physiology
Appendix II: Agents Used to Treat Bronchospasm and Airway Inflammation
Appendix III: Antibiotics
Appendix IV: Antifungal Agents
Appendix V: Mucolytic and Expectorant Agents
Appendix VI: Positive Inotropes and Vasopressors
Appendix VII: Diuretic Agents
Appendix VIII: The Ideal Alveolar Gas Equation
Appendix IX: Physiologic Dead Space Calculation
Appendix X: Units of Measure
Appendix XI: Poiseuille's Law
Appendix XII: PCO_2/HCO_3^-/pH Nomogram
Appendix XIII: Calculated Hemodynamic Measurements
Appendix XIV: DuBois Body Surface Area Chart
Appendix XV: Cardiopulmonary Profile

References

A list of references is provided on the Evolve site. The student is also encouraged to review the selected references from uptodate.com, especially the "state-of-the-art" references regarding the respiratory disorders discussed throughout the textbook.

Approach

In writing this textbook, we have tried to present a realistic balance between the often-esoteric language of pathophysiology and the simple, straight-to-the-point approach generally preferred by busy students.

Terry Des Jardins, MEd, RRT
George G. Burton, MD

Acknowledgments

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Terry Des Jardins, MEd, RRT
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Introduction

The Assessment Process—An Overview

Assessment is (1) the process of collecting clinical information about the patient's health status; (2) the evaluation of the data and identification of the specific problems, concerns, and needs of the patient; and (3) the development of a treatment plan that can be managed by the respiratory therapist. The clinical information gathered may consist of subjective and objective data (signs and symptoms) about the patient, the results of diagnostic tests and procedures, the patient's response to therapy, and the patient's general health practices.

The first step in the assessment process is **THINKING**—even before the actual collection of clinical data begins. In other words, the practitioner must first "think" about why the patient has entered the health care facility and about what clinical data will likely need to be collected. Merely obtaining answers to a specific list of questions does not serve the assessment process well. For example, while en route to evaluate a patient who is said to be having an asthma episode, the respiratory therapist might mentally consider the following: What are the likely signs and symptoms that can be observed at the bedside during a moderate or severe asthma attack? What are the usual emotional responses? What are the anatomic alterations associated with an asthma episode that would be responsible for the signs and symptoms observed? Table 1 presents a broader overview of what the practitioner might think about before assessing a patient said to be having an asthma episode.

It should be noted, however, that the respiratory therapist must always be on the alert for the following pitfalls: (1) the patient may have been misdiagnosed as having a certain respiratory problem—such as asthma—when, in fact, the problem is completely different—for example, a spontaneous pneumothorax or pulmonary embolus; (2) there are other abnormal conditions present that further compromise the patient's illness; or (3) there is no history or obvious signs or symptoms to enhance the practitioner's ability to identify the precise cause of the patient's respiratory problem. In short, the respiratory therapist must always be prepared to go through a complete and systematic approach to appropriately assess and treat the patient.

Purpose of Assessment

Relative to the purpose, an assessment may involve asking just two or three specific questions or it may involve an in-depth conversation with the patient. An assessment may involve a comprehensive focus (head-to-toe assessment) or a specific or narrow focus. The purpose of the assessment may include any of the following:

- To obtain a baseline databank about the patient's physical and mental status
- To supplement, verify, or refute any previous data
- To identify actual and potential problems
- To obtain data that will help the practitioner establish an assessment and treatment plan
- To focus on specific problems
- To determine immediate needs and establish priorities
- To determine the cause (etiology) of the problem
- To determine any related or contributing factors, such as comorbidities
- To identify patient strengths as a basis for changing behavior
- To identify the risk for complications
- To recognize complications

Types of Assessment

There are four major types of assessment: initial, focused, emergency, and ongoing.

The *initial assessment* is conducted at the first encounter with the patient. In the hospitalized patient, the initial assessment is typically performed by the admitting nurse and is more comprehensive than subsequent assessments. It starts with the reasons that prompted the patient to seek care and entails a holistic overview of the patient's health care needs. The general objective of the initial assessment is to rule out as well as to identify (rule in) specific problems. The initial assessment most commonly occurs when the patient has sought medical services for a specific problem or desires a general health status examination. The goals of the initial assessment include prevention, maintenance, restoration, or rehabilitation. In general, the thoroughness of the initial assessment is directly related to the length of expected care. In other words, discharge planning should begin at the time of the initial assessment!

The *focused assessment* consists of a detailed examination of the specific problem areas, or patient complaints. The focused assessment looks at clinical data in detail, considers possible causes, looks at possible contributing factors, and examines the patient's personal characteristics that will help—or hinder—the problem. The focused assessment also is used when the patient describes or manifests a new problem. Common patient complaints include pain, shortness of breath, dizziness, and fatigue. The practitioner must be prepared to evaluate the severity of such problems, assess the possible cause, and determine the appropriate plan of action.

TABLE 1 Examples of Topics That Might Be Considered Before Evaluating a Patient Having an Asthma Episode

Questions and/or Considerations	Likely Responses
What are the likely initial observations?	Shortness of breath, use of accessory muscles to breathe, intercostal retractions, pursed-lip breathing; cyanosis, barrel chest
What might be the patient's emotional response to his/her asthma?	Anxiety, concerned, frightened
What anatomic alterations of the lungs are associated with asthma?	Bronchospasm; excessive, thick, white, and tenacious bronchial secretions; air trapping; mucous plugging
What are the known causes of asthma?	*Extrinsic factors:* Pollen, grass, house dust, animal dander *Intrinsic factors:* Infection, cold air, exercise, emotional stress
What are the expected vital signs?	Increased respiratory rate, heart rate, and blood pressure
What are the expected chest assessment findings?	*Breath sounds:* Diminished, wheezing, crackles *Percussion:* Hyperresonant
What are the expected pulmonary function study findings?	*Decreased:* PEFR, FEF_T, FEV_T/FVC *Increased:* RV, FRC
What are the expected acute arterial blood gas findings?	*Early stage:* ↑ pH, ↓ $PaCO_2$, ↓ HCO_3^- (slightly), ↓ PaO_2, ↓ SaO_2 and SpO_2 *Late (severe) stage:* ↓ but normal pH, ↑ $PaCO_2$, ↑ HCO_3^- (slightly), ↓ PaO_2, ↓ SaO_2 and SpO_2
What are the expected chest radiograph findings?	Translucent lung fields; hyperinflated alveoli; depressed diaphragm
What are the usual respiratory treatments?	Bronchodilator therapy, bronchial hygiene therapy; oxygen therapy
What complications can occur?	Poor response to oxygen and bronchodilator therapy, acute ventilatory failure, severe hypoxia, mechanical ventilation

The *emergency assessment* identifies—or rules out—any life-threatening problems or problems that require immediate interventions. When the patient's medical condition is life threatening or when time is of the essence, the emergency assessment will include only key data needed for dealing with the immediate problem. Additional information can be gathered after the patient's condition has stabilized. The emergency assessment always follows the basic "ABCs" of cardiopulmonary resuscitation (i.e., the securing of the patient's *a*irway, *b*reathing, and *c*irculation).

The *ongoing assessment* consists of the data collection that occurs during each contact with the patient throughout the patient's hospital stay. Depending on the patient's condition, ongoing assessments may take place hourly, daily, weekly, or monthly. In fact, for the critically ill patient, assessments often take place continuously via electronic monitoring equipment. Ongoing assessments also take place while a patient is receiving anesthesia, as well as afterward until the effects of the anesthesia have worn off.

Respiratory therapists routinely make decisions about the frequency, depth, and breadth of the assessment requirements of the patient. To make these decisions effectively, the practitioner must anticipate the potential for a patient's condition to change, the speed at which it could change, and the clinical data that would justify a change. For example, when a patient experiencing an asthma episode inhales the aerosol of a selected bronchodilator, assessment decisions are based on the expected onset of drug action, expected therapeutic effects of the medication, and potential adverse effects that may develop.

Types of Data

Clinical information that is provided by the patient, and that cannot be observed directly, is called *subjective data*. When a patient's subjective data describe characteristics of a particular disorder or dysfunction, they are known as *symptoms*. For example, shortness of breath (dyspnea), pain, dizziness, nausea, and ringing in the ears are symptoms because they cannot be quantitated directly. The patient must communicate to the health care provider the symptoms he/she is experiencing and rate them as to severity. The patient is the only source of information about subjective findings.

Characteristics about the patient that can be observed directly by the practitioner are called *objective data*. When a patient's objective data describe characteristics of a particular disorder or dysfunction, they are known as *signs*. For example, swelling of the legs (pedal edema) is a sign of congestive heart failure. Objective data can be obtained through the practitioner's sense of sight, hearing, touch, and smell. Objective information can be measured (or quantified), and it can be replicated from one practitioner to another—a concept called *interrater reliability*. For example, the respiratory therapist can measure the patient's pulse, respiratory rate, blood pressure, inspiratory effort, and arterial blood gases. Because objective data are factual, they have a high degree of certainty.

Data Collection

To collect data wisely, health care providers must have well-developed skills in observing and listening. In addition, the practitioner must apply his/her mental skills of translation, reason, intuition, and validation to render the clinical data meaningful. Clinically, the collection of data is more useful when the evaluation process is organized into common problem areas, or categories. As the practitioner gathers information in each problem category, a clustering of related data about the patient will be generated. This framework for collecting clinical information enhances the practitioner's ability to establish priorities of care. Furthermore, any time the health care provider interacts with the patient, for any reason, an assessment of the patient's problems, needs, and concerns should be made. To efficiently and correctly gather data, the health care provider must make decisions about what type of assessment is needed, how to obtain the data, the framework and focus of the assessment, and what additional data may be needed before a complete treatment plan can be developed.

Sources of Data

Sources of clinical information include the patient, the patient's significant others, other members of the health care team, the patient's history and physical examination, and results of a variety of clinical tests and procedures. The practitioner must confirm that each data source is appropriate, reliable, and valid for the patient's assessment. *Appropriate* means the source is suitable for the specific purpose, patient, or event. *Reliable* means that the practitioner can trust the data to be accurate and honestly reported. *Valid* means that the clinical data can be verified or confirmed.

The Assessment Process—Role of the Respiratory Therapist

When the lungs are affected by disease or trauma, they are anatomically altered to some degree, depending on the severity of the process. In general, the anatomic alterations caused by an injury or disease process can be classified as resulting in an obstructive lung disorder, a restrictive lung disorder, or a combination of both. Common anatomic alterations associated with obstructive and restrictive lung disorders are illustrated in Fig. 1. Common respiratory diseases and their general classifications are listed in Table 2.

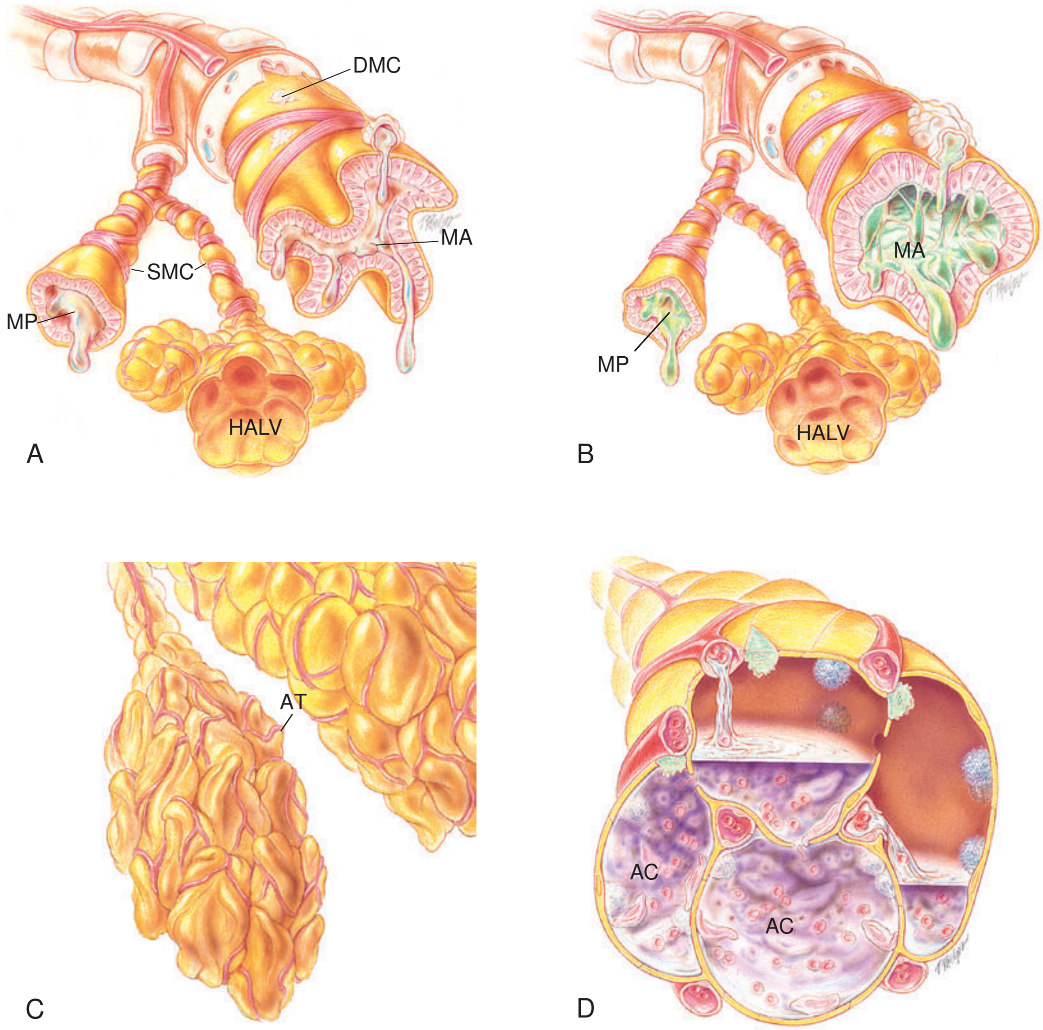

FIGURE 1 (A and B) Common anatomic alterations of the lungs in obstructive lung disorders. (A) Bronchial smooth muscle constriction accompanied by air trapping (as seen in asthma). (B) Tracheobronchial inflammation accompanied by mucus accumulation, partial airway obstruction, and air trapping (as seen in bronchitis). (C and D) Common anatomic alterations of the lungs in restrictive lung disorders. (C) Alveolar collapse or atelectasis (as seen in postoperative patients). (D) Alveolar consolidation (as seen in pneumonia). *AC,* Alveolar consolidation; *AT,* atelectasis; *DMC,* degranulation of mast cell; *HALV,* hyperinflated alveoli; *MA,* mucus accumulation; *MP,* mucus plug; *SMC,* smooth muscle constriction.

TABLE 2 General Classification of Respiratory Diseases

Respiratory Disease	Classification: Obstructive	Restrictive	Combination
Chronic obstructive pulmonary disease (chronic bronchitis and emphysema)	X		
Asthma	X		
Cystic fibrosis			X
Bronchiectasis			X
Atelectasis		X	
Pneumonia (lung abscess and fungal disease)		X	
Tuberculosis		X	
Pulmonary edema		X	
Flail chest		X	
Pneumothorax		X	
Pleural effusion		X	
Kyphoscoliosis		X	
Cancer of the lungs		X	
Chronic interstitial lung disease			X
Acute respiratory distress syndrome		X	
Meconium aspiration syndrome			X
Transient tachypnea of the newborn			X
Respiratory distress syndrome		X	
Pulmonary air leak syndrome			X
Respiratory syncytial virus			X
Chronic lung disease of infancy (bronchopulmonary dysplasia)			X
Diaphragmatic hernia		X	
Near drowning	X		

When the normal anatomy of the lungs is altered, certain pathophysiologic mechanisms throughout the cardiopulmonary system are activated. These pathophysiologic mechanisms in turn produce a variety of clinical manifestations specific to the illness. Such clinical manifestations can be readily—and objectively—identified in the clinical setting (e.g., increased heart rate, depressed diaphragm, or an increased functional residual capacity). Because differing chains of events happen as a result of anatomic alterations of the lungs, treatment selection is most appropriately directed at the basic causes of the clinical manifestations—that is, the anatomic alterations of the lungs. For example, a bronchodilator is used to offset the bronchospasm associated with an asthma episode.

The Knowledge Base

A strong knowledge base of the following four factors is essential to good respiratory care assessment and therapy selection skills:

1. Anatomic alterations of the lungs caused by common respiratory disorders
2. Major pathophysiologic mechanisms activated throughout the respiratory system as a result of the anatomic alterations
3. Common clinical manifestations
4. Treatment modalities used to correct the anatomic alterations and pathophysiologic mechanisms caused by the disorder

Specific Components of the Assessment Process

The respiratory therapist with good assessment and treatment selection skills also must be competent in performing the actual assessment process, which has the following components:

1. Quick and systematic collection of the important clinical manifestations demonstrated by the patient
2. Formulation of an accurate assessment of the clinical data—that is, identification of the cause and severity of the data abnormalities
3. Selection of the optimal treatment modalities
4. Quick, clear, and precise documentation of this process

Without this basic knowledge and understanding, the respiratory therapist merely goes through the motions of performing assigned therapeutic tasks with no measurable short- or long-term anticipated outcomes. In such an environment, the practitioner works in an unchallenging, task-oriented rather than goal-oriented manner.

Goal-orientated—patient-oriented—respiratory care became the standard of practice in the early 1990s by analyzing the work performance of other health care disciplines. For example, physical therapists have long been greatly empowered by virtue of the more generic physician's orders under which they work, whereas the respiratory therapists customarily received detailed and specific orders. For example, physical therapists are instructed to "improve back range of motion" or "strengthen quadriceps muscle groups," rather than to "provide warm fomentations to the lower back" or "initiate quadriceps setting exercises with 10-pound ankle weights, four times a day, for 10 minutes." In addition, and, importantly, the physical therapist has long been permitted to start, up-regulate, down-regulate, or discontinue the therapy on the basis of the patient's current needs and capabilities, not on the basis of a 2-hour-, 2-day-, or 2-week-old physician assessment. *Goal achievement,* not task completion, is the way the success of physical therapy is routinely measured.

In the current "sicker in, quicker out" cost-conscious environment, a change has come to respiratory care. Under fixed reimbursement programs, shorter lengths of stay have required hospital administrators and medical staff to examine allocation of health care resources. Recent data suggest that fully one-third of all hospitalized patients receive respiratory care services; therefore such services have come under close scrutiny. Studies using available peer-reviewed clinical practice guidelines have identified tremendous overuse (and, less frequently, underuse) of therapy modalities, and from this misallocation, the now firmly entrenched "therapist-driven protocol" (TDP) approach has emerged as the gold standard of respiratory care practice. Observing that the patient (and more accurately, the pulmonary pathophysiology!) should set the pace, some centers have called these protocols "patient-driven protocols," but the appellation of TDP or just "respiratory therapy protocols" has caught on more strongly. Clinical practice guidelines (CPGs), such as those developed by the American Association of Respiratory Care (AARC) and organizations such as the American Thoracic Society (ATS) and the American College of Chest Physicians (ACCP), are routinely used as the basis for TDPs in respiratory care.

The ACCP defines respiratory care protocols as follows:

> *"Patient care plans which are initiated and implemented by credentialed respiratory care workers. These plans are designed and developed with input from physicians and are approved for use by the medical staff and the governing body of the hospitals in which they are used. They share in common extreme reliance on assessment and evaluation skills. Protocols are by their nature dynamic and flexible, allowing up- or down-regulation of intensity of respiratory services. Protocols allow the respiratory care practitioner authority to evaluate the patient, [to] initiate care, to adjust, discontinue, or restart respiratory care procedures on a shift- by-shift or hour-to-hour basis once the protocol is ordered by the physician. They must contain clear strategies for various therapeutic interventions, while avoiding any misconception that they infringe on the practice of medicine."*

Numerous studies have now shown beyond a shadow of a doubt that when respiratory care protocol guidelines are followed appropriately, the outcomes of respiratory care services improve. This improvement is noted in both clinical and economic ways (e.g., shorter ventilator weaning time in postoperative coronary artery bypass graft [CABG] patients). Under this paradigm, respiratory care that is inappropriately ordered is either withheld or modified (whichever is appropriate), and patients who *need* respiratory care services (but are not receiving them) should now be able to receive care. (Chapters 10 and 11 discuss in detail the structure and implementations of a good TDP program.)

The notion that today's respiratory therapist "might" practice in the TDP setting has passed. Respiratory therapists who find that they are working in an archaic clinical setting—where protocols are not in daily use—should critically reexamine their employment options and career goals! To practice in today's health care environment without the cognitive (thinking) skills used in the protocol-rich environment is no longer acceptable—*and, importantly, can have serious, negative legal consequences*!

Experience, however, indicates that at least *some* respiratory therapists are not entirely comfortable with the new role and responsibility the TDP paradigm has thrust on them. These workers have difficulty separating the contents of *their* "little black bag" of diagnostic and therapeutic modalities from the one traditionally carried and used by the physician. The choice to be a "protocol safe and ready therapist," however, is no longer elective. The profession of respiratory care has changed and moved on. The Clinical Simulation Examination portion of the National Board for Respiratory Care (NBRC) Advanced Practitioner Examination reflects the actual, no longer just "simulated," bedside practice of respiratory care.

Similar to their physical therapist colleagues, today's respiratory therapists are now routinely asked to participate actively in the appropriate allocation of respiratory care services. Modern respiratory therapists must possess the basic knowledge, skills, and personal attributes to collect and assess clinical data and treat their patients effectively. Under the TDP paradigm, specific clinical indicators (clinical manifestations) for a particular respiratory care procedure must first be identified. In other words, a specific treatment plan is only started, up-regulated, down-regulated, or discontinued on the basis of the following:

1. The presence and collection of specific clinical indicators
2. An assessment made from the clinical data (i.e., the cause of the clinical data) that justifies the therapy order or change

In addition, after a particular treatment has been administered to the patient, all treatment outcomes must be measured and documented. Clearly, the success or failure of protocol work depends on accurate and timely patient assessment.

In view of these considerations, today's respiratory therapist *must* have competent bedside pulmonary assessment skills. Fundamental to this process is the ability to systematically gather clinical data, make an assessment, and develop an appropriate, safe, and effective action plan. Typically, once a treatment regimen has been implemented, the patient's progress is monitored on an ongoing assessment basis. In other words, clinical data are, again, collected, evaluated, and acted on based on the patient's response and progress toward a predefined goal.

To be fully competent in the assessment and treatment of respiratory disorders, the respiratory therapist must first have a strong academic foundation in the areas presented in Part I of this textbook. Part I is divided into three sections:

I. Bedside Diagnosis
II. Clinical Data Obtained From Laboratory Tests and Special Procedures
III. The Therapist-Driven Protocol Program—The Essentials

These three sections provide the reader with the essential knowledge base to assess and treat the patient with respiratory disease. The respiratory therapist must master the material in these sections to work efficiently and safely in a good TDP program.

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Contents

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PART I

Assessment of Cardiopulmonary Disease

SECTION I **Bedside Diagnosis**

CHAPTER 1

The Patient Interview

Chapter Objectives

After reading this chapter, you will be able to:

- Describe the major items found on a patient history form.
- Explain the primary tasks performed during the patient interview.
- Describe the internal factors the practitioner brings to the interview.
- Discuss the external factors that provide a good physical setting for the interview.
- Describe the cultural, religious, and spiritual issues in the patient interview.
- Differentiate between open-ended questions and closed or direct questions.
- Describe the nine types of verbal responses.
- Describe the nonproductive verbal messages that should be avoided during the patient interview.
- List the positive and negative nonverbal messages associated with the patient interview.
- Describe how to close the interview.
- Discuss the pitfalls and weaknesses associated with the patient interview.
- Define key terms and complete self-assessment questions at the end of the chapter and on Evolve.

Key Terms

Body language
Clarification
Closed or Direct Questions
Confrontation
Empathy
Explanation
External Factors
Facilitation
Internal Factors
Interpretation
Nonproductive Verbal Messages
Nonverbal Techniques
Open-Ended Questions
Reflection
Silence
Summary

Chapter Outline

Patient History

A complete patient assessment starts and ends with the patient interview. The purpose of the patient history is to gather pertinent historical subjective and objective data, which in turn can be used to develop a more complete picture of the patient's past and present health. In most nonacute clinical settings the patient is asked to fill out a printed history form or checklist. The patient should be allowed ample time to recall important dates, health-related landmarks, and family history. The patient interview is then used to validate what the patient has written and collect additional data on the patient's health status and lifestyle. Although history forms vary, most contain the following:

- Biographic data (age, gender, occupation)
- The patient's chief complaint or reason for seeking care, including the onset, duration, and characteristics of the signs and symptoms

- Present health or history of present illness
- List of current medications
- Reasons for stopping medications
- Past health, including childhood illnesses, accidents or injuries, serious or chronic illnesses, hospitalizations, operations, obstetric history, immunizations, last examination date, allergies, current medications, and history of smoking or other habits
- The patient's family history
- Review of each body system, including skin, head, eyes, ears, and nose, mouth and throat, respiratory system, cardiovascular system, gastrointestinal system, urinary system, genital system, and endocrine system
- Functional assessment (activities of daily living), including activity and exercise, work performance, sleep and rest, nutrition, interpersonal relationships, and coping and stress management strategies

The Patient Interview

The interview is a meeting between the respiratory care practitioner and the patient. It allows the collection of subjective data about the patient's feelings regarding his/her condition. During a successful interview, the practitioner performs the following tasks:

1. Gathers complete and accurate data about the patient's impressions about his or her health, including a description and chronology of any symptoms
2. Establishes rapport and trust so the patient feels accepted and comfortable in sharing all relevant information
3. Develops and shows interest in, and understanding about, the patient's health state, which in turn enhances the patient's participation in identifying problems

Interview skills are an art form that takes time and experience to develop. The most important components of a successful interview are communication and understanding. Understanding the various signals of communication is the most difficult part. An inability to convey the meaning of messages will lead to miscommunication between the practitioner and the patient.

Communication cannot be assumed just because two people have the ability to speak and listen. Communication is about behaviors—conscious and unconscious, verbal and nonverbal. All of these behaviors convey meaning. The following paragraphs describe important factors that enhance the sending and receiving of information during communication.

Internal Factors

Internal factors encompass what the practitioner brings to the interview—a genuine concern for others, empathy, understanding, and the ability to listen. A genuine liking of other people is essential in developing a strong rapport with the patient. It requires a generally optimistic view of people, a positive view of their strengths, and a nonjudgmental acceptance of their weaknesses. This affection generates an atmosphere of warmth and caring. The patient must feel accepted unconditionally.

Empathy is the art of viewing the world from the patient's point of view while remaining separate from it. Empathy entails recognition and acceptance of the patient's feelings without criticism. It is sometimes described as feeling with the patient rather than feeling like the patient. To have empathy the practitioner needs to listen. Listening is not a passive process. Listening is active and demanding. It requires the practitioner's complete attention. If the examiner is preoccupied with personal needs or concerns, he or she will invariably miss something important. Active listening is a cornerstone to understanding. Nearly everything the patient says or does is relevant.

During the interview the examiner should observe the patient's **body language** and note the patient's facial expressions, eye movement (e.g., avoiding eye contact, looking into space, diverting gaze), pain grimaces, restlessness, and sighing. The examiner should listen to the way things are said. For example, is the tone of the patient's voice normal? Does the patient's voice quiver? Are there pitch breaks in the patient's voice? Does the patient say only a few words and then take a breath? Such behaviors are often in opposition to what the patient is verbalizing, and further investigation may be indicated.

External Factors

External factors, such as a good physical setting, enhance the interviewing process. Regardless of the interview setting (the patient's bedside, a crowded emergency room, an office in the hospital or clinic, or the patient's home), efforts should be made to (1) ensure privacy, (2) prevent interruptions, and (3) secure a comfortable physical environment (e.g., comfortable room temperature, sufficient lighting, absence of noise). The interviewer's use of the *electronic health record* (EHR), also called the *electronic medical record* [EMR]), and its associated hardware can be threatening. In some cases, this may be a potential hazard to good patient communication—especially when combined with the anxiety that is often generated by simply being in the hospital and interacting with the various professional staff members about health issues, test results, and medical procedures; this form of anxiety is often referred to as the "white coat syndrome." In this situation, the patient can be intimidated to the point of "shutting down" and failing to ask questions or learn from the interview. In addition, the interviewer's focus is often shifted from the patient to the EHR and this can cause him/her to overlook important verbal and nonverbal messages. This situation also has the potential to cause patients to think they are not important.

Many respiratory care interviews must be performed in a much more hurried atmosphere than those described in this chapter—that is, relaxed and at the bedside of hospitalized patients. On many occasions, however, time is of the essence. Indeed, in some instances—such as in a "code" situation or emergency room visit—*no* interview may take place at all! Nevertheless, the thoughtful examiner should take away from this section the following conclusion: In any clinical setting, patients should think that their concerns are being heard—and, when things seem rushed, it should be understood that it is only because the urgency of the situation, *at that moment,* demands it! Even in these situations, however, the good interviewer should be able to modify and adapt his/her questions to a given clinical situation and patient ability. For example, if the patient is unable to speak, the respiratory therapist can simply phrase questions so they can be answered (or signed) with a "yes" or "no."

Cultural Sensitivity and Religious and Spirituality Considerations

Culture, religion, and spirituality strongly influence the way in which people think and behave and because of this have a definite and profound effect on their journey through the health care system. For example, in some cultures, the oldest man is the decision-maker for the rest of the family, including the making of health care decisions. In other cultures, elderly patients may be especially upset when an illness or hospitalization interrupts their religious practice. Failure to recognize cultural sensitivities can result in stereotyping, discrimination, racism, and prejudice. Future health care practitioners are now routinely trained in these considerations in "diversity" classes.

Culture can be defined as the values, beliefs, and practices shared by the majority in a group of people. Culture includes language, religious or spiritual practices, foods, social habits, music, and art accepted and expected by a cultural group. Although the terms *religion* and *spirituality* are often used interchangeably, they are different. *Religion* refers to a formalized system of belief and worship (e.g., Catholicism, Protestantism, Hinduism, Buddhism, etc.). *Spirituality* entails the spirit, or soul, and is an element of religion. It is intangible and may include a belief in a higher power, creative force, or divine being or a belief in spirits of departed people and the supernatural.

In the current health care system, all practitioners must work to develop cultural awareness, cultural sensitivity, and cultural competence to deliver effective care. *Cultural awareness* involves the knowledge of the patient's history and ancestry and an understanding of the patient's beliefs, artistic expressions, diets, celebrations, and rituals. *Cultural sensitivity* refers to refraining from using offensive language, respecting accepted and expected ways to communicate, and not speaking disrespectfully of a person's cultural beliefs. *Cultural competence* refers to knowing the health care practitioner's *own* values, attitudes, beliefs, and prejudices while, at the same time, keeping an open mind and trying to view the world through the perspective of culturally diverse groups of people.

All health care practitioners should continue to learn whatever they can about other cultures. When in doubt, the health care practitioner should simply ask the patient's preferences, rather than trying to guess or to stereotype the patient based on previous experiences with other cultures. Although mastery of the subject of diversity will be a lifelong learning process, the following cultural aspects are always a good place to start and should be routinely considered when caring for patients from different cultures:

- What is the patient's preferred method of communication?
- What is the appropriate form of address within the patient's culture?
- Are there potential language barriers (verbal and nonverbal)?
- Is an interpreter needed?
- Is the setting appropriate for the interview? Too private? Too public?
- What roles for women, men, and children are generally accepted within the patient's culture?
- Should a person of the same sex or religious persuasion as the patient be present at the interview?
- Are there religious and/or spiritual beliefs that need to be respected?
- Is direct eye contact considered polite or rude?
- What amount of space between the examiner and the patient is considered appropriate when communicating?
- What are the hidden meanings of nonverbal gestures such as head nodding, smiling, and hand gestures? Are these acceptable or not?
- When, where, and by whom is touch acceptable?
- Who is/are the primary decision-maker(s) within the culture and family?
- What are the appropriate manners and dress attire of a person considered a "professional"?

Health Literacy

Health literacy is defined as the patient's capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions and follow instructions for treatment. Health literacy includes the patient's ability to read, listen, analyze, and make decisions regarding his/her specific health situations. For example, an individual's degree of health literacy level includes the ability to understand the instructions that accompany prescription drugs, appointment slips, medical education brochures, doctor's directions and consent forms, and the ability to navigate the health care system, including filling out complex forms and locating providers and services.

It is estimated that more than 85% of adults in the United States have basic or below acceptable basic health literacy. In other words, nearly 9 in 10 adults may lack the skills needed to manage their health and prevent disease. Factors that affect health literacy include the patient's literacy skills, communication skills, health knowledge, demographics, culture and linguistic suitability, information dissemination channels, the complexity of the public health infrastructure, the health care provider's communication skills, and the patient's past experiences. In addition, health literacy includes numeracy skills. For example, calculating cholesterol and blood glucose levels, measuring medications, and understanding nutrition labels all require mathematical skills. The understanding of a simple *x-y* plot is beyond most patients and many health professionals. Moreover, choosing among different health plans or comparing prescription drug coverage often involves calculating premiums, copays, and deductibles.

Even for the individual with an advanced health literacy level, the ability to process medical information sometimes can be overwhelming. Medical equipment, techniques, and therapeutic procedures change rapidly. What an individual learned about certain health conditions or biology a few years ago often is outdated and obsolete today. Finally, it should be noted that health information presented during stressful or unfamiliar situations is not likely to be *retained* by the patient. Considerations of short-term or long-term memory problems, especially in older patients, open another set of issues in this category.

Enhancing the Value of the Health History

To enhance the accuracy of written and oral information, the plain language approach is the best strategy. Plain language is a verbal or written communication designed to ensure the intended audience quickly and fully understands the information presented. Plain language avoids verbose, convoluted language, medical terms the patient may not understand, and jargon. It is a language that avoids vagueness, inflated vocabulary, and long-winded written or verbal sentence construction. On the other hand, it is not baby talk, nor is it a simplified version of the English language. It is simply a clear, straightforward form of communication. In fact, in many countries, laws mandate that the public agencies use plain language to increase access to programs and services. The key elements of plain language include:

- Organization of information so that the most important points are presented first
- Extraction and presentation of complex information in small, understandable sections of one at a time
- Use of short sentences and common everyday words
- Use of active voice—for example, Jane changed the flat tire (active) versus the tire was changed by Jane (passive).
- Avoidance of technical terms and jargon
- Use of follow-up questions, such as "Do you understand?" or "Do you have any questions?" when communicating verbally

Finally, language that is plain and easy to understand for one group of people may not be clear and easy to comprehend to another group. Know one's audience and have written material tested and revised when necessary. The primary responsibility for improving health literacy belongs primarily to health professionals, health care facilities, and hospital systems, not the patient!

Techniques of Communication

During the interview, the patient should be addressed by his or her surname and the examiner should introduce himself or herself and state the purpose for being there. The following introduction serves as an example: "Good morning, Mr. Jones. I'm Phil Smith, and I'm your respiratory therapist today. I want to ask you some questions about your breathing so we can plan your respiratory care here in the hospital."

Verbal techniques of communication used by the examiner to facilitate the interview may include the skillful use of open-ended questions or closed or direct questions and responses.

Open-Ended Questions

An **open-ended question** asks the patient to provide narrative information. The examiner identifies the topic to be discussed but only in general terms. This technique is commonly used (1) to begin the interview, (2) to introduce a new section of questions, or (3) to gather further information whenever the patient introduces a new topic. The following are examples of open-ended questions:

"What brings you to the hospital today?"
"Tell me why you have come to the hospital today."
"Can you describe what your breathing has been like today?"
"You said that you have been short of breath. Tell me more about that."

The open-ended question is unbiased; it allows the patient freedom to answer in any way. This type of question encourages the patient to respond at greater length and give a spontaneous account of the condition. As the patient answers, the examiner should stop and listen. Patients often answer in short phrases or sentences and then pause, waiting for some kind of direction from the examiner. What the examiner does next is often the key to the direction of the interview. If the examiner presents new questions on other topics, much of the initial story may be lost. Ideally, the examiner should first respond by saying such things as "Tell me about it" and "Anything else?" The patient will usually add important information to the story when encouraged to expand with more details.

Closed or Direct Questions

A **closed or direct question** asks the patient for specific information. This type of question elicits a short one-word or two-word answer, a yes or no, or a forced choice. The closed question is commonly used after the patient's narrative to fill in any details the patient may have left out. Closed questions are also used to obtain specific facts, such as "Have you ever had this chest pain before?" Closed or direct questions speed up the interview and are often useful in emergency situations when the patient is unable to speak in complete sentences. The use of only open-ended questions is unwieldy and takes an unrealistic amount of time, causing undue stress in the patient. Box 1.1 compares closed and open-ended questions.

Responses: Assisting the Narrative

As the patient answers the open-ended questions, the examiner's role is to encourage free expression but not let the patient digress. The examiner's responses work to clarify the story. There are nine types of verbal responses. In the first five responses the patient leads; in the last four responses the examiner leads.

The first five responses require the examiner's reactions to the facts or feelings the patient has communicated. The examiner's response focuses on the *patient's* frame of reference; the examiner's frame of reference is not relevant. For the last four responses the examiner's reaction is not absolutely required. The frame of reference shifts from the patient's perspective to the examiner's perspective. These responses include the

BOX 1.1 Comparison of Closed and Open-Ended Questions

Open-Ended Questions	Closed Questions
Used for narrative	Used for specific information
Call for long answers	Call for short one- or two-word answers
Elicit feelings, options, ideas	Elicit "cold facts"
Build and enhance rapport	Limit rapport and leave interaction neutral

examiner's thoughts or feelings. The examiner should use these responses only when the situation calls for them. If these responses are used too often, the interview becomes focused more on the examiner than on the patient. The nine responses are described in the following sections.

Facilitation

Facilitation encourages patients to say more, to continue with the story. Examples of facilitating responses include the following: "Mm hmm," "Go on," "Continue," "Uh-huh." This type of response shows patients that the examiner is interested in what they are saying and will listen further. Nonverbal cues, such as maintaining eye contact and shifting forward in the seat, also encourage the patient to continue talking.

Silence

Silent attentiveness is effective after an open-ended question. **Silence** communicates that the patient has time to think and organize what he or she wishes to say without interruption by the examiner.

Reflection

Reflection is used to echo the patient's words. The examiner repeats a part of what the patient has just said to clarify or stimulate further communication. Reflection helps the patient focus on specific areas and continue in his or her own way. The following is a good example:

PATIENT: "I'm here because of my breathing. It's blocked."

EXAMINER: "It's blocked?"

PATIENT: "Yes, every time I try to exhale, something blocks my breath and prevents me from getting all my air out."

Reflection also can be used to express the emotions implicit in the patient's words. The examiner focuses on these emotions and encourages the patient to elaborate:

PATIENT: "I have three little ones at home. I'm so worried they're not getting the care they need."

EXAMINER: "You feel worried and anxious about your children."

The examiner acts as a mirror reflecting the patient's words and feelings. This technique helps the patient elaborate on the problem and, importantly, further helps the examiner ensure that he or she correctly understands what the patient is attempting to communicate.

Empathy

Empathy is defined as the identification of oneself with another and the resulting capacity to feel or experience sensations, emotions, or thoughts similar to those being experienced by another person. It is often characterized as the ability to "put oneself into another's shoes." A physical symptom, condition, or disease frequently has accompanying emotions. Patients often have trouble expressing these feelings. An empathic response recognizes these feelings and allows expression of them:

PATIENT: "This is just great! I used to work out every day, and now I don't have enough breath to walk up the stairs!"

EXAMINER: "It must be hard—you used to exercise every day, and now you can't do a fraction of what you used to do."

The examiner's response does not cut off further communication, which would occur by giving false reassurance (e.g., "Oh, you'll be back on your feet in no time"). Also, it does not deny the patient's feelings nor does it suggest that the patient's feelings are unjustified. An empathic response recognizes the patient's feelings, accepts them, and allows the patient to express them without embarrassment. It strengthens rapport.

Clarification

Clarification is used when the patient's choice of words is ambiguous or confusing:

"Tell me what you mean by bad air."

Clarification is also used to summarize and simplify the patient's words. When simplifying the patient's words, the examiner should ask whether the paraphrase is accurate. The examiner is asking for agreement, and this allows the patient to confirm or deny the examiner's understanding.

Confrontation

In using **confrontation**, the examiner notes a certain action, feeling, or statement made by the patient and focuses the patient's attention on it:

"You said it doesn't hurt when you cough, but when you cough you grimace."

Alternatively, the examiner may focus on the patient's affect:

"You look depressed today."

"You sound angry."

Interpretation

Interpretation links events and data, makes associations, and implies causes. It provides the basis for inference or conclusion:

"It seems that every time you have a serious asthma attack, you have had some kind of stress in your life."

In using this attempt at clarification, the examiner runs the risk for making an incorrect inference. However, if the patient corrects the inference, his/her response often serves to prompt further discussion of the topic.

Explanation

Explanation provides the patient with factual and objective information:

"It is very common for your heart rate to increase a bit after a bronchodilator treatment."

Summary-Making

The **summary** is the final overview of the examiner's understanding of the patient's statements. It condenses the facts and presents an outline of the way the examiner perceives the patient's respiratory status. It is a type of validation in that the patient can agree or disagree with the examiner's summary. Both the examiner and the patient should participate in the summary. The summary signals that the interview is about to end.

Nonproductive Verbal Messages

In addition to the verbal techniques commonly used to enhance the interview, the examiner must refrain from making **nonproductive verbal messages**. These defeating messages restrict the patient's response. They act as barriers to obtaining data and establishing rapport.

Providing Assurance or Reassurance

Providing assurance or reassurance gives the examiner the false sense of having provided comfort. In fact, this type of response probably does more to relieve the examiner's anxiety than that of the patient.

PATIENT: "I'm so worried about the mass the doctor found on my chest x-ray. I hope it doesn't turn out to be cancer! What happens to your lung?"

EXAMINER: "Now, don't worry. I'm sure you will be all right. You have a very good doctor."

The examiner's response trivializes the patient's concern and effectively halts further communication about the topic. Instead, the examiner might have responded in a more empathic way:

"You are really worried about that mass on your x-ray, aren't you? It must be very hard to wait for the lab results."

This response acknowledges the patient's feelings and concerns and, more important, keeps the door open for further communication.

Giving Advice

A key step in professional growth is to know when to give advice and when to refrain from it. Patients will often seek the examiner's professional advice and opinion on a specific topic:

"What types of things should I avoid to keep my asthma under control?"

This is a straightforward request for information that the examiner has and the patient needs. The examiner should respond directly, and the answer should be based on knowledge and experience. The examiner should refrain from dispensing advice that is based on a hunch or feeling. For example, consider the patient who has just seen the doctor:

"Dr. Johnson has just told me I may need an operation to remove the mass they found in my lungs. I just don't know. What would you do?"

If the examiner answers, the accountability for the decision shifts from the patient to the examiner. The examiner is not the patient. The patient must work this problem out. In fact, the patient probably does not really want to know what the examiner would do. In this case, the patient is worried about what he or she might have to do. A better response is reflection:

EXAMINER: "Have an operation?"

PATIENT: "Yes, and I've never been put to sleep before. What do they do if you don't wake up?"

Now the examiner knows the patient's real concern and can work to help the patient deal with it. For the patient to accept advice, it must be meaningful and appropriate. For example, in planning pulmonary rehabilitation for a male patient with severe emphysema, the respiratory therapist advises him to undertake a moderate walking program. The patient may treat the therapist's advice in one of two ways—either follow it or not. Indeed, the patient may choose to ignore it, thinking that it is not appropriate for him (e.g., he feels he gets plenty of exercise at work anyway).

By way of contrast, if the patient follows the therapist's advice, three outcomes are possible: The patient's condition stays the same, improves, or worsens. If the walking strengthens the patient, the condition improves. However, if the patient was not part of the decision-making process to initiate a walking program, the psychologic reward is limited, promoting further dependency. If the walking program does not improve his condition or compromises it, the advice did not work. Because the advice was not the patient's, he can avoid any responsibility for the failure:

"See, I did what you advised me to do, and it didn't help. In fact, I feel worse! Why did you tell me to do this anyway?"

Although giving advice might be faster, the examiner should take the time to involve the patient in the problem-solving process. A patient who is an active player in the decision-making process is more likely to learn and modify behavior. The giving of advice is often best spread out over several visits, as rapport develops and diagnostic and therapeutic response data accumulate.

Using Authority

The examiner should avoid responses that promote dependency and inferiority:

"Now, your doctor and therapist know best."

Although the examiner and the patient cannot have equality in terms of professional skills and experience, both are equally worthy human beings and owe each other respect.

Using Avoidance Language

When talking about potentially frightening topics, people often use euphemisms (e.g., "passed on" rather than "died") to avoid reality or hide their true feelings. Although the use of euphemisms may appear to make a topic less frightening, it does not make the topic or the fear go away. In fact, not talking about a frightening subject suppresses the patient's feelings and often makes the patient more fearful. The use of direct and clear language is the best way to deal with potentially uncomfortable topics.

Distancing

Distancing is the use of impersonal conversation that places space between a frightening topic and the speaker. For example, a patient with a lung mass may say, "A friend of mine has a tumor on her lung. She is afraid that she may need an operation" or "There is a tumor in the left lung." By using "the" rather than "my," the patient can deny any association with the tumor. Occasionally, health care workers also use distancing to soften reality. As a general rule, this technique does not work because it communicates to the patient that the health care practitioner is also afraid of the topic. The use of frank, patient-specific terms usually helps defuse anxiety rather than causing it.

Professional Jargon

What a health care worker calls a myocardial infarction, a patient calls a heart attack. The use of professional jargon can sound exclusionary and paternalistic to the patient. Health care practitioners should always try to adjust their vocabulary to the patient's understanding without sounding condescending. Even if patients use medical terms, the examiner cannot assume that they fully understand the meaning. For example, patients often think the term *hypertension* means that they are very tense and therefore take their medication only when they are feeling stressed, not when they feel relaxed!

Asking Leading or Biased Questions

Asking a patient "You don't smoke anymore, do you?" implies that one answer is better than another. The patient is forced either to answer in a way corresponding to the examiner's values or to feel guilty when admitting the other answer. When responding to this type of question, the patient risks the examiner's disapproval and possible alienation, which are undesirable responses from the patient's point of view. Better to slowly extract the smoke and exercise information slowly (see below), time-consuming as that may be.

Talking Too Much

Some examiners feel that helpfulness is directly related to verbal productivity. If they have spent the session talking, they leave feeling that they have met the patient's needs. In fact, the opposite is true. *The patient needs time to talk*. Some studies have found that "touch" is as important as "talk." As a general rule, the examiner should listen more than talk.

Interrupting and Anticipating

While patients are speaking, the examiner should refrain from interrupting them, even when the examiner believes he/she knows what is about to be said. Interruptions do not facilitate the interview. Rather, they communicate to the patient that the examiner is impatient or bored with the interview. Another trap is thinking about the next question while the patient is answering the last one, or anticipating the answer. Examiners who are overly preoccupied with their role as interviewer are not really listening to the patient. As a general rule, the examiner should allow a second or so of silence between the patient's statement and the next question.

Using "Why" Questions

The examiner should be careful in presenting "why" questions. The use of "why" questions often implies blame; it puts the patient on the defensive:

"Why did you wait so long before calling your doctor?"

"Why didn't you bring your asthma medication with you?"

The only possible answer to a "why" question is "Because …," and this places the patient in an uncomfortable position. To avoid this trap, the examiner might say, "I noticed you didn't call your doctor right away when you were having trouble breathing. I'd like to find out what was happening during this time."

BOX 1.2 Nonverbal Messages of the Interview

Positive	Negative
Professional appearance	Nonprofessional appearance
Sitting next to patient	Sitting behind a desk and/or computer screen
Close proximity to patient	Far away from patient
Turned toward patient	Turned away from patient
Relaxed, open posture	Tense, closed posture
Leaning toward patient	Slouched away from patient
Facilitating gestures	Nonfacilitating gestures
• Nodding of head	• Looking at watch
Positive facial expressions	Negative facial expressions
• Appropriate smiling	• Frowning
• Interest	• Yawning
Good eye contact	Poor eye contact
Moderate tone of voice	Strident, high-pitched voice
Moderate rate of speech	Speech too fast or too slow
Appropriate touch	Overly frequent or inappropriate touch

Nonverbal Techniques of Communication

Nonverbal techniques of communication include physical appearance, posture, gestures, facial expression, eye contact, voice, and touch. Nonverbal messages are important in establishing rapport and conveying feelings. Nonverbal messages may either support or contradict verbal messages—and, thus generate a positive or negative influence on the interview process. Therefore an awareness of the nonverbal messages that may be conveyed by either the patient or the examiner during the interview process is important.

Box 1.2 provides an overview of nonverbal messages that may occur during an interview.

Physical Appearance

The examiner's general personal appearance, grooming, and choice of clothing send a message to the patient. Professional dress codes vary among hospitals and clinical settings. Depending on the setting, a professional uniform can project a message that ranges from comfortable or casual to formal or distant. Regardless of one's personal choice in clothing and general appearance, the aim should be to convey a competent and professional image.

Examiner's Body Posture

An *open position* is one in which a communicator extends the large muscle groups (i.e., arms and legs are not crossed). An open position shows relaxation, physical comfort, and a willingness to share information. A *closed position*, with arms and legs crossed, sends a defensive and anxious message. The examiner should be aware of any posture changes. For example, if the patient suddenly shifts from a relaxed to a tense position, it suggests discomfort with the topic. In addition, the examiner should try to sit comfortably next to the patient during the interview. Sitting too far away or standing over the patient often sends a negative nonverbal message.

Gestures

Gestures send nonverbal messages. For example, pointing a finger may show anger or blame. Nodding of the head or an open hand with the palms turned upward can show acceptance, attention, or agreement. Wringing the hands suggests worry and anxiety. The patient often describes a crushing chest pain by holding a fist in front of the sternum. When a patient has a sharp, localized pain, one finger is commonly used to point to the exact spot.

Facial Expression

An individual's face can convey a wide range of emotions and conditions. For example, facial expressions can reflect alertness, relaxation, anxiety, anger, suspicion, and pain. The examiner should work to convey an attentive, sincere, and interested expression. Patient rapport will deteriorate if the examiner exhibits facial expressions that suggest boredom, distraction, disgust, criticism, and disbelief.

Eye Contact

Lack of eye contact suggests that a person may be insecure, intimidated, shy, withdrawn, confused, bored, apathetic, or depressed. The examiner should work to maintain good eye contact but not stare the patient down with a fixed, penetrating look. Generally, an easy gaze toward the patient's eyes with occasional glances away works well. The examiner, however, should be aware that this approach may not work when interviewing a patient from a culture in which direct eye contact is generally avoided. For example, Asian, Native American, Indochinese, Arab, and some Appalachian people may consider direct eye contact impolite or aggressive, and they may avert their own eyes during the interview.

Voice Style

Nonverbal messages are reflected through the tone of voice, intensity and rate of speech, pitch, and long pauses. These messages often convey more meaning than the spoken word. For example, a patient's voice may show sarcasm, anxiety, sympathy, or hostility. An anxious patient frequently talks in a loud and fast voice. A soft voice may reflect shyness and fear. A patient with hearing impairment generally speaks in a loud voice. Long pauses may have important meanings. For instance, when a patient pauses for a long time before answering an easy and straightforward question, the honesty of the answer may be questionable. Slow speech with long and frequent pauses, combined with a weak and monotonous voice, suggests depression.

Touch

The meaning and social implications of touch are often misinterpreted; they can be influenced by an individual's age, gender, cultural background, past experiences, and the present setting. As a general rule, the examiner should not touch patients during interviews unless he or she knows the patient well and is sure that the gesture will be interpreted correctly. When appropriate, touch (e.g., a touch of the hand or arm) can be effective in conveying empathy.

To summarize, extensive nonverbal messages, communicated by both the examiner and patient, may be conveyed during the interview. Therefore the examiner must be aware of the patient's various nonverbal messages while working to communicate nonverbal messages that are productive and enhancing to the examiner-patient relationship.

Closing the Interview

The interview should end gracefully. If the session has an abrupt or awkward closing, the patient may be left with a negative impression. This final moment may destroy any rapport gained during the interview. To ease into the closing, the examiner might ask the patient one of the following questions:

"Is there anything else that you would like to talk about?"

"Do you have any other questions that you would like to ask me?"

"Are there any other problems that we have not discussed?"

These types of questions give the patient an opportunity for self-expression. The examiner may choose to summarize or repeat what was learned during the interview. This serves as a final statement of the examiner's and the patient's assessment of the situation. Finally, the examiner should thank the patient for the time and cooperation provided during the interview. If appropriate, the examiner should (may) suggest a follow-up visit. If this is not possible, simply telling the patient what is scheduled next—for example, "I see your chest x-ray is scheduled this afternoon" implies a sense of continuity and trust that the examiner is part of the team and knows what is going on!

Pitfalls and Weaknesses Associated With the Patient Interview

The respiratory therapist must be acutely aware of the various pitfalls and weaknesses associated with the patient interview. For example, after completing the interview, the following might be concluded:

A strength of the patient interview is its ownership by the patient—who better than the patient to correctly and completely present his/her side of the story? In turn, this information can be readily transferred and acted on by a skilled examiner, in a cost-effective and timely manner. After all, if anyone knows what is going on, it should be the patient. Right? ***WRONG!***

This is because the patient's description of his/her present and past abnormal respiratory conditions—for example, dyspnea, abnormal breathing patterns, cough, sputum production, and pleurisy—can be extremely complex to verbalize, misleading, and often very subjective. Some causes of incorrect information and/or misleading data during the patient interview include the following:

- *The sinister nature of symptoms during the "early stages" of pulmonary disease.* The cardiopulmonary system has an enormous resilience to the early insult of certain pulmonary

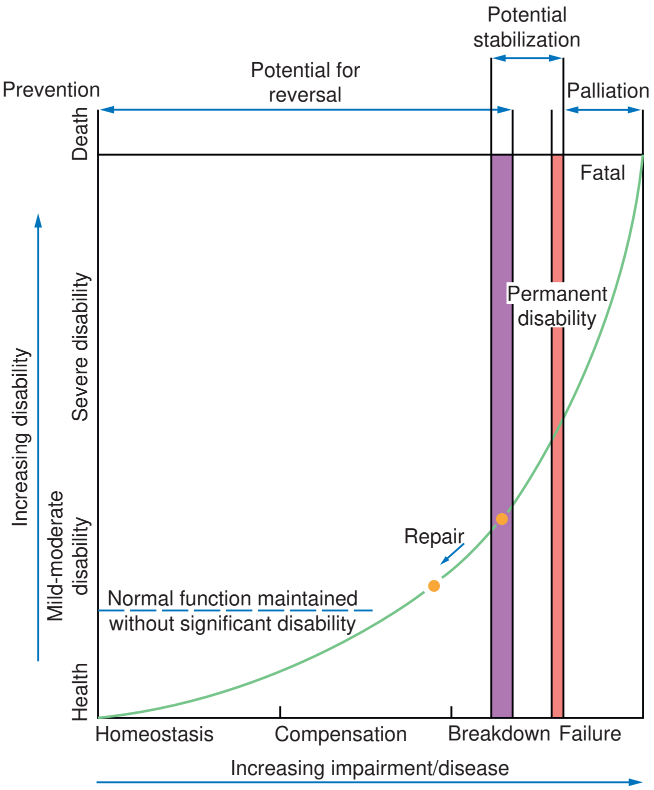
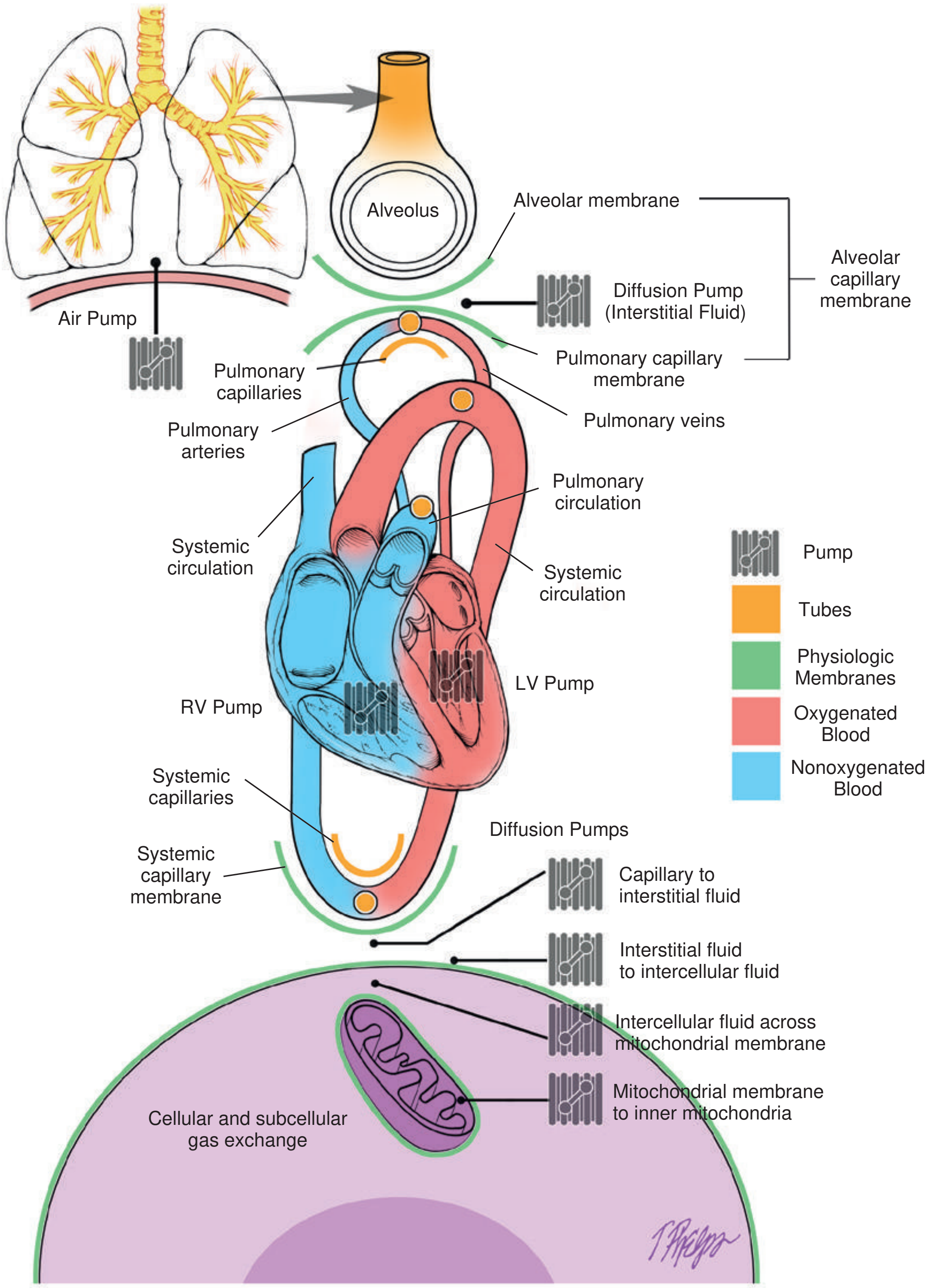


FIGURE 1.1 Graphic Description of Relationship of Symptoms to Extent of Pulmonary Pathology. Early in the process (left side of diagram), when prevention may be possible, the patient may experience few symptoms unless the system is stressed, for example, exercise or sleep. Later in the process (see right side of diagram), small increases in pathologic burden, such as a small pleural effusion in a lung already afflicted with emphysema, may produce extremely severe symptoms, if not death.

diseases. For example, it is not unusual to observe an otherwise healthy young individual who has had long exposures to industrial dust and fumes, has smoked cigarettes for years, or has had a partial or total pneumonectomy readily demonstrate remarkable physical activities such as running, biking, and swimming. This is why, in part, mild injuries to the cardiopulmonary system often go unnoticed during the "early stages" of a particular pulmonary disorder (e.g., chronic obstructive pulmonary disease).

- *The menacing nature of the effect of small pathologic changes during the "late stages" of pulmonary disease.* During the late phases of chronic pulmonary diseases (e.g., chronic obstructive pulmonary disease), even a minor insult, such as mild pneumonia or small pleural effusion, often results in a sudden "system breakdown" and respiratory failure. It should be understood that during the advanced phases of respiratory disorders, the old saying "little things mean a lot," is truly an important and meaningful statement when assessing these patients. Fig. 1.1 illustrates this important nonlinear relationship of symptoms to the extent of pulmonary pathologic condition.
- *The complexity and interdependence of the gas exchange system.* In its simplest form, the purpose of history-taking is to answer these basic questions: "What is going on here?" or, "Why is the patient here?" To answer these types of questions, the respiratory therapist must work to identify the precise cause and location within the cardiopulmonary system that is responsible for the patient's signs and symptoms. To fully accomplish this, it is critical to understand (1) how each component of the gas exchange system works independently from one another and (2) how each component works to support the other components of the entire system. When any "one" component of the gas exchange system begins to fail, the entire system is affected. Because of the complexity of the gas exchange system, however, the ability to isolate the precise source of the problem can be difficult. A strong knowledge and understanding of the gas exchange system are essential. Fig. 1.2 provides an overview of the major components—that is, the essential knowledge base—of the gas exchange system, which includes:
  - Pumps
  - Air and blood conducting tubes
  - Phyiologic gas exchange membranes

  To function properly, each of the components of the cardiopulmonary system must work together in harmony with each other. If any one of the mechanisms fails, the body's ability to efficiently move oxygen and carbon dioxide becomes jeopardized; in short, the failure of only one cardiopulmonary component can create a "Go-no-Go" situation for the entire gas exchange system.
- As illustrated in Fig. 1.3, each component of the gas exchange system is separate and unique in design but strongly interdependent with all the other components to appropriately perform their specific functions. Each cardiopulmonary component must work, or the whole system becomes impaired and, ultimately, causes the entire network to shut down. Throughout the cardiopulmonary system, all the tubes, pumps, and membrane interfaces must all function like gears in a bicycle, simultaneously and continuously. If only one part of the gas exchange system fails, even though the remainder is functioning normally, the total system will be impaired and ultimately fail. Thus one must continually ask this question during the patient assessment: "Is there is any evidence to suggest a malfunction in one or more components of the gas exchange system?
- *The poor memory and/or mental confusion of the patient.* For a variety of reasons, it is not uncommon to elicit incorrect or misleading information during the patient interview. For example, the patient may be confused because of advanced age, poor hearing, hypoxemia, or medications. Or, in some cases, the signs and symptoms associated with the patient pulmonary problem may appear only during physical exertion or exercise. In addition, because of the negative impressions associated with tobacco, many patients who do smoke or have smoked often give ambiguous answers about their smoking history. For example, the following patient-examiner dialog is *not* unusual:
  EXAMINER: "Are you a smoker?"
  PATIENT: "No."
  EXAMINER: "Have you ever smoked?"
  PATIENT: "Not for a long time."
  EXAMINER: "When did you stop?"
  PATIENT: "About 2 weeks ago."
  EXAMINER: "Okay. How much did you smoke?"
  PATIENT: "Some every day."



Components of the gas exchange system		
Pumps	**Tubes**	**Transmembrane diffusion pumps**
• Respiratory muscles (diaphragm and chest wall) • Right ventricle • Left ventricle	• Tracheobronchial tree • Pulmonary vascular system including capillaries • Systemic vascular system including capillaries	• Alveolar-capillary membrane • Systemic capillary membrane • Systemic capillary-cellular membrane • Mitochondrial membranes

FIGURE 1.2 The cardiorespiratory gas exchange system is seen as a complex of intertwined pumps, tubes, and transmembrane diffusion pumps that serve the demands of the energy "factory" of metabolism at the end-user location, the mitochondria. There, oxygen is consumed and carbon dioxide is produced in the process of energy generation with the formation of adenosine triphosphate (ATP) and water. Disease processes can occur at any one or more of these components of the gas exchange system. *LV,* Left ventricular; *RV,* right ventricular.

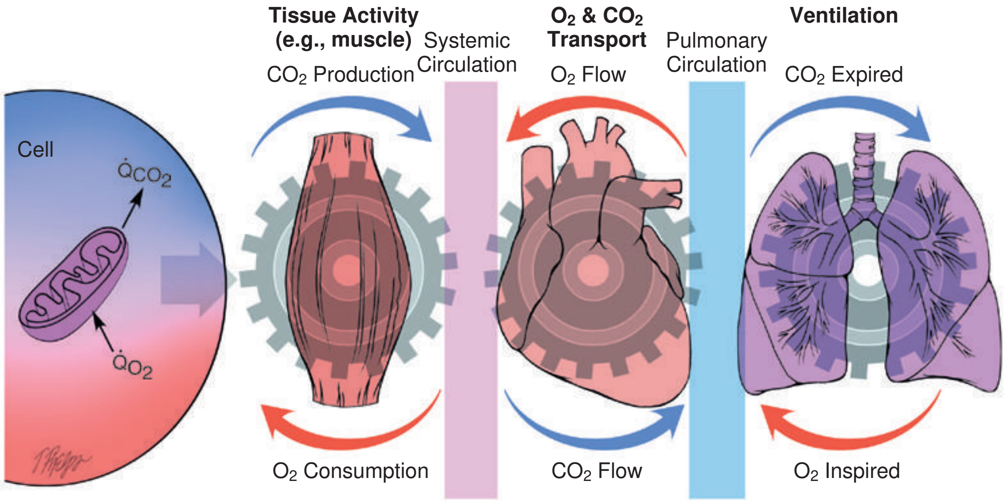


FIGURE 1.3 A Different Model Emphasizing the Interdependence and Interface of Its Major Components of the Gas Exchange System. The major components and functions include the (1) lungs (function: tidal volume [V_T], respiratory frequency [f], oxygen [O_2] intake, and carbon dioxide [CO_2] output), (2) pulmonary circulation (function: recruitment that increased perfusion and ventilation of alveolar capillary units that are quiescent at rest, (3) heart (function: stroke volume [SV] and heart rate [HR]), (4) system circulation (vasodilation and vasoconstriction), and (5) tissue, muscle, and mitochondria activity (O_2 consumption [$\dot{V}O_2$] and CO_2 production [$\dot{V}CO_2$]. Read the figure from right to left to understand the entry of "good" air into the system and left to right to see the process in which CO_2 is removed.

EXAMINER: "How *much* every day?"
PATIENT: "Two packs a day."
Etc. etc. etc.

This whole dialog is much like pulling teeth. Suffice it to say, misleading historical information may be given by the patient on an intentional or nonintentional basis. The former may be in the form of out-and-out lying about historical points; the latter because of inability to recall events from the distant past or because the patient simply does not think such information as "The pneumonia I had twice (!) as a child was important." Encouraging patients to complete an extensive medical history form *before* their first office visit is often a valuable procedure to help streamline the interview process.

A Note of Reassurance

Do not let the foregoing material belittle in any way the value of a carefully obtained history. Thankfully, the history is rarely obtained in a vacuum; it is most often followed by a carefully performed physical examination that will "fill in the blanks" and answer many questions that were prompted by the most careful interviewer.

SELF-ASSESSMENT QUESTIONS

1. During the patient interview, the practitioner states: "You are worried about your child." This type of statement is an example of which of the following techniques:
   a. Reflection
   b. An open-ended question
   c. Confrontation
   d. Facilitation

2. Which of the following is a closed or direct question?
   a. Can you tell me why you appear depressed and angry today?
   b. Have you had this pain before?
   c. How did you first notice the problem?
   d. Why did you wait so long before calling your doctor?

3. Which of the following is considered a negative nonverbal message of the interview?
   a. Nodding of head
   b. Sitting behind a desk
   c. Moderate tone of voice
   d. Sitting next to the patient

4. Which of the following is/are likely to be found on a complete patient history form?
   1. The patient's family history
   2. Activities of daily living
   3. The patient's chief complaint
   4. Review of each body system
      a. 2 and 3 only
      b. 1 and 4 only
      c. 2, 3, and 4 only
      d. 1, 2, 3, and 4

5. Which one of the following is considered a "facilitation" response?
   a. "You feel anxious about your children."
   b. "It must be hard to not be able to do that now."
   c. "Mm hmmm, go on."
   d. "Tell me what you mean by bad air."

CHAPTER 2 The Physical Examination

Chapter Objectives

After reading this chapter, you will be able to:

- Describe the major components of a patient's vital signs, including
  - Body temperature
  - Pulse
  - Respiration
  - Blood pressure
  - Oxygen saturation
- Describe the lung and chest topography, including
  - Thoracic cage landmarks
  - Imaginary lines
  - Lung borders and fissures
- Describe the purpose of inspection
- Describe palpation, including
  - Chest excursion
  - Tactile and vocal fremitus
- Describe percussion, including
  - Abnormal percussion notes
  - Diaphragmatic excursion
- Describe auscultation, including
  - Normal breath sounds
  - Abnormal breath sounds
- Define key terms and complete self-assessment questions at the end of the chapter and on Evolve.

Key Terms

Abnormal Breathing Patterns
Adventitious Lung Sounds
Afebrile
Anterior Axillary Line
Apnea
Auscultation
Biot's Respiration
Blood Pressure (BP)
Body Temperature (T°)
Bradycardia
Bradypnea
Bronchovesicular breath sounds
Cardiac Diastole
Cardiac Output (CO)
Cardiac Systole
Chest Excursion
Constant Fever
Core Temperature
Crackles
Crepitus
Diaphragmatic Excursion
Diastole
Diastolic Blood Pressure
Diminished Breath Sounds
Distended Neck Veins
Diurnal Variations
Dull Percussion Note
Febrile
Horizontal Fissure
Hyperpyrexia
Hyperresonant Note
Hypertension
Hyperthermia
Hyperventilation
Hypotension
Hypothermia
Hypoventilation
Inspection
Intermittent Fever
Kussmaul's Respiration
Lung and Chest Topography
Midaxillary Line
Midclavicular Line
Midscapular Line
Midsternal Line
Mild Hypoxemia
Moderate Hypoxemia
Normal Breath Sounds
Oblique Fissure
Palpation
Pedal (Dorsalis Pedis) Pulse
Percussion
Posterior Axillary Line
Pulse (P)
Pulse Oximetry (SpO_2)
Pulse Pressure
Pulsus Alternans
Pulsus Paradoxus
Pyrexia
Relapsing Fever
Remittent Fever
Respiratory Rate
Severe Hypoxemia
Sinus Arrhythmia
Stridor
Subcutaneous Emphysema
Systole
Systolic Blood Pressure
Tachycardia
Tachypnea
Tactile Fremitus
Tripod Position
Tympany
Ultrasonic Doppler
Vasoconstriction

Vasodilation
Vertebral Line
Vesicular Breath Sounds
Vocal Fremitus
Wheezing
Whispering Pectoriloquy

Chapter Outline

Vital Signs

The four major vital signs—**body temperature (T°)**, **pulse (P)**, respiratory rate (R), and **blood pressure (BP)**—are excellent bedside clinical indicators of the patient's physiologic and psychologic health. In many patient care settings, the oxygen saturation as measured by **pulse oximetry (SpO_2)** is considered to be the "fifth vital sign." Table 2.1 shows the normal values that have been established for various age groups.

During the initial measurement of a patient's vital signs, the values are compared with these normal values. After several vital signs have been documented for the patient, they can be used as a baseline for subsequent measurements. Isolated vital sign measurements are not as valuable as a series of measurements. By evaluating a series of values, the practitioner can identify important vital sign trends for the patient. Vital sign trends that deviate from the patient's normal measurements are often more important than an isolated measurement.

Although the skills involved in obtaining the vital signs are easy to learn, interpretation and clinical application require knowledge, problem-solving skills, critical thinking, and experience. Even though vital sign measurements are part of routine bedside care, they provide vital information and should always be considered an important part of the assessment process. The frequency with which vital signs should be assessed depends on the individual needs of each patient.

Body Temperature

Body temperature is routinely measured to assess for signs of inflammation or infection. Even though the body's skin temperature varies widely in response to environmental conditions and physical activity, the temperature inside the body, the **core temperature**, remains relatively constant—about 37°C (98.6°F), with a daily variation of ± 0.5°C (1° to 2°F). Under normal circumstances, the body is able to maintain this constant temperature through various physiologic compensatory mechanisms, such as the autonomic nervous system and special receptors located in the skin, abdomen, and spinal cord.

In response to temperature changes, the receptors sense and send information through the nervous system to the hypothalamus. The hypothalamus, in turn, processes the information and activates the appropriate response. For example, an increase in body temperature causes the blood vessels near the skin surface to dilate, a process called **vasodilation**. Vasodilation, in turn, allows more warmed blood to flow near the skin surface, thereby enhancing heat loss. In contrast, a decrease in body temperature causes **vasoconstriction**, which works to keep warmed blood closer to the center of the body, thus working to maintain the core temperature.

At normal body temperature, the metabolic functions of all body cells are optimal. When the body temperature increases or decreases significantly from the normal range, the metabolic

TABLE 2.1 Average Range of Values for Vital Signs According to Age Group

Age Group	Core Temperature (°F)	Pulse (bpm)	Respirations (breaths/min)	Blood Pressure (mm Hg)	
				Systolic	Diastolic
Newborn	96–99.5	120–170	30–60	45–75	20–50
Infant (1 mo–1 yr)	99.4–99.7	80–160	30–60	75–100	50–70
Toddler (1–3 yr)	99.4–99.7	80–130	25–40	80–110	55–80
Preschooler (3–6 yr)	98.6–99	80–120	20–35	80–110	50–80
Child (6–12 yr)	98.6	65–100	20–30	100–110	60–70
Adolescent (12–18 yr)	97–99	60–90	12–20	110–120	60–65
Adult	97–99	60–100	12–20	110–140	60–90
Older adult (>70 yr)	95–99	60–100	12–20	120–140	70–90

rate and therefore the demands on the cardiopulmonary system also change. For example, during a fever the metabolic rate increases. This action leads to an increase in oxygen consumption and an increase in carbon dioxide production at the cellular level. According to estimates, for every 1°C increase in body temperature, the patient's oxygen consumption increases about 10%. As the metabolic rate increases, the cardiopulmonary system must work harder to meet the additional cellular demands. Hypothermia reduces the metabolic rate and cardiopulmonary demand.

As shown in Fig. 2.1, the normal body temperature is positioned within a relatively narrow range. A patient who has a temperature within the normal range is said to be **afebrile**. A body temperature above the normal range is called **pyrexia** or **hyperthermia**. When the body temperature rises above the normal range, the patient is said to have a *fever* or to be **febrile**. An exceptionally high temperature, such as 41°C (105.8°F), is called **hyperpyrexia**.

The four common types of fevers are **intermittent fever**, **remittent fever**, **relapsing fever**, and **constant fever**. An intermittent fever is said to exist when the patient's body temperature alternates at regular intervals between periods of fever and periods of normal or below-normal temperatures. In other words, the patient's temperature undergoes peaks and valleys, with the valleys representing normal or below-normal temperatures. During a remittent fever, the patient has marked peaks and valleys (more than 2°C [3.6°F]) over a 24-hour period, all of which are above normal—that is, the body temperature does not return to normal between the spikes. A relapsing fever is said to exist when short febrile periods of a few days are interspersed with 1 or 2 days of normal temperature. A continuous fever is present when the patient's body temperature remains above normal with minimal or no fluctuation.

Hypothermia is the term used to describe a core temperature below the normal range. Hypothermia may occur as a result of (1) excessive heat loss, (2) inadequate heat production to counteract heat loss, and (3) impaired hypothalamic thermoregulation. Box 2.1 lists the clinical signs of hypothermia.

Hypothermia may be caused accidentally or may be induced. Accidental hypothermia is commonly seen in the patient who (1) has had an excessive exposure to a cold environment, (2) has been immersed in a cold liquid environment for a prolonged time, or (3) has inadequate clothing, shelter, or heat. It should be noted that geriatric patients generally display a lower temperature than younger adults. In addition, a reduced metabolic rate may compound hypothermia in older patients. Older patients often take sedatives, which further depress the metabolic rate. Box 2.2 lists common therapeutic interventions for patients with hypothermia.

Induced hypothermia refers to the intentional lowering of a patient's body temperature to reduce the oxygen demand of the tissue cells. Induced hypothermia may involve only a portion of the body or the whole body. Induced hypothermia is often indicated before certain surgeries, such as heart or brain surgery, or after return of spontaneous circulation after a cardiac arrest.

BOX 2.1 Clinical Signs of Hypothermia

- Below normal body temperature
- Decreased pulse and respiratory rate
- Severe shivering (initially)
- Patient indicating coldness or presence of chills
- Pale or bluish cool, waxy skin
- Hypotension
- Decreased urinary output
- Lack of muscle coordination
- Disorientation
- Drowsiness or unresponsiveness
- Coma

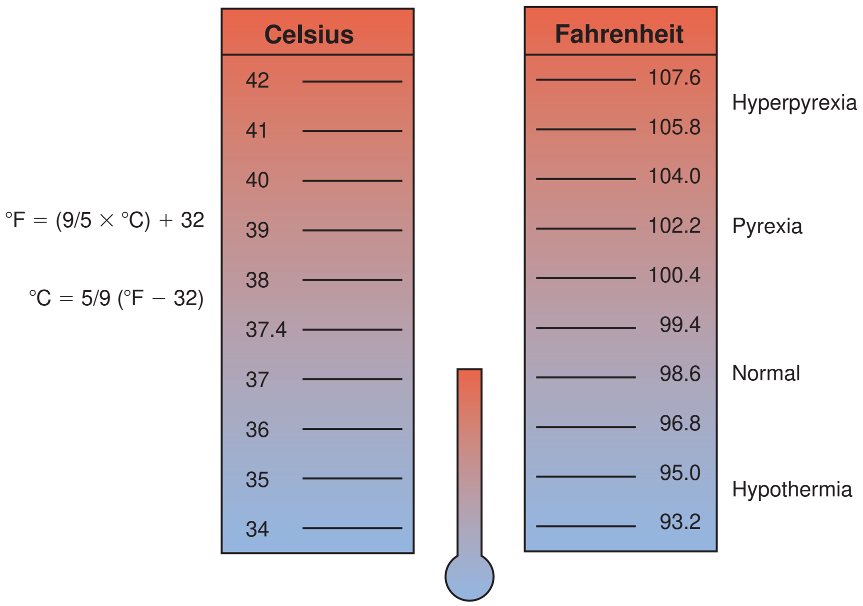


FIGURE 2.1 Range of normal body temperature and alterations in body temperature on the Celsius and Fahrenheit scales. See conversion formulas for Fahrenheit and Celsius scales on the left side of the figure.

Factors Affecting Body Temperature

Table 2.2 lists several factors that affect body temperature. Knowing these factors can help the practitioner better assess the significance of expected or normal variations in a patient's body temperature.

Body Temperature Measurement

The measurement of body temperature establishes an essential baseline for clinical comparison as a disease progresses or as therapies are administered. To ensure the reliability of a temperature reading, the practitioner must (1) select the correct measuring equipment, (2) choose the most appropriate site, and (3) use the correct technique or procedure. The four most commonly used sites are the mouth, rectum, ear (tympanic membrane/auditory canal) and axilla. Any of these sites is satisfactory when the proper technique is used.

BOX 2.2 Common Therapeutic Interventions for Hypothermia

- Remove wet clothing
- Provide dry clothing
- Place patient in a warm environment (slowly increase room temperature)
- Cover patient with warm blankets or electric heating blanket
- Apply warming pads (increase temperature slowly)
- Keep patient's limbs close to body
- Cover patient's head with a cap or towel
- Supply warm oral or intravenous fluids

Additional measurement sites include the esophagus and pulmonary artery. Temperatures measured at these sites, and in the rectum and at the tympanic membrane, are considered core temperatures. The skin, typically that of the forehead or abdomen, also may be used for general temperature purposes. However, practitioners must remember that although skin temperature–sensitive strips or disposable paper thermometers may be satisfactory for general temperature measurements, the patient's precise temperature should always be confirmed—when indicated—with a glass or tympanic thermometer.

Because body temperature is usually measured orally, the practitioner must be aware of certain external factors that can lead to false oral temperature measurements. For example, drinking hot or cold liquids can cause small changes in oral temperature measurements. The most significant temperature changes have been reported after a patient drinks ice water. Drinking ice water may lower the patient's actual temperature by 0.2°F to 1.6°F. Before taking an oral temperature, the practitioner should wait 15 minutes after a patient has ingested ice water. Oral temperature may increase in the patient receiving heated oxygen aerosol therapy and decrease in the patient receiving a cool mist aerosol. Table 2.3 lists the body temperature sites, their advantages and disadvantages, and the equipment used.

Pulse

A pulse is generated through the vascular system with each ventricular contraction of the heart (**systole**). Thus a pulse is a rhythmic arterial blood pressure throb created by the pumping action of the ventricular muscle. Between contractions, the ventricle rests (**diastole**) and the pulsation ceases. The pulse can be assessed at any location where an artery lies close to the skin surface and can be palpated against a firm underlying

TABLE 2.2 Factors Affecting Body Temperature

Factor	Effects
Age	Temperature varies with age. For example, the core temperature of the newborn infant is unstable because of immature thermoregulatory mechanisms. It is not uncommon for the elderly person to have a body temperature below 36.4°C (97.6°F). The normal temperature decreases with age.
Environment	Normally, variations in environmental temperature do not affect the core temperature. However, exposure to extreme hot or cold temperatures can alter body temperature. If an individual's core temperature falls to 25°C (77°F), death may occur. Conversely, in conditions of extreme humidity (>80%) and temperatures (>50°C [>122°F]) death may occur.
Time of day	Body temperature normally varies throughout the day, a phenomenon called **diurnal variation**. Typically, an individual's temperature is lowest around 3:00 a.m. and highest between 5:00 p.m. and 7:00 p.m. Approximately 95% of patients have their highest temperature around 6:00 p.m. Body temperature often fluctuates by as much as 2°C (1.8°F) between early morning and late afternoon.
Exercise	Body temperature increases with exercise because exercise increases heat production as the body breaks down carbohydrates and fats to provide energy. During strenuous exercise, the core body temperature can increase to as high as 40°C (104°F).
Stress	Physical or emotional stress may increase body temperature because stress can stimulate the sympathetic nervous system, causing the epinephrine and norepinephrine levels to increase. When this occurs, the metabolic rate increases, causing increased heat production. Stress and anxiety may cause a patient's temperature to increase without an underlying disease.
Hormones	Women normally have greater fluctuations in temperature than do men. The female hormone progesterone, which is secreted during ovulation, causes the temperature to increase 0.3° to 0.6°C (0.5° to 1°F). After menopause, women have the same mean temperature norms as men.

TABLE 2.3 Body Temperature Measurements: Sites, Normal Values, Advantages and Disadvantages, and Equipment Used

Site and Temperature	Advantages and Disadvantages	Equipment
Oral (most common) Average 37°C (98.6°F)	*Advantages:* Convenient, easy access, and patient comfort *Disadvantages:* Affected by ingestion of hot or cold liquids. Contraindicated in patients who cannot follow directions to keep mouth closed, who are mouth breathing, or who might bite down and break the thermometer. Smoking, drinking, and eating can slightly alter the oral temperature, about 1°F lower than rectal temperature.	Glass mercury thermometer, electronic thermometers
Rectal (core) Average 0.7°C (0.4°F) higher than oral	*Advantages:* Very reliable, considered most accurate. *Disadvantages:* Contraindicated in patients with diarrhea, patients who have undergone rectal surgery, or patients who have diseases of the rectum. *General Comment:* Used less often now that tympanic thermometers are available.	Glass mercury thermometer
Ear (tympanic) Also reflects core temperature. Also calibrated to oral or rectal scales	*Advantages:* Convenient, readily accessible, fast, safe, and noninvasive. Does not require contact with any mucous membrane. Infection control is less of a concern. With the advent of the tympanic membrane thermometer, the ear is now a site where a temperature can be easily and safely measured. Reflects the core body temperature because it reflects the tympanic membrane blood supply—the same vascular system that supplies the hypothalamus. Smoking, drinking, and eating do not affect tympanic temperature measurements. Allows rapid temperature measurements in the very young, confused, or unconscious patient. *Disadvantages:* No remarkable disadvantages, assuming site is available.	Tympanic thermometer
Axillary Average 0.6°C (1°F) lower than oral	*Advantages:* Safe and noninvasive. Recommended for infants and children, this is the route of choice in patients whose temperature cannot be measured at other sites. *Disadvantages:* Considered the least accurate and least reliable site because a number of factors can adversely affect the measurement. For example, if the patient has recently been given a bath, the temperature may reflect the temperature of the bathwater. Similarly, body motion and friction applied to dry the patient's skin may influence the temperature.	Glass mercury thermometer

structure, such as muscle or bone. Nine common pulse sites are the temporal, carotid, apical, brachial, radial, femoral, popliteal, **pedal (dorsalis pedis)**, and posterior tibial area (see Fig. 2.2).

In clinical settings the pulse is usually assessed by **palpation**. Initially the practitioner uses the first, second, or third finger and applies light pressure to any one of the pulse sites (e.g., carotid or radial artery) to detect a pulse with a strong pulsation. After locating the pulse, the practitioner may apply a more forceful palpation to count the rate, determine the cardiac rhythm, and evaluate the quality of pulsation. The practitioner then counts the number of pulsations for 15, 30, or 60 seconds and then multiplies appropriately to determine the pulse rate per minute. Shorter measurement time intervals may be used for patients with normal rates or regular cardiac rhythms.

In patients with irregular, abnormally slow, or fast cardiac rhythms, the pulse rates should be counted for 1 minute. To prevent overestimation for any time interval, the practitioner should count the first pulsation as zero and not count pulses at or after the completion of a selected time interval. Counting even one extra pulsation during a 15-second interval leads to an overestimation of the pulse rate by 4. *The characteristics of the pulse are described in terms of rate, rhythm, and strength.*

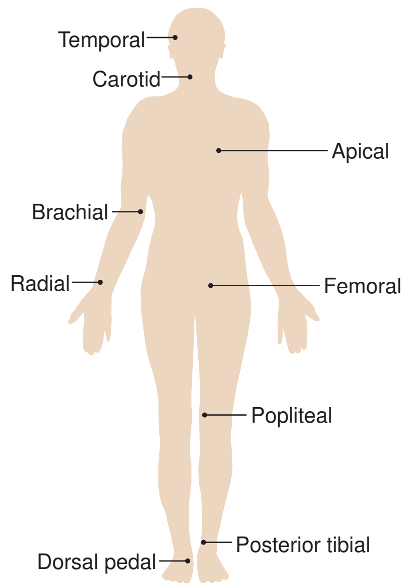


FIGURE 2.2 The nine common pulse measurement sites.

Rate

The normal pulse rate (or heart rate) varies with age. For example, in the newborn the normal pulse rate range is 100 to 180 beats per minute (bpm). In the toddler the normal range is 80 to 130 bpm. The normal range for the child is 65 to 100 bpm, and the normal adult range is 60 to 100 bpm (see Table 2.1).

A heart rate lower than 60 bpm is called **bradycardia**. Bradycardia may be seen in patients with hypothermia and in physically fit athletes. The pulse also may be lower than expected when the patient is at rest or asleep or as a result of head injury, drugs such as beta-blockers (e.g., propranolol), vomiting, or advanced age. A pulse rate greater than 100 bpm in adults is called **tachycardia**. Tachycardia may occur as a result of hypoxemia, anemia, fever, anxiety, emotional stress, fear, hemorrhage, **hypotension**, dehydration, shock, and exercise. Tachycardia is also a common side effect in patients receiving certain medications, such as sympathomimetic agents (e.g., adrenaline or dobutamine).

Rhythm

Normally the ventricular contraction is under the control of the sinus node in the atrium, which generates a normal rate and regular rhythm. Certain conditions and chemical disturbances, such as inadequate blood flow and oxygen supply to the heart or an electrolyte imbalance, can cause the heart to beat irregularly. In children and young adults, it is not uncommon for the heart rate to increase during inspiration and decrease during exhalation. This is called **sinus arrhythmia**.

Strength

The quality of the pulse reflects the strength of left ventricular contraction and the volume of blood flowing to the peripheral tissues. A normal left ventricular contraction combined with an adequate blood volume will generate a strong, throbbing pulse. A weak ventricular contraction combined with an inadequate blood volume will result in a weak, thready pulse. An increased heart rate combined with a large blood volume will generate a full, bounding pulse.

Several conditions may alter the strength of a patient's pulse. For example, heart failure can cause the *strength* of the pulse to vary every other beat while the *rhythm* remains regular. This condition is called **pulsus alternans**. The practitioner may detect a pulse that decreases markedly in strength during inspiration and increases back to normal during exhalation, a condition called **pulsus paradoxus** that is common among patients experiencing a severe asthmatic episode. This phenomenon also can be observed when blood pressure is measured.

Finally, the stimulation of the sympathetic nervous system increases the force of ventricular contraction, increasing the volume of blood ejected from the heart and creating a stronger pulse. Stimulation of the parasympathetic nervous system decreases the force of the ventricular contraction, leading to decreased volume of blood ejected from the heart and a weaker pulse. Clinically, the strength of the pulse may be recorded on a scale of 0 to 4+ (Box 2.3).

For peripheral pulses that are difficult to detect by palpation, an **ultrasonic Doppler** device also may be used. A transmitter attached to the Doppler is placed over the artery to be assessed. The transmitter amplifies and transmits the pulse sounds to an earpiece or to a speaker attached to the Doppler device. During normal sinus rhythm, the heart rate also can be obtained through **auscultation** by placing a stethoscope over the apex of the heart.

BOX 2.3 Scale to Rate Pulse Quality

0: Absent or no pulse detected
1+: Weak, thready, easily obliterated with pressure; difficult to feel
2+: Pulse difficult to palpate; may be obliterated by strong pressure
3+: Normal pulse
4+: Bounding, easily palpated, and difficult to obliterate

Respiration

The diaphragm is the primary muscle of respiration. Inspiration is an active process whereby the diaphragm contracts and causes the intrathoracic pressure to decrease. This action, in turn, causes the pressure in the airways to fall below the atmospheric pressure to allow for inflow of air. At the end of inspiration, the diaphragm relaxes and the natural lung elasticity (recoil) causes the pressure in the lung to increase. This action, in turn, causes air to flow out of the lung. Under normal circumstances, expiration is a passive process.

The normal **respiratory rate** varies with age. For example, in the newborn the normal respiratory rate varies between 30 and 60 breaths per minute. In the toddler the normal range is 25 to 40 breaths per minute. The normal range for the preschool child is 20 to 25 breaths per minute, and the normal adult range is 12 to 20 breaths per minute (see Table 2.1).

Ideally the respiratory rate should be counted when the patient is not aware. One good method is to count the respiratory rate immediately after taking the pulse, while leaving the fingers over the patient's artery. As respirations are being counted, the practitioner should observe for variations in the pattern of breathing. For example, an increased breathing rate is called **tachypnea**. Tachypnea is commonly seen in patients with fever, metabolic acidosis, hypoxemia, pain, or anxiety. A respiratory rate below the normal range is called **bradypnea**. Bradypnea may occur with hypothermia, head injuries, and drug overdose. Table 2.4 provides an overview of common normal and **abnormal breathing patterns**.

Blood Pressure

The arterial blood pressure is the force exerted by the circulating volume of blood on the walls of the arteries. The pressure peaks when the ventricles of the heart contract and eject blood into the aorta and pulmonary arteries. The blood pressure measured during ventricular contraction (**cardiac systole**) is the **systolic blood pressure**. During ventricular relaxation (**cardiac diastole**), blood pressure is generated by the elastic recoil of the arteries and arterioles. This pressure is called the **diastolic blood pressure**.

The normal blood pressure in the aorta and large arteries varies with age. For example, in the newborn the normal systolic blood pressure range is 60 to 90 mm Hg. In the toddler the normal range is 80 to 110 mm Hg. The normal range for the child is 100 to 110 mm Hg, and the normal adult range is 110 to 140 mm Hg (see Table 2.1 for normal systolic and diastolic blood pressures according to age). The numeric difference between the systolic and diastolic blood pressure is the **pulse pressure**. For example, a systolic pressure of 120 mm Hg and a diastolic pressure of 80 mm Hg equal a pulse pressure of 40 mm Hg.

Blood pressure is a function of (1) the blood flow generated by ventricular contraction and (2) the resistance to blood flow caused by the vascular system. Thus blood pressure (BP) equals flow ($\dot{V}$) multiplied by resistance (R): $BP = \dot{V} \times R$.

Blood Flow

Blood flow is equal to cardiac output. Cardiac output is equal to the product of (1) the volume of blood ejected from the ventricles during each heartbeat (stroke volume) multiplied by (2) the heart rate. Thus a stroke volume (SV) of 75 mL and a heart rate (HR) of 70 bpm produce a **cardiac output (CO)** of 5250 mL/min, or 5.25 L/min ($CO = SV \times HR$).

TABLE 2.4 Common Normal and Abnormal Breathing Patterns

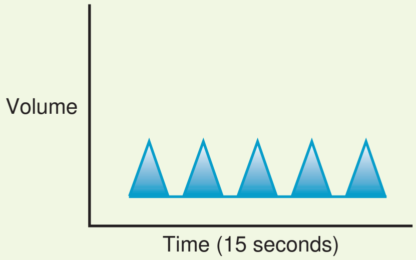
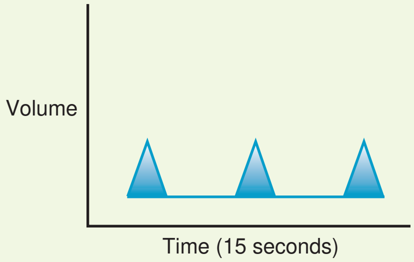
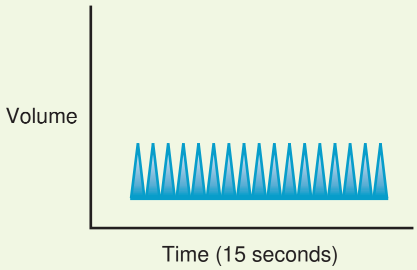
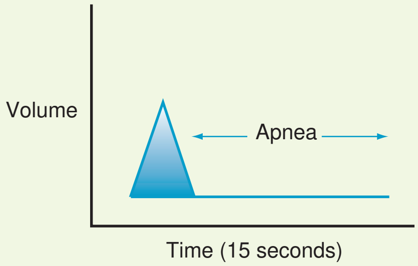
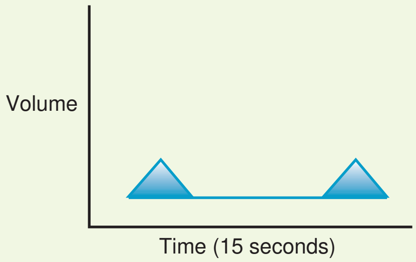
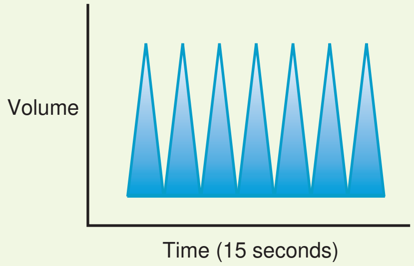
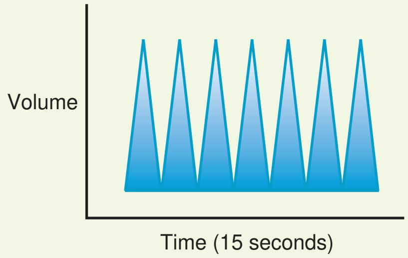
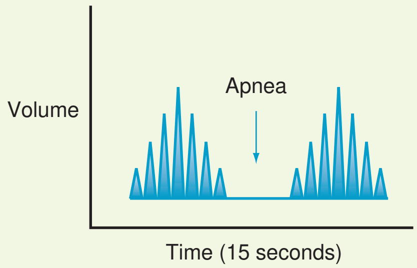
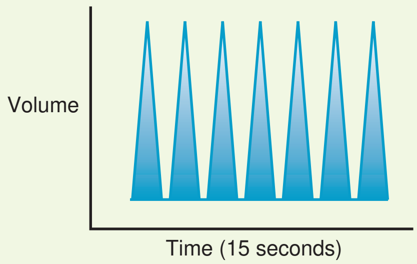
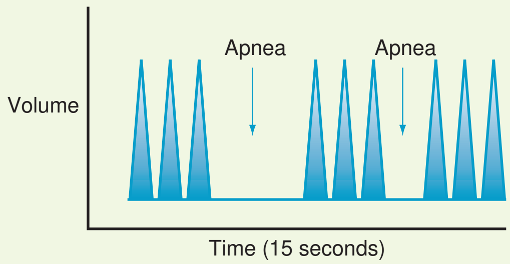
Pattern	Graphic Overview	Description
Eupnea		Normal rate and rhythm; 12–20 breaths/min in regular rhythm and of moderate depth for an adult
Bradypnea		Regular rhythm of fewer than 12 breaths/min
Tachypnea		Regular rhythm of more than 20 breaths/min for an adult
Apnea		Absence of breathing that leads to respiratory arrest and death
Hypoventilation		Decreased rate and depth, which decreases alveolar ventilation and leads to an increased $PaCO_2$

TABLE 2.4 Common Normal and Abnormal Breathing Patterns—cont'd

Pattern	Graphic Overview	Description
Hyperventilation		Increased rate and depth, which increases alveolar ventilation and leads to a decreased $PaCO_2$
Hyperpnea		Increased depth and rate of breathing. Similar to hyperventilation, but is commonly considered normal during periods of exercise to meet metabolic needs.
Cheyne-Stokes respiration		Respirations that progressively become faster and deeper, followed by respirations that progressively become slower and shallower and ending with a period of apnea
Kussmaul's respiration		Increased rate and depth of breathing. Usually associated with diabetic ketoacidosis as a compensatory mechanism to eliminate carbon dioxide, by buffering the metabolic acidosis
Biot's respiration		Fast, deep respirations with (abrupt, irregular) pauses

The average cardiac output in the resting adult is approximately 5 L/min.

A number of conditions can alter stroke volume and therefore blood flow. For instance, a decreased stroke volume may develop as a result of poor cardiac pumping (e.g., ventricular failure) or as a result of a decreased blood volume (e.g., during severe hemorrhage). Bradycardia also may reduce cardiac output and blood flow. Conversely, an increased heart rate or blood volume will likely increase cardiac output and blood flow. In addition, an increased heart rate in response to a decreased blood volume (or stroke volume) also may occur as a compensatory mechanism to maintain normal cardiac output and blood flow.

Resistance

The friction between the components of the blood ejected from the ventricles and the walls of the arteries results in a natural resistance to blood flow. Friction between the blood components and the vessel walls is inversely related to the dimensions of the vessel lumen (size). Thus as the vessel lumen narrows (or constricts), vascular resistance increases. As the vessel lumen widens (or relaxes), the resistance decreases. The autonomic nervous system monitors and regulates the vascular tone.

Table 2.5 presents factors that affect the blood pressure.

Abnormalities of Blood Pressure

Hypertension. **Hypertension** is the condition in which an individual's blood pressure is chronically above normal range. Whereas blood pressure normally increases with aging, hypertension is considered a dangerous disease and is associated with an increased risk for morbidity and mortality. According to the Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure, the physician may make the diagnosis of hypertension in the adult when an average of two or more diastolic readings on at least two different visits is 90 mm Hg or higher or when the average of two or more systolic readings on at least two visits is consistently higher than 140 mm Hg.

An elevated blood pressure of unknown cause is called *primary hypertension.* An elevated blood pressure of a known cause is called *secondary hypertension.* Factors associated with hypertension include arterial disease (usually on the basis of arteriosclerosis), obesity, a high serum sodium level, pregnancy, obstructive sleep apnea, and a family history of high blood pressure. The incidence of hypertension is higher in men than in women and is twice as common in blacks as in whites. People with mild or moderate hypertension may be asymptomatic or may experience suboccipital headaches (especially on rising), tinnitus, light-headedness, easy fatigability, and cardiac palpitations. With sustained hypertension, the arterial walls become thickened, inelastic, and resistant to blood flow. This process in turn causes the left ventricle to distend and hypertrophy. Hypertension may lead to congestive heart failure.

Hypotension. **Hypotension** is said to be present when the patient's blood pressure falls below 90/60 mm Hg. It is an abnormal condition in which the blood pressure is not adequate for normal perfusion and oxygenation of vital organs. Hypotension is associated with peripheral vasodilation, decreased vascular resistance, hypovolemia, and left ventricular failure. Hypotension also can be caused by analgesics such as meperidine hydrochloride (Demerol) and morphine sulfate, severe burns, prolonged diarrhea, and vomiting. Signs and symptoms include pallor, skin mottling, clamminess, blurred vision, confusion, dizziness, syncope, chest pain, increased heart rate, and decreased urine output. Hypotension is life threatening.

Orthostatic hypotension, also called *postural hypotension,* occurs when blood pressure quickly drops as the individual rises to an upright position or stands. Orthostatic hypotension develops when the peripheral blood vessels—especially in central body organs and legs—are unable to constrict or respond appropriately to changes in body position. Orthostatic hypotension is associated with decreased blood volume, anemia, dehydration, prolonged bed rest, and antihypertensive medications. The assessment of orthostatic hypotension is made by obtaining pulse and blood pressure readings when the patient is in the supine, sitting, and standing positions.

TABLE 2.5 Factors Affecting Blood Pressure

Factors	Effects
Age	Blood pressure gradually increases throughout childhood and correlates with height, weight, and age. In the adult, blood pressure tends to gradually increase with age.
Exercise	Vigorous exercise increases cardiac output and thus blood pressure.
Autonomic nervous system	Increased sympathetic nervous system activity causes an increased heart rate, an increased cardiac contractility, changes in vascular smooth muscle tone to enhance blood flow to vital organs and skeletal muscles, and an increased blood volume. Collectively, these actions cause increased blood pressure.
Stress	Stress stimulates the sympathetic nervous system and thus can increase blood pressure.
Circulating blood volume	A decreased circulating blood volume, either from blood or fluid loss, causes blood pressure to decrease. Common causes of fluid loss include abnormal, unreplaced fluid losses such as in diarrhea or diaphoresis and overenthusiastic use of diuretics. Inadequate oral fluid intake also can result in a fluid volume deficit. Excess fluid, such as in congestive heart failure, can cause blood pressure to increase.
Medications	Any medication that affects one or more of the previous conditions may cause blood pressure changes. For example, diuretics reduce blood volume; cardiac pharmaceuticals may increase or decrease heart rate and contractility; pain medications may reduce sympathetic nervous system stimulation; and specific antihypertensive agents may also exert their effects.
Normal fluctuations	Under normal circumstances, blood pressure varies from moment to moment in response to a variety of stimuli. For example, an increased environmental temperature causes blood vessels near the skin surface to dilate, causing blood pressure to decrease. In addition, normal respirations alter blood pressure. Blood pressure increases during expiration and decreases during inspiration. Blood pressure fluctuations caused by inspiration and expiration may be significant during a severe asthmatic episode.
Race	Black males over 35 years of age often have elevated blood pressure.
Obesity	Blood pressure is often higher in overweight and obese individuals.
Diurnal (daily diurnal variations)	Blood pressure is usually lowest early in the morning, when the metabolic rate is lowest.

Pulsus Paradoxus

Pulsus paradoxus is defined as a systolic blood pressure that is more than 10 mm Hg lower on inspiration than on expiration. This exaggerated waxing and waning of arterial blood pressure can be detected with a sphygmomanometer or, in severe cases, by palpating the pulse at the wrist or neck. Commonly associated with severe asthmatic episodes, pulsus paradoxus is believed to be caused by the major intrapleural pressure swings that occur during inspiration and expiration. The reason for this phenomenon is described in the following sections.

Decreased Blood Pressure During Inspiration. During inspiration the asthmatic patient frequently relies on use of the *accessory muscles of inspiration*. The accessory muscles help produce an extremely negative intrapleural pressure, which in turn enhances intrapulmonary gas flow. The increased negative intrapleural pressure also causes blood vessels in the lungs to dilate, creating pooled blood. Consequently, the volume of blood returning to the left ventricle decreases, causing a reduction in cardiac output and arterial blood pressure during inspiration.

Increased Blood Pressure During Expiration. During expiration, the patient often activates the *accessory muscles of expiration* in an effort to overcome the increased airway resistance (R_{aw}). The increased power produced by these muscles generates a greater positive intrapleural pressure. Although increased positive intrapleural pressure helps offset R_{aw}, it also works to narrow or squeeze the blood vessels of the lung. This increased pressure on the pulmonary blood vessels enhances left ventricular filling and results in increased cardiac output and arterial blood pressure during expiration.

Oxygen Saturation

Oxygen saturation, often considered the "fifth vital sign," is used to establish an immediate baseline SpO_2 value. It is an excellent monitor by which to assess the patient's response to respiratory care interventions. In the adult, normal SpO_2 values range from 95% to 99%. SpO_2 values of 91% to 94% indicate **mild hypoxemia**. Mild hypoxemia warrants additional evaluation by the respiratory practitioner but does not usually require supplemental oxygen. SpO_2 readings of 86% to 90% indicate **moderate hypoxemia**. These patients often require supplemental oxygen. SpO_2 values of 85% or lower indicate **severe hypoxemia** and warrant immediate medical intervention, including the administration of oxygen, ventilatory support, or both. Table 2.6 presents the relationship of SpO_2 to PaO_2 for the adult and newborn. Table 2.7 provides an overview of the signs and symptoms of inadequate oxygenation. For a more in-depth discussion on oxygenation, see Chapter 6, Assessment of Oxygenation.

TABLE 2.6 SpO_2 and PaO_2 Relationships for the Adult and Newborn

	Adult		Newborn	
Oxygen Status	SpO_2 (%)	PaO_2 (mm Hg)	SpO_2 (%)	PaO_2 (mm Hg)
Normal	95–99	75–100	91–96	60–80
Mild hypoxemia	90–95	60–75	88–90	55–60
Moderate hypoxemia	85–90	50–60	85–89	50–58
Severe hypoxemia	<85	<50	<85	<50

NOTE: The SpO_2 will be lower than predicted when the following are present: low pH, high $PaCO_2$, and high temperature.

TABLE 2.7 Signs and Symptoms of Inadequate Oxygenation

Central Nervous System	
Apprehension	Early
Restlessness or irritability	Early
Confusion or lethargy	Early or late
Combativeness	Late
Coma	Late
Respiratory	
Tachypnea	Early
Dyspnea on exertion (see Chapter 3)	Early
Dyspnea at rest (see Chapter 3)	Late
Use of accessory muscles	Late
Intercostal retractions	Late
Takes a breath between each word or sentence	Late
Cardiovascular	
Tachycardia	Early
Mild hypertension	Early
Arrhythmias	Early or late
Hypotension	Late
Cyanosis	Late
Skin is cool or clammy	Late
Other	
Diaphoresis	Early or late
Decreased urinary output	Early or late
General fatigue	Early or late

Systematic Examination of the Chest and Lungs

The physical examination of the chest and lungs should be performed in a systematic and orderly fashion. The most common sequence is as follows:

- Inspection
- Palpation
- Percussion
- Auscultation

Before the practitioner can adequately inspect, palpate, percuss, and auscultate the chest and lungs, however, he/she must have a good working knowledge of the topographic landmarks of the lung and chest. Various anatomic landmarks and imaginary vertical lines drawn on the chest are used to identify and document the location of specific abnormalities.

Lung and Chest Topography

Thoracic Cage Landmarks

Anteriorly, the first rib is attached to the manubrium just beneath the clavicle. After the first rib is identified, the rest of the ribs can easily be located and numbered. The sixth rib and its cartilage are attached to the sternum just above the xiphoid process (Fig. 2.3).

Posteriorly, the spinous processes of the vertebrae are useful landmarks. For example, when the patient's head is extended forward and down, two prominent spinous processes usually can be seen at the base of the neck. The top one is the spinous process of the seventh cervical vertebra (C-7); the bottom one is the spinous process of the first thoracic vertebra (T-1). When only one spinous process can be seen, it is usually C-7 (see Fig. 2.3).

Imaginary Lines

Various imaginary vertical lines are used to locate abnormalities on chest examination (Fig. 2.4). The vertical **midsternal line**, which is located in the middle of the sternum, equally divides the anterior chest into left and right hemithoraces. The **midclavicular lines**, which start at the middle of either the right or left clavicle, run parallel to the sternum, traditionally down through the male nipple.

On the lateral portion of the chest, three imaginary vertical lines are used. The **anterior axillary line** originates at the anterior axillary fold and runs down along the anterolateral aspect of the chest, the **midaxillary line** divides the lateral chest into two equal halves, and the **posterior axillary line** runs parallel to the midaxillary line along the posterolateral wall of the thorax.

Posteriorly, the **vertebral line** (also called the *midspinal line*) runs along the spinous processes of the vertebrae. The **midscapular line** runs through the middle of either the right or the left scapula parallel to the vertebral line.

Lung Borders and Fissures

Anteriorly, the apex of the lung extends approximately 2 to 4 cm above the medial third of the clavicle. Under normal conditions the lungs extend down to about the level of the sixth rib. Posteriorly, the superior portion of the lung extends to about the level of T-1 and down to about the level of T-10 (Fig. 2.5).

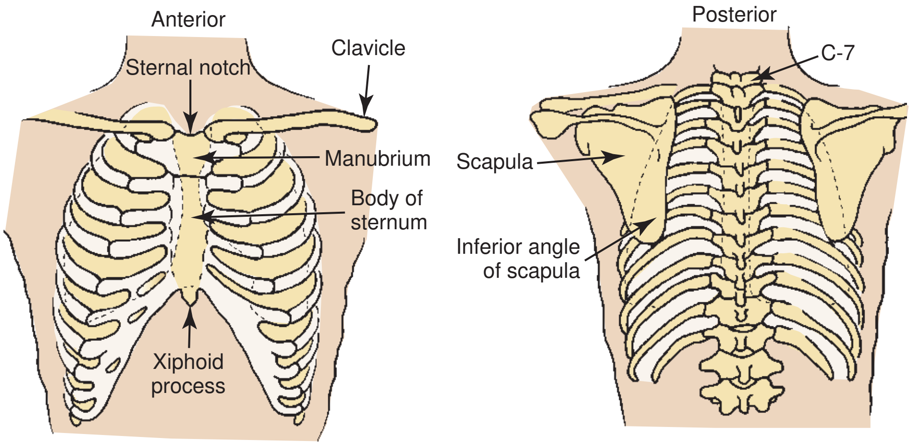


FIGURE 2.3 Anatomic landmarks of the chest.

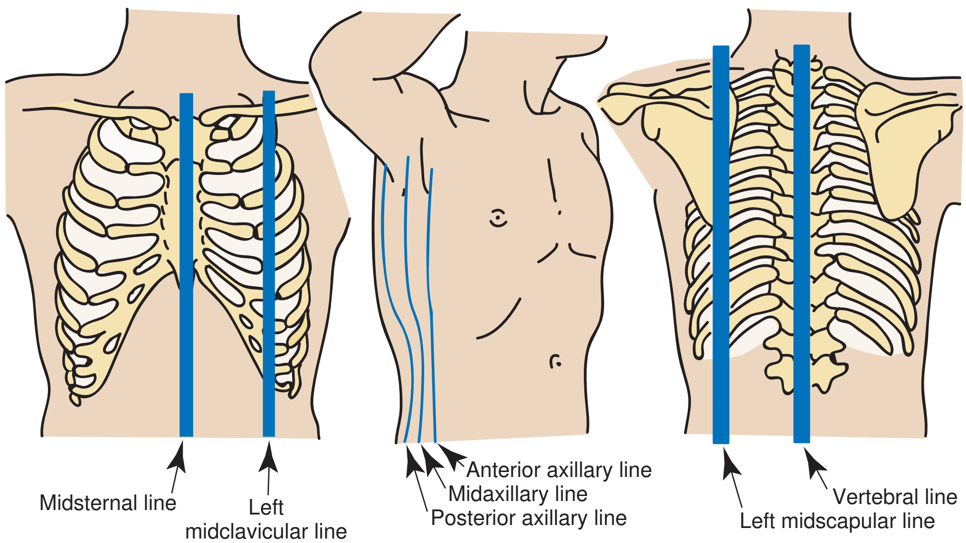


FIGURE 2.4 Imaginary vertical lines on the chest.

The right lung is separated into the upper, middle, and lower lobes by the **horizontal fissure** and the **oblique fissure**. The horizontal fissure runs anteriorly from the fourth rib at the sternal border to the fifth rib at the midaxillary line. The horizontal fissure separates the right anterior upper lobe from the middle lobe. The oblique fissure runs laterally from the sixth or seventh rib and the midclavicular line to the fifth rib at the midaxillary line. From this point, the oblique fissure continues to run around the chest posteriorly and upward to about the level of T-3. Anteriorly, the oblique fissure divides the lower lobe from the lower border of the middle lobe. Posteriorly, the oblique fissure separates the upper lobe from the lower lobe.

The left lung is separated into the upper and lower lobes by the oblique fissure. Anteriorly, the oblique fissure runs laterally from the sixth or seventh rib and the midclavicular line to the fifth rib at the midaxillary line. The fissure continues to run around the chest posteriorly and upward to about the level of T-3.

Inspection

The **inspection** of the patient is an ongoing observational process that begins with the history and continues throughout the patient interview, taking of vital signs, and physical examination. The inspection consists of a series of observations to gather clinical manifestations—signs and symptoms—that are directly or indirectly related to the patient's respiratory status. For example, during the patient interview and physical examination, the respiratory therapist might observe the patient demonstrating an abnormal ventilatory pattern, the use of accessory muscles, pursed-lip breathing, nasal flaring, splinting of the chest, a productive cough, or having clubbed fingers or lip or digital cyanosis.

A more in-depth discussion of the pathophysiologic basis for commonly seen respiratory disease clinical manifestations can be found in Chapter 3, The Pathophysiologic Basis for Common Clinical Manifestations.

Palpation

Palpation is the process of touching the patient's chest to evaluate the symmetry of chest expansion, the position of the trachea, skin temperature, muscle tone, areas of tenderness, lumps, depressions, and tactile fremitus and vocal fremitus. When palpating the chest, the clinician may use the heel or ulnar side of the hand, the palms, or the fingertips. As shown in Fig. 2.6, both the anterior and posterior chest should be palpated from side to side in an orderly fashion, from the apices of the chest down.

To evaluate the position of the trachea, the examiner places an index finger over the sternal notch and gently moves it from side to side. The trachea should be in the midline directly above the sternal notch. A number of abnormal pulmonary conditions can cause the trachea to deviate from its normal position. For example, a tension pneumothorax, pleural effusion,

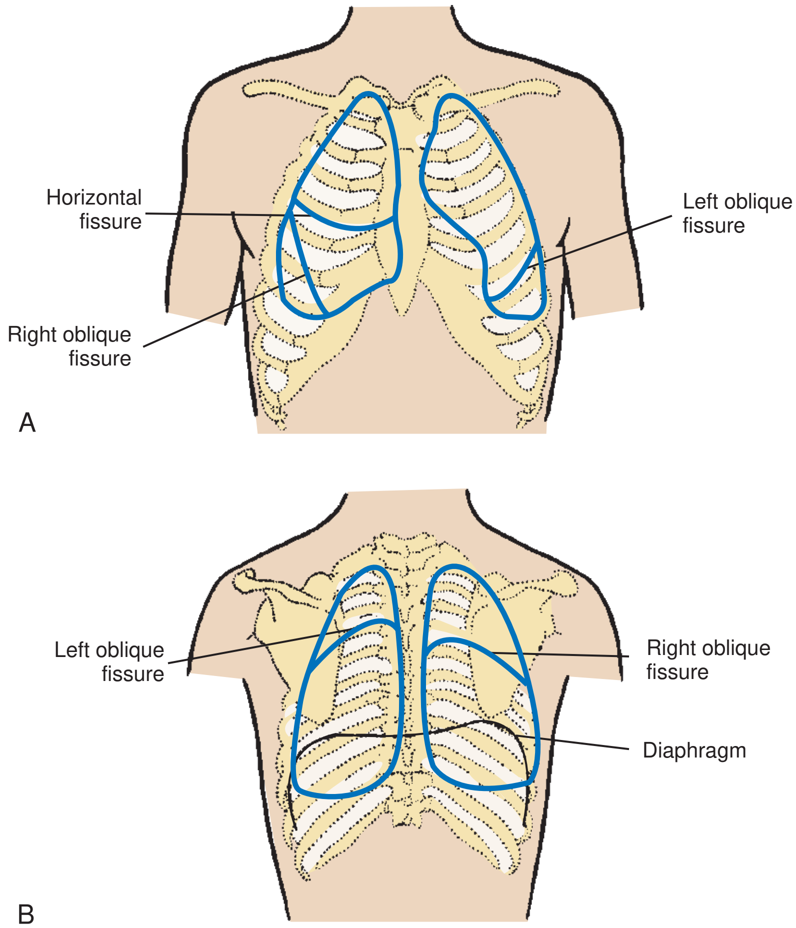


FIGURE 2.5 Topographic location of lung fissures projected on the anterior chest (A) and posterior chest (B).

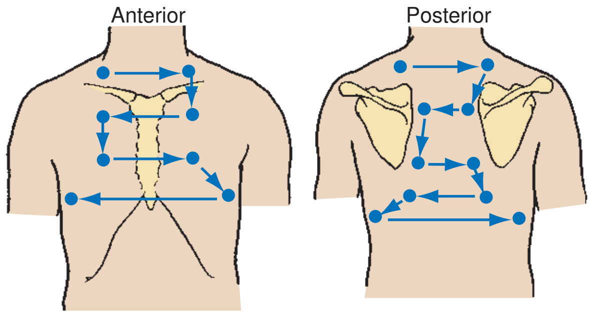


FIGURE 2.6 Path of palpation for vocal or tactile fremitus.

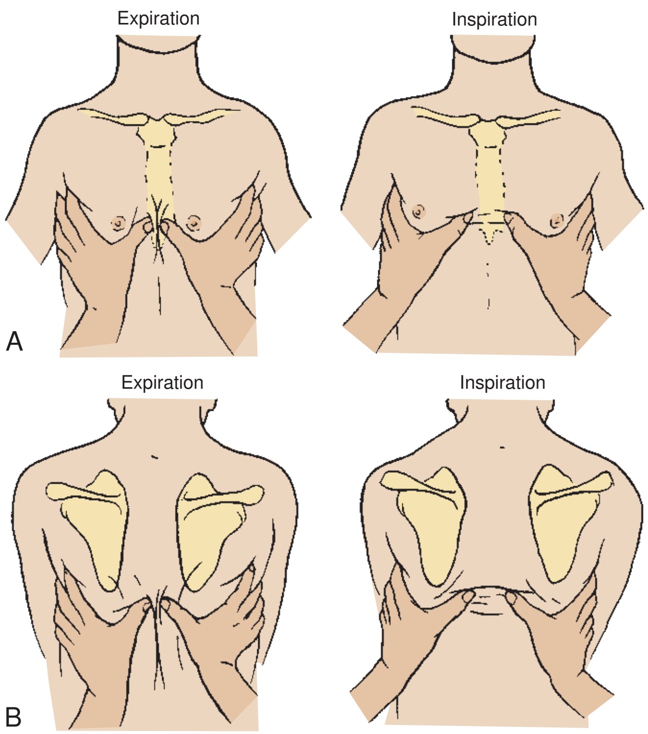


FIGURE 2.7 Assessment of chest excursion. (A) Anterior. (B) Posterior. Note that the thumbs move apart on inspiration as the volume of the thorax increases.

or tumor mass may push the trachea to the unaffected side, whereas atelectasis and pulmonary fibrosis pull the trachea to the affected side.

Chest Excursion

The symmetry of chest expansion is evaluated by lightly placing each hand over the patient's posterolateral chest so that the thumbs meet at the midline at about the T-8 to T-10 level. The patient is instructed to exhale slowly and completely and then inhale deeply. As the patient is inhaling, the examiner evaluates the distance that each thumb moves from the midline. Normally, each thumb tip moves equally about 3 to 5 cm from the midline (Fig. 2.7).

The examiner next faces the patient and lightly places each hand on the patient's anterolateral chest so that the thumbs meet at the midline along the costal margins near the xiphoid process. The patient is again instructed to exhale slowly and completely and then to inhale deeply. As the patient is inhaling, the examiner observes the distance each thumb moves from the midline. Again, an excursion of 3 to 5 cm from the midline (xiphoid process) is normally seen.

A number of pulmonary disorders can alter the patient's **chest excursion**. For example, bilaterally decreased chest expansion (excursion) may be caused by both obstructive and restrictive lung disorders. An unequal chest expansion may occur when one or more of the following develop in or around one lung only: alveolar consolidation (e.g., pneumonia), lobar atelectasis, pneumothorax, large pleural effusions, or chest trauma (e.g., fractured ribs).

Tactile and Vocal Fremitus

Vibration that can be perceived by palpation over the chest is called **tactile fremitus** (also known as *rhonchial fremitus*). This condition is commonly caused by gas flowing through thick secretions that are partially obstructing the large airways. Tactile fremitus is often noted during inhalation and exhalation and may clear after a strong cough. It is often associated with coarse, low-pitched crackles that are audible without a stethoscope. Vibration that can be perceived by palpation or auscultation over the chest during phonation is called **vocal fremitus.** Sounds produced by the vocal cords are transmitted down the tracheobronchial tree and through the lung parenchyma to the chest wall, where the examiner can feel the vibration. Vocal fremitus can often be elicited by having the patient repeat the phrase "ninety-nine" or "blue moon." These are resonant phrases that produce strong vibrations. Normally, fremitus is most prominent between the scapulae and around the sternum, sites where the large bronchi are closest to the chest wall.

Tactile and vocal fremitus decreases when anything obstructs the transmission of vibration. Such conditions include chronic obstructive pulmonary disease, tumors or thickening of the pleural cavity, pleural effusion, pneumothorax, and a muscular or obese chest wall. Tactile and vocal fremitus increases in patients with alveolar consolidation, atelectasis, pulmonary edema, lung tumors, pulmonary fibrosis, and thin chest walls.

Crepitus (also called **subcutaneous emphysema**) is a coarse, crackling sensation that may be palpable over the skin surface. It occurs when air escapes from the thorax and enters the subcutaneous tissue. It may occur after a tracheostomy and mechanical ventilation, open thoracic injury, or thoracic surgery. In severe cases, crepitus also may be felt over the abdomen, genitalia, extremities, and face.

Percussion

Percussion over the chest wall is performed to determine the size, borders, and consistency of air, liquid, or solid material in the underlying lung. When percussing the chest, the examiner firmly places the distal portion of the middle finger of the nondominant hand between the ribs over the surface of the chest area to be examined. No other portion of the hand should touch the patient's chest. With the end of the middle finger of the dominant hand, the examiner quickly strikes the distal joint of the finger positioned on the chest wall and then quickly withdraws the tapping finger (Fig. 2.8). The examiner should perform the chest percussion in an orderly fashion from top to bottom, comparing the sounds generated

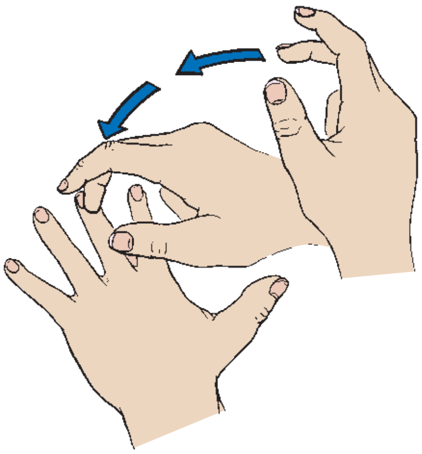


FIGURE 2.8 Chest percussion technique.

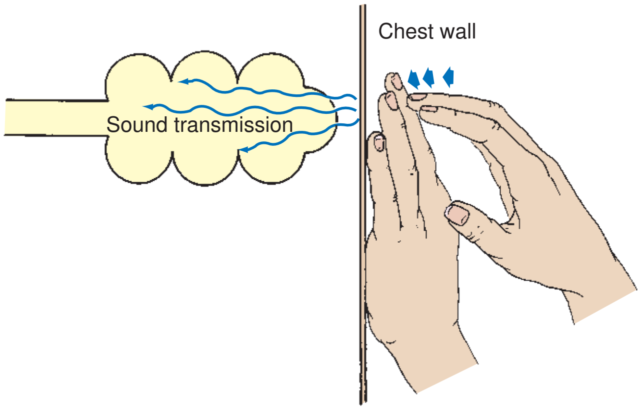


FIGURE 2.10 Chest percussion of a normal lung.

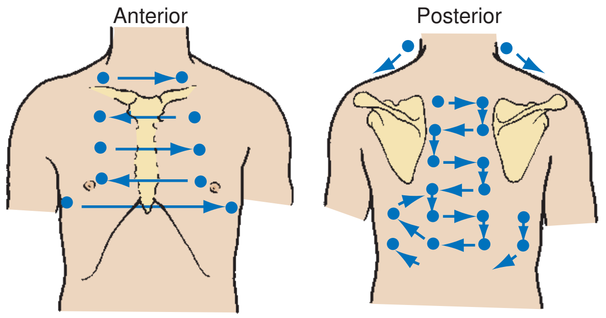


FIGURE 2.9 Path of systematic percussion to include all important areas.

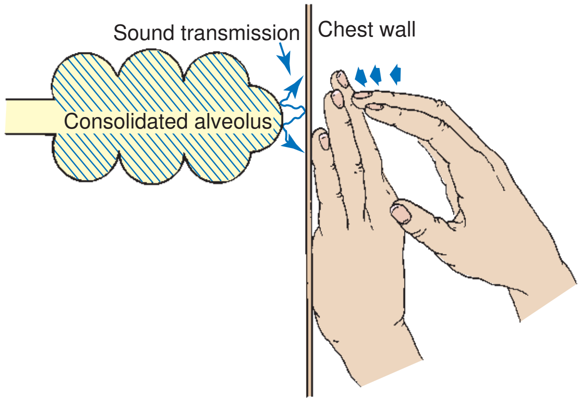


FIGURE 2.11 A short, dull, or flat percussion note is typically produced over areas of alveolar consolidation.

on both sides of the chest, both anteriorly and posteriorly (Fig. 2.9).

In the normal lung the sound created by percussion is transmitted throughout the air-filled lung and is typically described as loud, low in pitch, and long in duration. The sounds elicited by the examiner vibrate freely throughout the large surface area of the lungs and create a sound similar to that elicited by knocking on a watermelon (Fig. 2.10).

Resonance may be muffled somewhat in the individual with a heavily muscular chest wall and in the obese person. When percussing the anterior chest, the examiner should take care not to confuse the normal borders of cardiac dullness with pulmonary pathologic conditions. In addition, the upper border of liver dullness is normally located in the right fifth intercostal space and midclavicular line. Over the left side of the chest, **tympany** (hyperresonance) is produced over the gastric space. When percussing the posterior chest, the examiner should avoid the damping effect of the scapulae.

Abnormal Percussion Notes

A **dull percussion note** is heard when the chest is percussed over areas of pleural thickening, pleural effusion, atelectasis, and consolidation. When these conditions exist, the sounds produced by the examiner do not freely vibrate throughout the lungs. A dull percussion note is described as flat or soft, high in pitch, and short in duration, similar to the sound produced by knocking on a full barrel (Fig. 2.11).

When the chest is percussed over areas of trapped gas, a **hyperresonant note** is heard. These sounds are described as very loud, low in pitch, and long in duration, similar to the sound produced by knocking on an empty barrel (Fig. 2.12). A hyperresonant note is commonly elicited from air trapping in the patient with chronic obstructive pulmonary disease or pneumothorax.

Diaphragmatic Excursion

The relative position and range of motion of the hemidiaphragms also can be determined by percussion. Clinically, this evaluation is called the determination of **diaphragmatic excursion**. To assess the patient's diaphragmatic excursion, the examiner first maps out the lower lung borders by percussing the posterior chest from the apex down and identifying the point at which the percussion note definitely changes from a resonant to flat sound. This procedure is then performed at maximal inspiration and again at maximal expiration. Under normal conditions the diaphragmatic excursion should be equal bilaterally and should measure approximately 4 to 8 cm in the adult.

When severe alveolar hyperinflation is present (e.g., severe emphysema, asthma), the diaphragm is low and flat in position and has minimal excursion. Lobar collapse of one lung may pull the diaphragm up on the affected side and reduce excursion. The diaphragm also may be elevated and immobile in neuromuscular diseases that affect it.

Auscultation

Auscultation of the chest provides information about the heart, blood vessels, and air flowing in and out of the tracheobronchial tree and alveoli. A stethoscope is used to evaluate the frequency, intensity, duration, and quality of the sounds. During auscultation the patient should ideally be in the upright position and instructed to breathe slowly and deeply through the mouth. The anterior and posterior chest should be auscultated in an orderly fashion from the apex to base while the right side of the chest is compared with the left (Fig. 2.13). When examining the posterior chest, the examiner should ask the patient to rotate the shoulders forward so that a greater surface area of the lungs can be auscultated. Lung sounds are classified as either normal breath sounds or abnormal lung sounds (also called **adventitious lung sounds**).

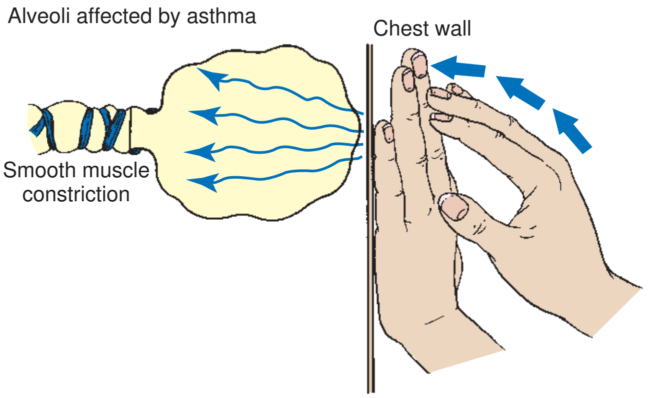


FIGURE 2.12 Percussion becomes more hyperresonant with alveolar hyperinflation.

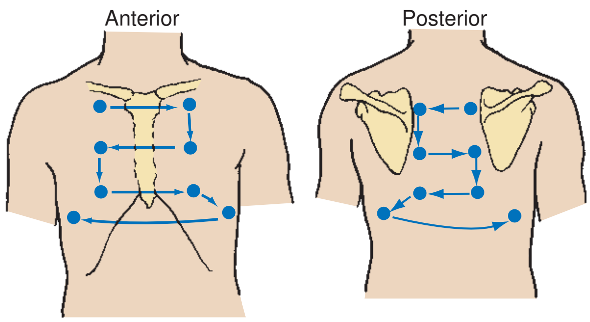


FIGURE 2.13 Path of systematic auscultation to include all important areas. Note the exact similarity of this pathway to that in Fig. 2.6.

Normal Breath Sounds

Three different **normal breath sounds** can be auscultated over the normal chest. They are called *bronchial*, *bronchovesicular*, and *vesicular breath sounds*. Important characteristics of breath sounds include the pitch (vibration frequency), amplitude or intensity (loudness), and the duration of inspiratory sounds compared with expiration. Fig. 2.14 presents a sound diagram that illustrates the audio characteristics of the normal vesicular breath sound. Table 2.8 provides an overview of the normal breath sounds in regard to their location, pitch, intensity, and sound diagram.

Bronchial Breath Sounds. Bronchial breath sounds are normally auscultated directly over the trachea and are caused by the turbulent flow of gas through the upper airway. Bronchial breath sounds have a harsh, hollow, or tubular quality. They are loud, high in pitch, and about equal in duration in length

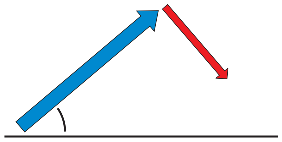
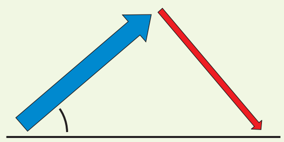
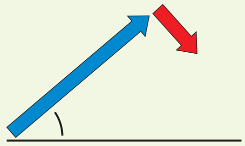
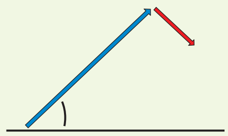


FIGURE 2.14 The normal vesicular breath sound. The blue upward arrow represents *inhalation*. The red downward arrow symbolizes *exhalation*. The length of the arrow signifies *duration*. The thickness of the arrow denotes *intensity* or *loudness*. The angle between the blue inhalation arrow and the horizontal line symbolizes *pitch* (i.e., fast or slow vibration frequency).

TABLE 2.8 Normal Breath Sounds

Breath Sound	Location	Pitch	Intensity	Sound Diagram*
Bronchial	Over trachea	High	Loud	
Bronchovesicular	Upper portion of anterior sternum, between scapulae	Moderate	Moderate	
Vesicular	Peripheral lung regions	High	Soft	

*For the sound diagrams above, the blue upward arrow represents *inhalation*. The red downward arrow symbolizes *exhalation*. The length of the arrow signifies *duration*. The thickness of the arrow denotes *intensity* or *loudness*. The angle between the blue inhalation arrow and the horizontal line symbolizes *pitch* (i.e., fast or slow vibration frequency).

of inspiration and expiration. A slight pause occurs between these two components. These sounds are also called *tracheal, tracheobronchial,* and *tubular breath sounds.*

Bronchovesicular Breath Sounds. Bronchovesicular breath sounds are auscultated directly over the mainstem bronchi. They are softer and lower in pitch and intensity than bronchial breath sounds and do not have a pause between the inspiratory and expiratory phase. These sounds are reduced in pitch and intensity as a result of the filtering of sound that occurs as gas moves between the large airways and alveoli. Anteriorly, bronchovesicular breath sounds can be heard directly over the mainstem bronchi between the first and second ribs. Posteriorly, they are heard between the scapulae near the spinal column between the first and sixth ribs, especially on the right side (Fig. 2.15A).

Vesicular Breath Sounds. Vesicular breath sounds are the normal sounds of gas rustling or swishing through the small bronchioles and the alveoli. Under normal conditions, vesicular breath sounds are auscultated over most lung fields, both anteriorly and posteriorly (see Fig. 2.15B). They are primarily heard during inspiration. As the gas molecules enter the alveoli, they are able to spread out over a large surface area and, as a result of this action, create less gas turbulence. Vesicular breath sounds also are heard during the initial third of exhalation as gas leaves the alveoli and bronchioles and moves into the large airways (Fig. 2.16).

Abnormal Lung Sounds. Abnormal lung sounds (ALS) are atypical, or uncharacteristic, lung sounds that are not *normally* heard over a specific area of the thorax. To describe the *pitch* of an ALS, the experts recommend the use of such words as high, moderate, or low—for example, "high-pitched wheezes were auscultated." For *the intensity* or *loudness* of the ALS, words such as faint, soft, mild, moderate, or loud should be used—for example, "loud bronchial breath sounds were auscultated." The part of the respiratory cycle in which the ALS occurs should be recorded—for example, "crackles were heard both during inspiration and expiration." In addition, include mention of when the ALS occurs during inspiration—for example, "late-inspiratory crackles." Also, document the magnitude of the ALS—for example, "small, scant, or profuse crackles." Always record the precise location over the chest the ALS is auscultated—for example, "expiratory wheezes were noted over the anterior right lower lobe."

Although the experts (American Thoracic Society [ATS] and the American College of Chest Physicians [ACCP] Joint Committee on Pulmonary Nomenclature) have debated for many years the value of some of the terms and adjectives used to describe ALS, they have agreed—for the most part—that several terms or phrases are either ambiguous or very subjective and therefore should not be used for clinical reports, charting, and/or electronic documentation. *Terms, adjectives, and phrases not recommended at present are wet, dry, rales, rhonchi, crepitations, sonorous rales, musical rales, and sibilant rales.*

Currently, the recommended terms, adjectives, and phrases for ALS are the following: fine crackles, medium crackles, or coarse crackles, wheezes, bronchial breath sounds, stridor, pleural friction rub, diminished breath sound, and whispering pectoriloquy. Fig. 2.17 illustrates the general location and cause for these ALS. Table 2.9 provides an overview and description of the common ALS.

Table 2.10 summarizes the common assessment abnormalities found during inspection, palpation, percussion, and auscultation.

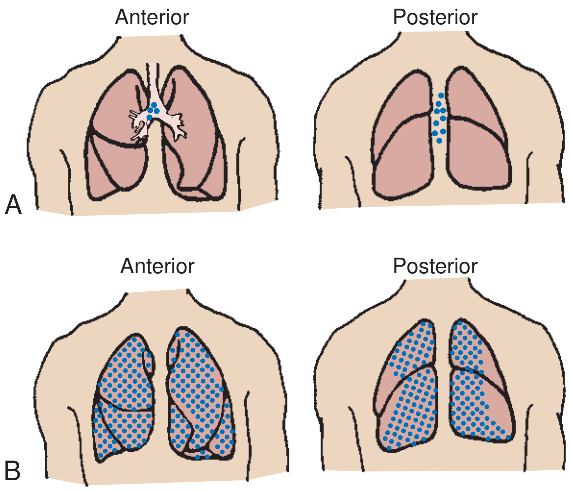


FIGURE 2.15 The location at which bronchovesicular breath sounds (A) and vesicular breath sounds (B) are normally auscultated.

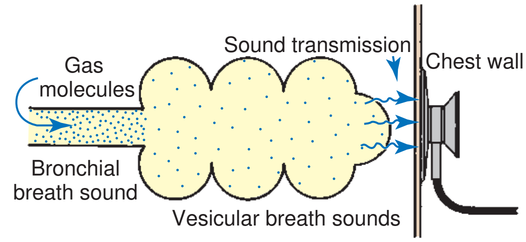


FIGURE 2.16 Auscultation of vesicular breath sounds over a normal lung unit.

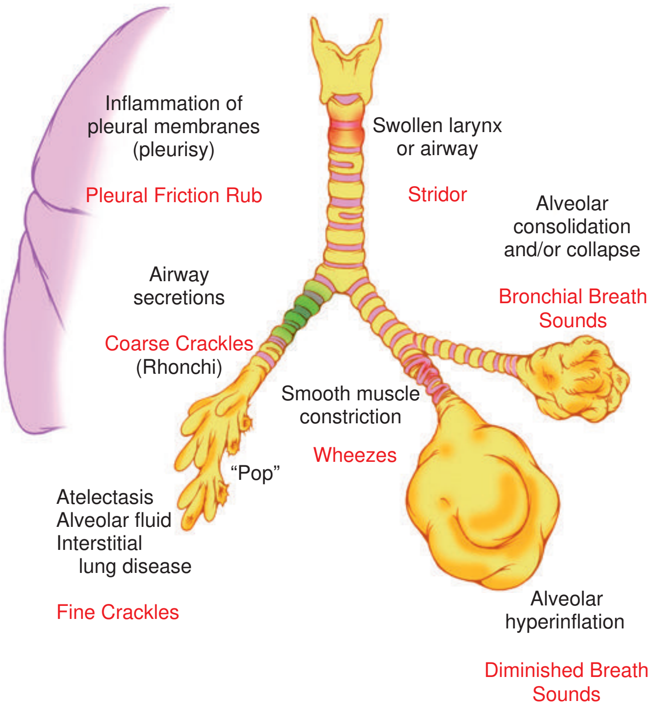


FIGURE 2.17 General location and origin of abnormal lung sounds.

TABLE 2.9 Abnormal Lung Sounds

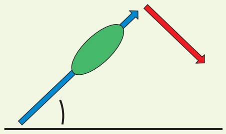
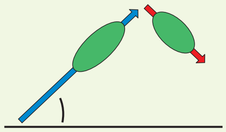
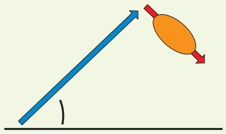
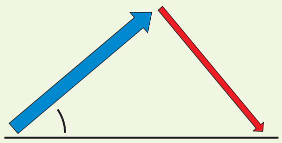
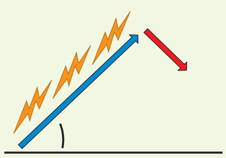
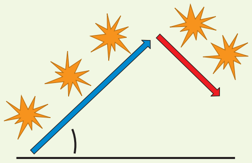
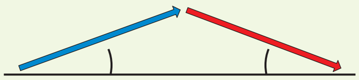
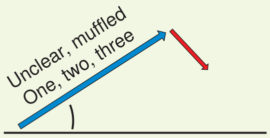
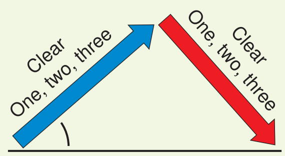
Abnormal Lung Sound	Sound Diagrams*
Crackles Crackles (previously called *rales*) can be categorized as fine, medium, and coarse crackles. *Fine crackles* are discontinuous, high-pitched, crackling, and popping sounds similar to popping of bubble wrap or the sound created by rolling hair between fingers near one's ear and is heard near the end of inspiration (see Sound Diagram A). Fine crackles are produced by the rapid equalization of gas pressure when collapsed alveoli or terminal bronchioles suddenly snap open (see Fig. 2.17). Fine crackles usually do not clear after a strong cough. Fine crackles are associated with alveolar collapse (atelectasis), interstitial fibrosis, early pulmonary edema, and pneumonia. *Medium crackles* are the same as fine crackles but are medium in pitch and have a moist quality as the disease process worsens. *Coarse crackles* (previously called *rhonchi*[†]) are discontinuous, low-pitched, rumbling, bubbling, or gurgling sounds that start early during inspiration and extend into exhalation. These sounds are caused by air moving through excessive airway secretions in the larger airways (see Sound Diagram B). Coarse crackles are commonly associated with severe chronic obstructive pulmonary disease, cystic fibrosis, bronchiectasis, and congestive heart failure (pulmonary edema). Coarse crackles may or may not change in nature after a strong, vigorous cough.	 A. **Fine crackles.** The green oval shape represents crackles.  B. **Coarse crackles.** The green oval shape represents crackles.
Wheezing **Wheezing** is the characteristic sound produced by airway obstruction. Found in all bronchospasm disorders, it is one of the cardinal findings in asthma (see Fig. 2.17). Wheezes are continuous, high-pitched, musical whistles generally heard on expiration (see Sound Diagram). In severe cases, they may be heard during inspiration. In addition to bronchospasm, other common causes of partial or total airway obstruction include mucosal edema, inflammation, tumors, and foreign bodies. Partial airway obstruction is often made greater by this mechanism: When the bronchial airway is narrowed, the velocity of air flow through the constricted airway increases, which, in turn, causes the lateral airway wall pressure to decrease. This condition causes the airways to narrow even further and/or collapse. As the airways narrow, they vibrate similar to a reed on a woodwind instrument, thereby producing a wheezing sound (Fig. 2.18).	 **Wheezing** The orange oval shape represents wheezing.
Bronchial Breath Sounds Bronchial breath sounds have a harsh, hollow, or tubular quality. They are loud, high in pitch, and about equal in duration during inspiration and expiration. The inspiratory phase is louder (see Fig. 2.17 and Sound Diagram). Bronchial breath sounds are associated with alveolar consolidation and atelectasis (Fig. 2.19).	 **Bronchial breath sound** Note the thickness of the inspiratory and expiratory arrows, which denote loudness.
Stridor **Stridor** is a continuous, loud, high-pitched sound caused by an upper obstruction in the trachea or larynx (see Fig. 2.17 and Sound Diagram). It is generally heard during inspiration. Stridor is usually loud enough to hear without a stethoscope, as in infantile croup. Stridor indicates a neoplastic or inflammatory condition, including glottic edema, diphtheria, laryngospasm croup, and papilloma (a benign epithelial neoplasm of the larynx).	 **Stridor** The orange shapes represent stridor sounds.

TABLE 2.9 Abnormal Lung Sounds—cont'd

Abnormal Lung Sound	Sound Diagrams*
Pleural Friction Rub If pleurisy accompanies a respiratory disorder, the inflamed pleural membranes resist movement during breathing and create a peculiar and characteristic sound known as a *pleural friction rub* (see Fig. 2.17 and Sound Diagram). It is a continuous, low-pitched, coarse creaking or grating-type sound reminiscent of that made by a creaking shoe. It is usually heard throughout inspiration and expiration over the area where the patient complains of pain. The intensity of a pleural rub often increases with deep breathing. A pleural friction rub does not clear with cough. A pleural friction rub is associated with pleurisy, tuberculosis, pneumonia, pulmonary fibrosis, pulmonary infarction, or after thoracic surgery.	 **Pleural friction rub** The orange shapes represent pleural friction rub sounds.
Diminished Breath Sounds Breath sounds are diminished or distant in any respiratory disorder that reduces the sound intensity of air flow as in obesity. In another example, chronic obstructive pulmonary disease leads to air trapping, an increased function residual capacity, and hypoventilation, which, in turn, result in **diminished breath sounds** (Fig. 2.20). Heart sounds also may be diminished in patients with air trapping. The intensity of breath sounds is also reduced in any condition that causes shallow or slow breathing patterns—for example, drug overdose, major sedation, or neuromuscular diseases such as Guillain-Barré syndrome or myasthenia gravis. Diminished breath sounds are also found in respiratory disorders that cause hypoventilation by compressing the lung, such as flail chest, pleural effusion, and pneumothorax.	 **Diminished breath sound** Note the decreased angle on the inspiratory and expiratory arrows, which represent decreased intensity or loudness.
Whispering Pectoriloquy **Whispering pectoriloquy** is the term used to describe the unusually clear transmission of the whispered voice of a patient as heard through the stethoscope. When the patient whispers "one, two, three," the sounds produced by the vocal cords are transmitted not only toward the mouth and nose but also throughout the lungs. As the whispered sounds travel down the tracheobronchial tree, they remain relatively unchanged, but as the sound disperses throughout the large surface area of the alveoli, it diminishes sharply. Consequently, when the examiner listens with a stethoscope over a normal lung while the patient whispers "one, two, three," the sounds are diminished, distant, muffled, and unintelligible (Fig. 2.21). When a patient who has atelectasis or consolidated lung areas whispers "one, two, three," the sounds produced are prevented from spreading out over a large alveolar surface area. Even though the consolidated area may act as a sound barrier and diminish the sounds somewhat, the reduction in sound is not as great as it would be if the sounds were allowed to dissipate throughout a normal lung. Consequently, the whispered sounds are much louder and more intelligible over the affected lung areas (Fig. 2.22).	 **Normal vesicular breath sounds—**unclear, muffled words ("one, two, three") auscultated.  **Consolidation and/or atelectasis—**clear words ("one, two, three") auscultated.

*For the sound diagrams, the blue upward arrow represents *inhalation*. The red downward arrow symbolizes *exhalation*. The length of the arrow signifies *duration*. The thickness of the arrow denotes *intensity* or *loudness*. The angle between the blue inhalation arrow and the horizontal line symbolizes *pitch* (i.e., fast or slow vibration frequency).

†Historically, coarse crackles have also been called *rhonchi*, a term not currently recommended. Coarse crackles often produce palpable vibrations called *tactile fremitus*, also known as *rhonchial fremitus*. Coarse crackles are sometimes referred to as a "death rattle." It is this abnormal lung sound that every practicing respiratory therapist knows all too well—that is, the patient, whose loud, rumbling, gurgling secretions can be heard across the patient's room, which clearly signals the immediate need for tracheal suctioning or chest physical therapy.

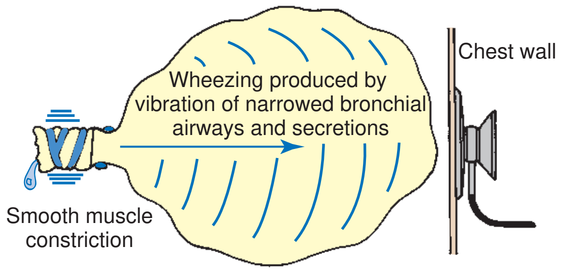


FIGURE 2.18 Wheezing and coarse crackles often develop during an asthmatic episode because of smooth muscle constriction, wall edema, and mucous accumulation.

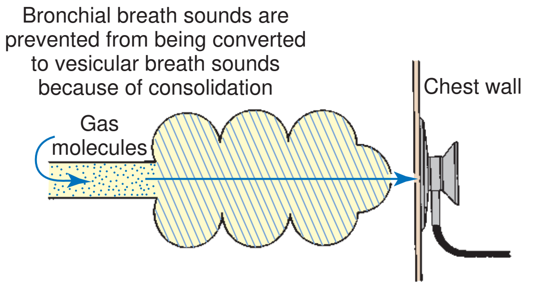


FIGURE 2.19 Auscultation of bronchial breath sounds over a consolidated lung unit.

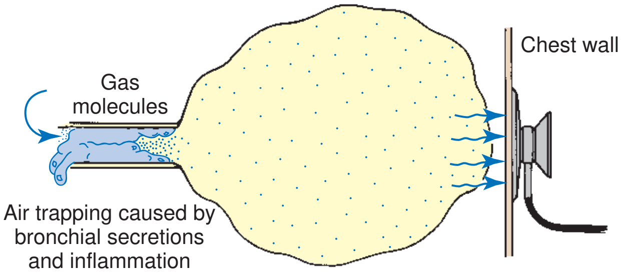


FIGURE 2.20 As air trapping and alveolar hyperinflation develop in obstructive lung diseases, breath sounds progressively diminish.

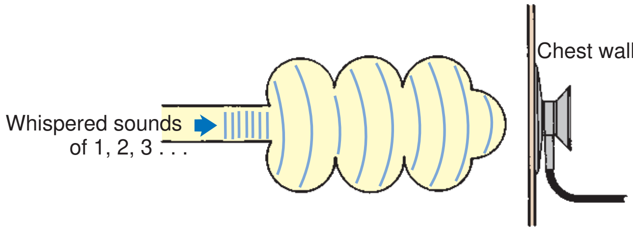


FIGURE 2.21 Whispered voice sounds auscultated over a normal lung are usually faint and unintelligible.

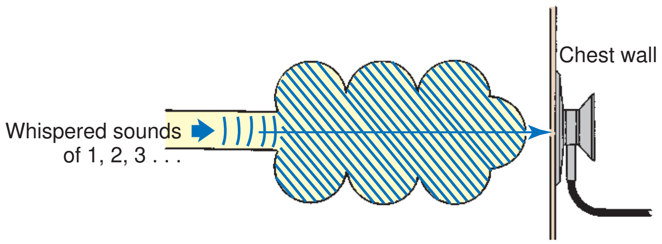


FIGURE 2.22 Whispering Pectoriloquy. Whispered voice sounds heard over a consolidated lung are often louder and more intelligible compared with those of a normal lung.

TABLE 2.10 Common Assessment Abnormalities

Finding	Description	Possible Cause and Significance
Inspection		
Pursed-lip breathing	Exhalation through mouth with lips pursed together to slow exhalation.	COPD, asthma. Suggests ↑ breathlessness. Strategy taught to slow expiration, ↓ dyspnea.
Tripod position; inability to lie flat	Leaning forward with arms and elbows supported on overbed table.	COPD, asthma in exacerbation, pulmonary edema. Indicates moderate to severe respiratory distress.
Accessory muscle use; intercostal retractions	Neck and shoulder muscles used to assist breathing. Muscles between ribs pull in during inspiration.	COPD, asthma in exacerbation, secretion retention. Indicates severe respiratory distress, hypoxemia.
Splinting	Voluntary ↓ in tidal volume to ↓ pain on chest expansion.	Thoracic or abdominal incision pain. Chest trauma, pleurisy.
↑ AP diameter	AP chest diameter equal to lateral. Slope of ribs more horizontal (90 degrees) to spine.	COPD, asthma, cystic fibrosis. Lung hyperinflation. Advanced age.
Tachypnea	Rate >20 breaths/min; >25 breaths/min in elderly.	Fever, anxiety, hypoxemia, restrictive lung disease. Magnitude of ↑ above normal rate reflects magnitude of increased work of breathing.

TABLE 2.10 Common Assessment Abnormalities—cont'd

Finding	Description	Possible Cause and Significance
Kussmaul's respiration	Regular, rapid, and deep respirations.	Metabolic acidosis; ↑ in rate aids body in ↑ CO_2 excretion.
Cyanosis	Bluish color of skin best seen in earlobes, under the eyelids, or in nail beds.	↓ Oxygen transfer in lungs, ↓ cardiac output. Nonspecific, unreliable indicator.
Clubbing of fingers	↑ Depth, bulk, sponginess of distal digits of fingers.	Chronic hypoxemia. Cystic fibrosis, lung cancer, bronchiectasis.
Peripheral edema	Pitting edema.	Congestive heart failure, cor pulmonale.
Distended neck veins	Jugular venous distention.	Cor pulmonale, flail chest, pneumothorax.
Cough	Productive or nonproductive.	Bronchial airway and alveolar disease.
Sputum	See Table 3.4.	COPD, asthma, cystic fibrosis, pneumonia.
Abdominal paradox	Inward (rather than normal outward) movement of abdomen during inspiration.	Inefficient and ineffective breathing pattern. Nonspecific indicator of severe respiratory distress.
Palpation		
Tracheal deviation	Leftward or rightward movement of trachea from normal midline position.	Nonspecific indicator of change in position of mediastinal structures. Medical emergency if caused by tension pneumothorax.
Altered tactile fremitus	Increase or decrease in examiner-felt vibrations.	↑ In pneumonia, atelectasis; pulmonary edema; ↓ in pleural effusion, lung hyperinflation; absent in pneumothorax.
Altered chest movement	Unequal or equal but diminished movement of two sides of chest with inspiration.	Unequal movement caused by atelectasis, pneumothorax, pleural effusion, splinting; equal but diminished movement caused by barrel chest, restrictive disease, neuromuscular disease.
Percussion		
Hyperresonance	Loud, lower-pitched sound over areas that normally produce a resonant sound on chest percussion.	Lung hyperinflation (COPD), lung collapse (pneumothorax), air trapping (asthma).
Dullness/flatness	Medium-pitched sound over areas that normally produce a resonant sound on chest percussion.	↑ Density (pneumonia, large atelectasis), ↑ fluid pleural space (pleural effusion).
Auscultation		
Fine crackles	Series of discontinuous short, crackling, and popping sounds, high-pitched sounds heard just before the end of inspiration; result of rapid equalization of gas pressure when collapsed alveoli or terminal bronchioles suddenly snap open; similar sound to that made by rolling hair between fingers just behind ear.	Loss of lung volume (atelectasis), interstitial fibrosis (asbestosis), interstitial edema (early pulmonary edema), alveolar filling (pneumonia), early phase of congestive heart failure.
Coarse crackles	Series of discontinuous short, low-pitched bubbling or gurgling sounds caused by air passing through airway intermittently occluded by mucus, unstable bronchial wall, or fold of mucosa; evident on inspiration and, in more severe cases, expiration; similar sound to blowing through straw under water; increase in bubbling quality with more fluid.	COPD, cystic fibrosis, congestive heart failure, bronchiectasis, pulmonary edema, pneumonia with severe congestion, COPD.
Wheezes	Continuous high-pitched whistling sound caused by rapid vibration of bronchial walls; first evident on expiration but also possibly evident on inspiration as obstruction of airway increases; possibly audible even without a stethoscope.	Bronchospasm (caused by asthma), airway obstruction (caused by mucosal edema, inflammation, foreign body, tumor), COPD.

Continued

TABLE 2.10 Common Assessment Abnormalities—cont'd

Finding	Description	Possible Cause and Significance
Bronchial breath sound	A harsh, hollow, or tubular breath sound. They are loud, high in pitch, and about equal in duration during inspiration and expiration. Inspiration is louder.	Alveolar consolidation and alveolar collapse (atelectasis).
Stridor	Continuous, loud, high-pitched sound caused by a partial obstruction of the larynx or trachea. Generally heard during inspiration.	Croup, epiglottitis, vocal cord edema after extubation, foreign body.
Pleural friction rub	A continuous, low-pitched creaking, or grating sound from roughened, inflamed surfaces of the pleura rubbing together. Generally heard during both inspiration and expiration. There is no change with coughing. The patient is usually uncomfortable, especially on deep inspiration.	Pleurisy, pneumonia, pulmonary fibrosis, pulmonary embolism, and thoracic surgery.
Diminished breath sounds	Diminished or distant breath sounds.	COPD, drug overdose or major sedation, neuromuscular disease (Guillain-Barré or myasthenia gravis), flail chest, pleural effusion, and pneumothorax.
Whispering pectoriloquy	Spoken or whispered syllable more distinct than normal on auscultation.	Alveolar consolidation and alveolar collapse (atelectasis).

AP, Anteroposterior; *COPD*, chronic obstructive pulmonary disease.

SELF-ASSESSMENT QUESTIONS

1. Which of the following pathologic conditions increases vocal fremitus?
1. Atelectasis
2. Pleural effusion
3. Pneumothorax
4. Pneumonia
   a. 3 only
   b. 4 only
   c. 2 and 3 only
   d. 1 and 4 only

2. A dull or soft percussion note would likely be heard in which of the following pathologic conditions?
1. Chronic obstructive pulmonary disease
2. Pneumothorax
3. Pleural thickening
4. Atelectasis
   a. 1 only
   b. 2 only
   c. 2 and 3 only
   d. 3 and 4 only

3. Bronchial breath sounds are likely to be heard in which of the following pathologic conditions?
1. Alveolar consolidation
2. Chronic obstructive pulmonary disease
3. Atelectasis
4. Fluid accumulation in the tracheobronchial tree
   a. 3 only
   b. 4 only
   c. 1 and 3 only
   d. 2 and 4 only

4. Wheezing is:
1. Produced by bronchospasm
2. Generally auscultated during inspiration
3. A cardinal finding of bronchial asthma
4. Usually heard as high-pitched sounds
   a. 1 only
   b. 1 and 3 only
   c. 2 and 4 only
   d. 1, 3, and 4 only

5. In which of the following pathologic conditions is transmission of the whispered voice of a patient through a stethoscope unusually clear?
1. Chronic obstructive pulmonary disease
2. Alveolar consolidation
3. Atelectasis
4. Pneumothorax
   a. 1 only
   b. 2 and 3 only
   c. 1 and 4 only
   d. 1, 2, and 3 only

6. Which of the following abnormal breathing patterns is commonly associated with diabetic acidosis?
a. Orthopnea
b. Kussmaul's respiration
c. Biot's respiration
d. Hypoventilation

CHAPTER 3

The Pathophysiologic Basis for Common Clinical Manifestations

Chapter Objectives

After rteading this chapter, you will be able to:

- Discuss the pathophysiologic basis for abnormal ventilatory patterns, including
  - Effects of lung compliance
  - Airway resistance
  - Peripheral chemoreceptors
  - Central chemoreceptors
  - Pulmonary reflexes
  - Pain, anxiety, and fever
- Describe the function of the accessory muscles of inspiration.
- Describe the function of the accessory muscles of expiration.
- Discuss the effects of pursed-lip breathing.
- Describe the pathophysiologic basis for substernal and intercostal retractions.
- Explain nasal flaring.
- Discuss splinting and decreased chest expansion caused by pleuritic and nonpleuritic chest pain.
- List abnormal chest shape and configurations.
- List abnormal extremity findings.
- Describe normal and abnormal sputum production.
- Define key terms and complete self-assessment questions at the end of the chapter and on Evolve.

Key Terms

Abnormal Ventilatory Patterns
Accessory Muscles of Expiration
Accessory Muscles of Inspiration
Acute-Onset Conditions
Airway Resistance (R_{aw})
Aortic and Carotid Sinus Baroreceptor Reflexes
Borg Dyspnea Scale
Capability-to-Breathe
Cardiac Dyspnea
Cardiopulmonary Exercise Testing
Central Chemoreceptors
Central Cyanosis
Chronic Conditions
Cough
Cyanosis
Demand-to-Breathe
Digital Clubbing
Distended Neck Veins
Dorsal Respiratory Group (DRG)
Dyspnea
Eupnea
Exertional Dyspnea
External Oblique Muscle
Hering-Breuer Reflex
Hemoptysis
Hypothermia
Hysteresis
Inspiratory-to-Expiratory Ratio (I/E Ratio)
intercostal retractions
Internal Oblique Muscle
Irritant Reflex
jungular venous distention
Juxtapulmonary-Capillary Receptors (J Receptors) Reflex
Lung Compliance (C_L)
Modified (British) Medical Research Council (mMRC) Questionnaire
Mucociliary Escalator
Mucous Blanket
Nasal Flaring
Nonpleuritic Chest Pain
Nonproductive Cough
Orthopnea
Paroxysmal Nocturnal Dyspnea
Pectoralis Major Muscle
Peripheral Chemoreceptors
Peripheral Edema
Pitting Edema
Pleural Friction Rub
Pleuritic Chest Pain
Poiseuille's Law
Positional Dyspnea
Productive Cough
Pulmonary Shunting
Pursed-Lip Breathing
Rectus Abdominis Muscles
Renal Dyspnea
Scalene Muscles
Splinting
Sternocleidomastoid Muscles
Substernal
Substernal Retraction
Tidal Volume (V_T)
Transairway Pressure
Transversus Abdominis Muscles
Trapezius Muscles
Tripod Position
Venous Admixture
Ventilation-Perfusion Ratio ($\dot{V}/\dot{Q}$)
Ventral Respiratory Group (VRG)
Work of Breathing (WOB)

Chapter Outline