CHAPTER

Chest and Lungs

13

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The chest and lungs allow for respiration. The purpose of respiration is to keep the body adequately supplied with oxygen and protected from excess accumulation of carbon dioxide. It involves the movement of air back and forth from the alveoli to the outside environment, gas exchange across the alveolar-pulmonary capillary membranes, and circulatory system transport of oxygen to, and carbon dioxide from, the peripheral tissues.

Physical Examination Preview

Here is a preview of the steps involved in conducting physical examination of the chest and lungs. These procedures are explained in detail in this chapter and are available on evolve at *http://evolve.elsevier.com/Seidel* in printable PDFs or downloadable formats for PDA, iPod, or smartphone use.The following steps are performed with the patient sitting.

1. Inspect the chest; front and back, noting thoracic landmarks, for the following (see p. ••):
   - Size and shape (anteroposterior [AP] diameter compared with the lateral diameter)
   - Symmetry
   - Color
   - Superficial venous patterns
   - Prominence of ribs
2. Evaluate respirations for the following (see p. ••):
   - Rate
   - Rhythm or pattern
3. Inspect chest movement with breathing for the following (see p. ••):
   - Symmetry
   - Use of accessory muscles
4. Note any audible sounds with respiration (i.e., stridor or wheezes) (see p. ••).
5. Palpate the chest for the following (see p. ••):
   - Symmetry
   - Thoracic expansion
   - Sensations such as crepitus, grating vibrations
   - Tactile fremitus
6. Perform direct or indirect percussion on the chest, comparing sides, for the following (see p. ••):
   - Diaphragmatic excursion
   - Percussion tone intensity, pitch, duration, and quality
7. Auscultate the chest with the stethoscope diaphragm, from apex to base; comparing sides for the following (see p. ••):
   - Intensity, pitch, duration, and quality of breath sounds
   - Unexpected breath sounds (crackles, rhonchi, wheezes, friction rubs)
   - Vocal resonance

ANATOMY AND PHYSIOLOGY

The chest, or thorax, is a cage of bone, cartilage, and muscle capable of movement as the lungs expand. It consists anteriorly of the sternum, manubrium, xiphoid process, and costal cartilages; laterally, of the 12 pairs of ribs; and posteriorly, of the 12 thoracic vertebrae (Figs. 13-1 and 13-2). All the ribs are connected to the thoracic vertebrae; the upper seven are attached anteriorly to the sternum by the costal cartilages, and ribs 8, 9, and 10 join with the costal cartilages just above them. Ribs 11 and 12, sometimes referred to as floating ribs, attach posteriorly but not anteriorly. The lateral diameter of the chest generally exceeds the AP diameter in adults.

The primary muscles of respiration are the diaphragm and the intercostal muscles. The diaphragm, the dominant muscle, contracts and moves downward during inspiration, lower-

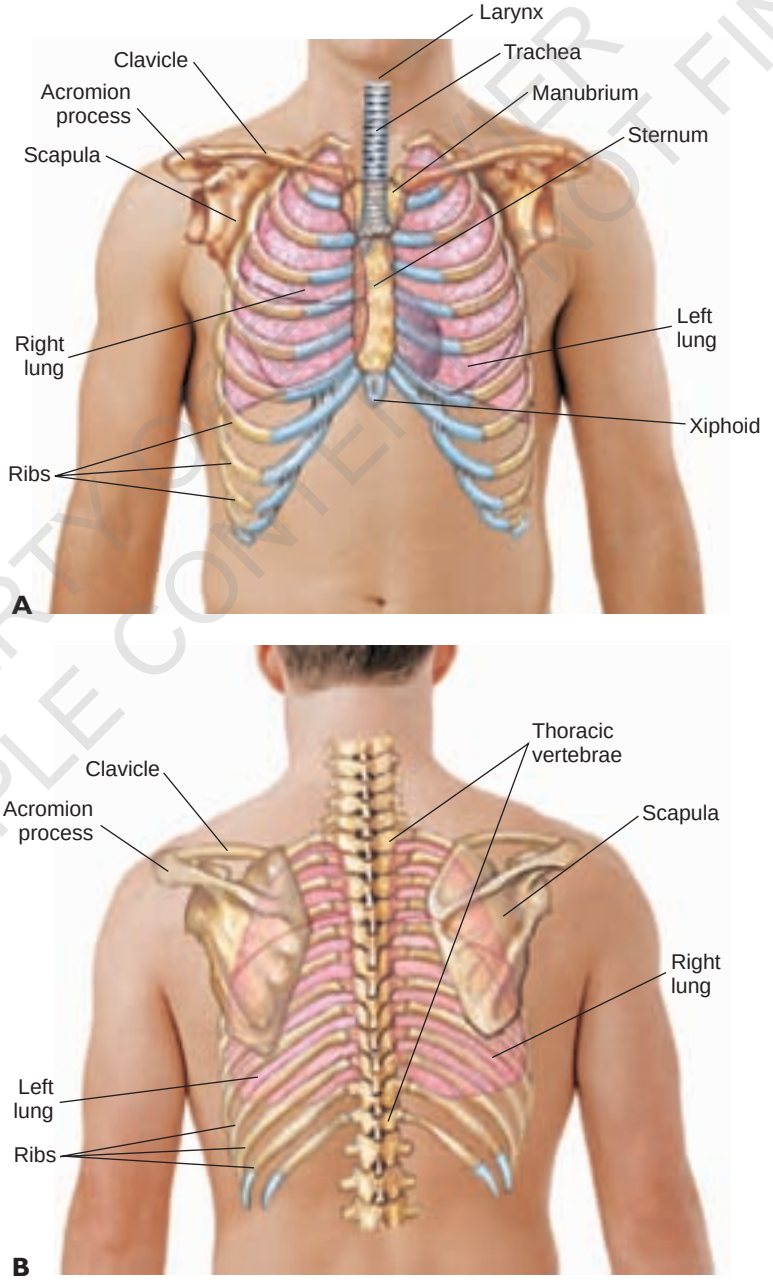


FIGURE 13-1
The bony structures of the chest form a protective expandable cage around the lungs and heart. **A,** Anterior view. **B,** Posterior view. *(From Thompson and Wilson, 1996.)*

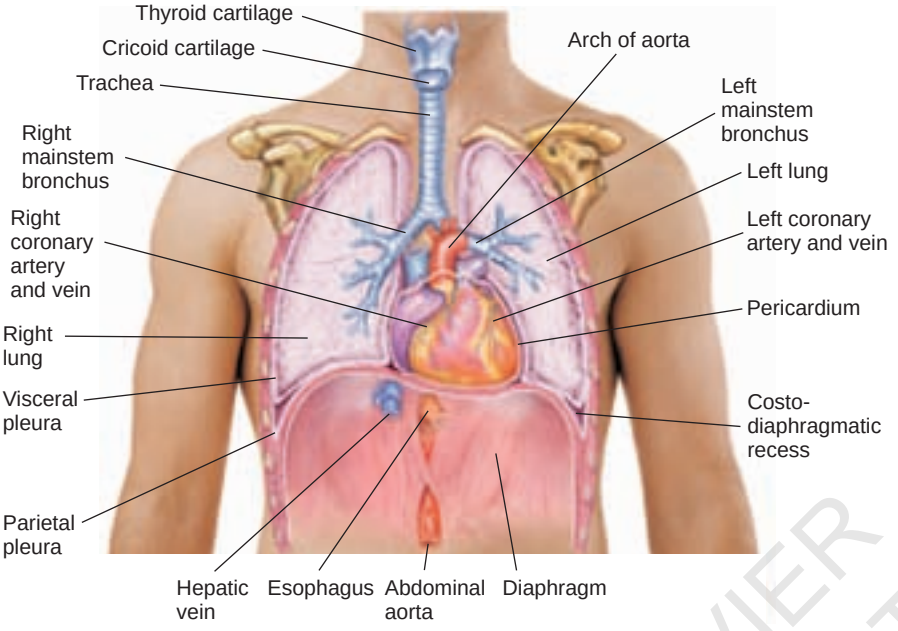


FIGURE 13-2
Chest cavity and related anatomic structures.

ing the abdominal contents to increase the intrathoracic space. The external intercostal muscles increase the AP chest diameter during inspiration, and the internal intercostals decrease the lateral diameter during expiration. The sternocleidomastoid and trapezius muscles may also contribute to respiratory movements. These "accessory" muscles are used during exercise or when there is pulmonary compromise (Fig. 13-3).

The interior of the chest is divided into three major spaces: the right and left pleural cavities and the mediastinum. The mediastinum, situated between the lungs, contains all of the thoracic viscera except the lungs. The pleural cavities are lined with the parietal and visceral pleurae, serous membranes that enclose the lungs. The spongy and highly elastic lungs are paired but not symmetric, the right having three lobes and the left having two (Fig. 13-4). The left upper lobe has an inferior tonguelike projection, the lingula, which is a counterpart of the right middle lobe. Each lung has a major fissure—the oblique—that divides the upper and lower portions. In addition, a lesser horizontal fissure divides the upper portion of the right lung into the upper and middle lobes at the level of the fifth rib in the axilla and the fourth rib anteriorly. Each lobe consists of blood vessels, lymphatics, nerves, and an alveolar duct connecting with the alveoli (as many as 300 million in an adult). The entire lung parenchyma is shaped by an elastic subpleural tissue that limits its expansion. Each lung is conical; the apex is rounded and extends anteriorly about 4 cm above the first rib into the base of the neck in adults. Posteriorly, the apexes of the lungs rise to about the level of T1. The lower borders descend on deep inspiration to about T12 and rise on forced expiration to about T9. The base of each lung is broad and concave, resting on the convex surface of the diaphragm. The medial surfaces of the lung are to some extent concave, providing a cradle for the heart.

The tracheobronchial tree is a tubular system that provides a pathway along which air is filtered, humidified, and warmed as it moves from the upper airway to the alveoli. The trachea is 10 to 11 cm long and about 2 cm in diameter. It lies anterior to the esophagus and posterior to the isthmus of the thyroid. The trachea divides into the right and left main bronchi at about the level of T4 or T5 and just below the manubriosternal joint (Box 13-1).

The right bronchus is wider, shorter, and more vertically placed than the left bronchus (and therefore more susceptible to aspiration of foreign bodies). The main bronchi are divided into three branches on the right and two on the left, each branch supplying one lobe of the lungs. The branches then begin to subdivide into terminal bronchioles and ultimately into respiratory bronchioles.

The bronchial arteries branch from the anterior thoracic aorta and the intercostal arteries, supplying blood to the lung parenchyma and stroma. The bronchial vein is formed at the

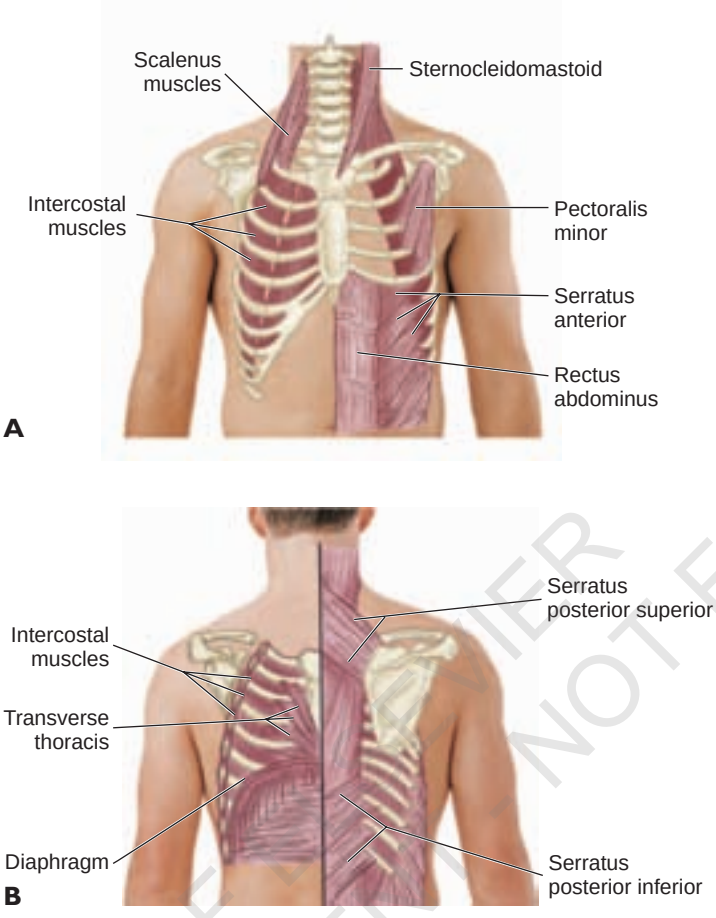


FIGURE 13-3
Muscles of ventilation. **A,** Anterior view. **B,** Posterior view.

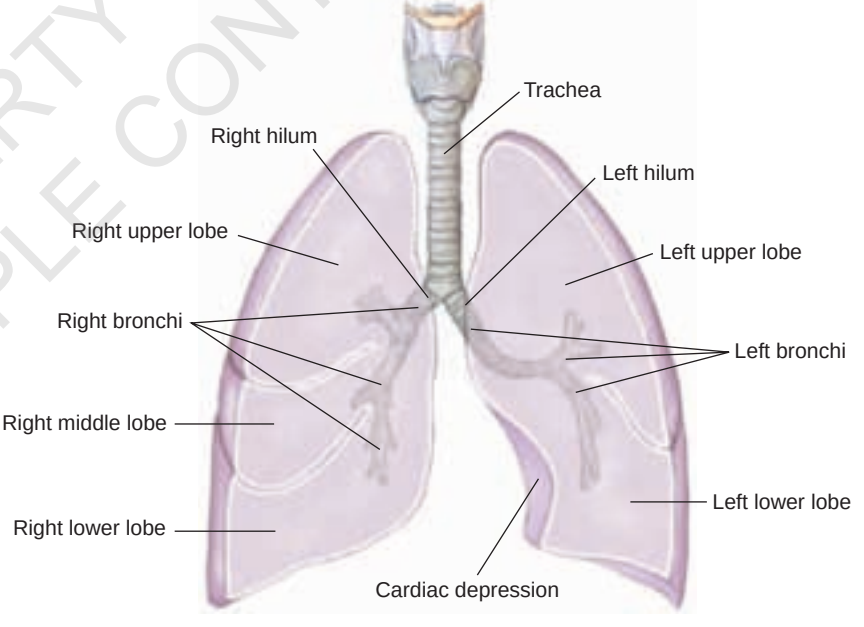


FIGURE 13-4
The lobes of the lungs. *(From Wilson and Thompson, 1990.)*

BOX 13-1

VISUALIZING THE LUNGS FROM THE SURFACE

Anteriorly

The right lung may ride higher because of the fullness of the dome of the liver. Except for an inferior lateral triangle, the anterior view on the right is primarily the upper and middle lobes, separated by the horizontal fissure at about the fifth rib in the midaxilla to about the fourth at the sternum; on the left as on the right, the lower lobe is set off by a diagonal fissure stretching from the fifth rib at the axilla to the sixth at the midclavicular line.

Posteriorly

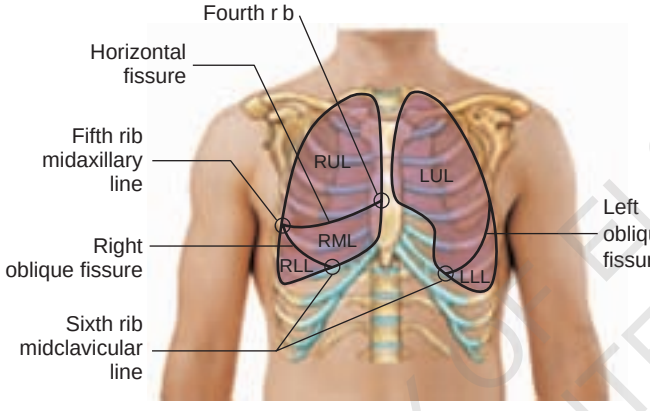
Except for the apices, the posterior view is primarily the lower lobe, which extends from about T3 to T10 or T12 during the respiratory cycle.

Right Lateral

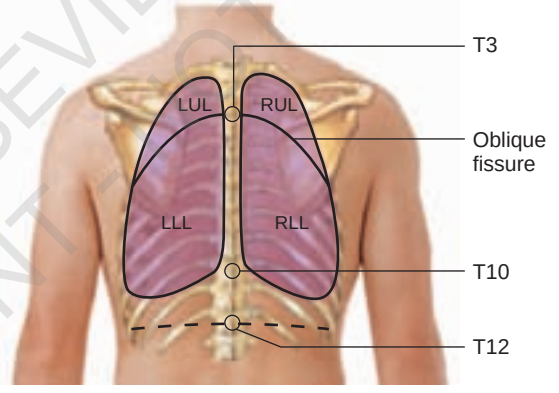
The lung underlies the area extending from the peak of the axilla to the seventh or eighth rib. The upper lobe is demarcated at about the level of the fifth rib in the midaxillary line and the sixth rib more anteriorly.

Left Lateral

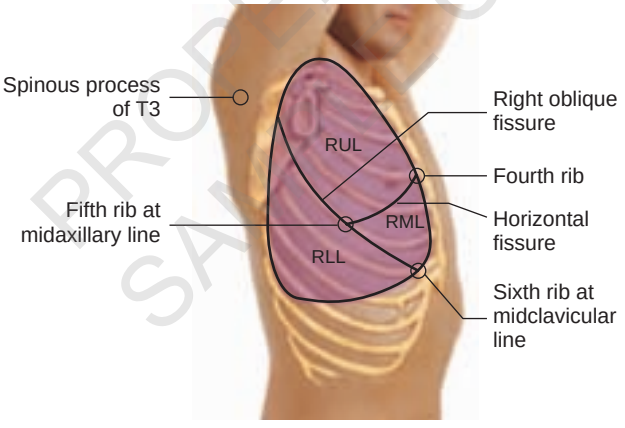
The lung underlies the area extending from the peak of the axilla to the seventh or eighth rib. The entire expanse is virtually bisected by the oblique fissure from about the level of the third rib medially to the sixth rib anteriorly.



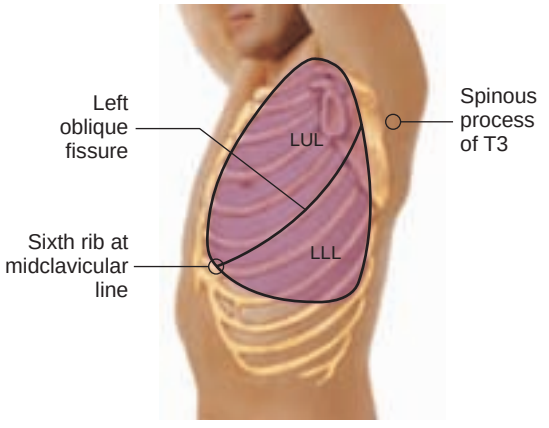
Anterior



Posterior



Right lateral



Left lateral

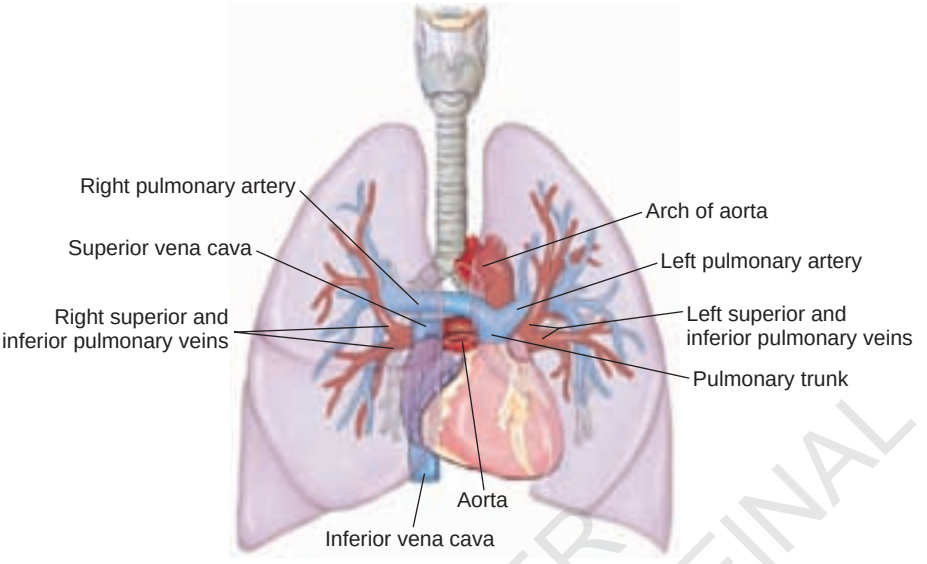


FIGURE 13-5
Pulmonary circulation. *(From Wilson and Thompson, 1990.)*

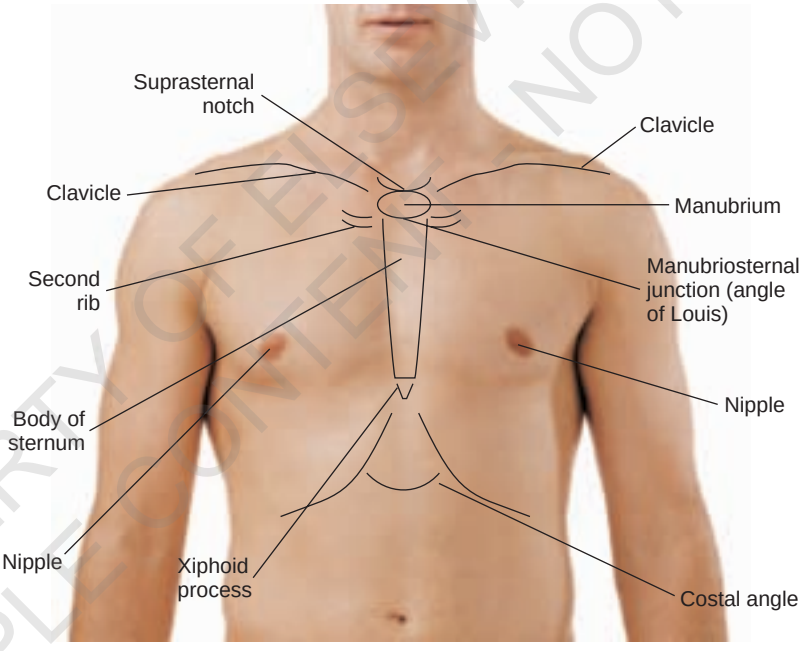


FIGURE 13-6
Topographic landmarks of the chest. *(From Thompson and Wilson, 1996.)*

hilum of the lung, but most of the blood supplied by the bronchial arteries is returned by the pulmonary veins (Fig. 13-5).

ANATOMIC LANDMARKS

The following topographic markers on the chest are used to describe findings (Fig. 13-6):

1. The nipples
2. The manubriosternal junction (angle of Louis). A visible and palpable angulation of the sternum and the point at which the second rib articulates with the sternum. One can count the ribs and intercostal spaces from this point. The number of each intercostal space corresponds to that of the rib immediately above it.
3. The suprasternal notch. A depression, easily palpable and most often visible at the base of the ventral aspect of the neck, just superior to the manubriosternal junction.

4. Costal angle. The angle formed by the blending together of the costal margins at the sternum. It is usually no more than 90 degrees, with the ribs inserted at approximately 45-degree angles.
5. Vertebra prominens. The spinous process of C7. It can be more readily seen and felt with the patient's head bent forward. If two prominences are felt, the upper is that of the spinous process of C7, and the lower is that of T1. It is difficult to use this as a guide to counting ribs posteriorly because the spinous processes from T4 down project obliquely, thus overlying the rib below the number of its vertebra.
6. The clavicles

INFANTS AND CHILDREN

At about 4 weeks of gestation, the lung is a groove on the ventral wall of the gut. It evolves ultimately from a simple sac to an involuted structure of tubules and spaces. The lungs contain no air, and the alveoli are collapsed. Relatively passive respiratory movements occur throughout much of gestation; they do not open the alveoli or move the lung fields. Rather, they prepare the term infant to respond to postnatal chemical and neurologic respiratory stimuli. Fetal gas exchange is mediated by the placenta.

At birth the change in respiratory function is rapid and dramatic. After the cord is cut, the lungs fill with air for the first time; this first respiratory effort is great. No longer coursing through the placenta, blood flows through the lungs more vigorously. The pulmonary arteries expand and relax, offering much less resistance than the systemic circulation. This relative decrease in pulmonary pressure most often leads to closure of the foramen ovale within minutes after birth, and the increased oxygen tension in the arterial blood usually stimulates contraction and closure of the ductus arteriosus. (*Reminder:* The foramen ovale and the ductus arteriosus do not always close so readily.) The pulmonary and systemic circulations adopt their mature configurations, and the lungs are fully integrated for postnatal function.

The chest of the newborn is generally round, the AP diameter approximating the lateral diameter, and the circumference is roughly equal to that of the head until the child is about 2 years old (Fig. 13-7). With growth, the chest assumes adult proportions, with the lateral diameter exceeding the AP diameter.

The relatively thin chest wall of the infant and young child makes the bony structure more prominent than in the adult. It is more cartilaginous and yielding, and the xiphoid process is often more prominent and more movable.

CLINICAL PEARL

Lung Development

The lung is not fully grown at birth. The number of alveoli increases at a very rapid rate in the first 2 years of life. This slows down by the age of 8 years.

PREGNANT WOMEN

Mechanical and biochemical factors, including the enlarged uterus and an increased level of circulating progesterone, interact to create changes in the respiratory function of the pregnant woman. Anatomic changes that occur in the chest as the lower ribs flare include an increase in the lateral diameter of about 2 cm and an increase in the circumference of 5 to

FIGURE 13-7
Chest of healthy infant. Note that the anteroposterior diameter is approximately the same as the lateral diameter.

7 cm. The subcostal angle progressively increases from about 68.5 degrees to approximately 103.5 degrees in later pregnancy. The diaphragm at rest rises as much as 4 cm above its usual resting position, yet diaphragmatic movement increases so that the major work of breathing is done by the diaphragm. Minute ventilation increases due to increased tidal volume, though the respiratory rate remains unchanged.

OLDER ADULTS

The barrel chest that is seen in many older adults results from loss of muscle strength in the thorax and diaphragm (see Fig. 13-9), coupled with the loss of lung resiliency. In addition, skeletal changes of aging tend to emphasize the dorsal curve of the thoracic spine, resulting in an increased AP chest diameter. There may also be stiffening and decreased expansion of the chest wall.

The alveoli become less elastic and relatively more fibrous. The associated loss of some of the interalveolar folds decreases the alveolar surface available for gas exchange. This and the loss of some tensile strength in the muscles of respiration result in underventilation of the alveoli in the lower lung fields and a decreased tolerance for exertion. The net result of these changes is a decrease in vital capacity and an increase in residual volume.

Aging mucous membranes tend to become drier and older adults are less able to rid themselves of mucus. Retained mucus encourages bacterial growth and predisposes the older adult to respiratory infection.

REVIEW OF RELATED HISTORY

For each of the symptoms or conditions discussed in this section, targeted topics to include in the history of the present illness are listed. Responses to questions about these topics provide clues for focusing the physical examination and the development of an appropriate diagnostic evaluation. Questions regarding medication use (prescription and over-the-counter preparations) as well as complementary and alternative therapies are relevant for each.

HISTORY OF PRESENT ILLNESS

- Coughing
  - Onset: sudden, gradual; duration
  - Nature of cough: dry, moist, wet, hacking, hoarse, barking, whooping, bubbling, productive, nonproductive
  - Sputum production: duration, frequency, with activity, at certain times of day
  - Sputum characteristics: amount, color (clear, mucoid, purulent, blood-tinged, mostly blood), foul odor
  - Pattern: occasional, regular, paroxysmal; related to time of day, weather, activities (e.g., exercise), talking, deep breaths; change over time
  - Severity: tires patient, disrupts sleep or conversation, causes chest pain
  - Associated symptoms: shortness of breath, chest pain or tightness with breathing, fever, coryza, stuffy nose, noisy respirations, hoarseness, gagging, choking, stress
  - Efforts to treat: prescription or nonprescription drugs, vaporizers; effectiveness
- Shortness of breath (Box 13-2)
  - Onset: sudden or gradual; duration; gagging or choking event before onset
  - Pattern
  - Position most comfortable, number of pillows used
  - Related to extent of exercise, certain activities, time of day, eating
  - Harder to inhale or exhale
  - Severity: extent of activity limitation, fatigue with breathing, anxiety about getting air

BOX 13-2

DESCRIPTORS OF RESPIRATION

Dyspnea, difficult and labored breathing with shortness of breath, is commonly observed with pulmonary or cardiac compromise. A sedentary lifestyle and obesity can cause it in an otherwise well person. In general, dyspnea increases with the severity of the underlying condition. It is important to establish the amount and kind of effort that produces dyspnea:

- Is it present even when the patient is resting?
- How much walking? On a level surface? Upstairs?
- Is it necessary to stop and rest when climbing stairs?
- With what other activities of daily life does dyspnea begin? With what level of physical demand?

Other manifestations of respiratory difficulty include the following:

- *Orthopnea*—shortness of breath that begins or increases when the patient lies down; ask whether the patient needs to sleep on more than one pillow and whether that helps.
- *Paroxysmal nocturnal dyspnea*—a sudden onset of shortness of breath after a period of sleep; sitting upright is helpful.
- *Platypnea*—dyspnea increases in the upright posture.

  - Associated symptoms: pain or discomfort (relationship to specific point in respiratory exertion, location), cough, diaphoresis, ankle edema
  - Efforts to treat: oxygen use
- Chest pain
  - Onset and duration; associated with trauma, coughing, lower respiratory infection, recent anesthesia, history of thrombophlebitis
  - Associated symptoms: shallow breathing, fever, coughing, anxiety about getting air, radiation of pain to neck or arms
  - Efforts to treat: heat, splinting, pain medication
  - Other medications: recreational drugs (e.g., cocaine)

PAST MEDICAL HISTORY

- Thoracic, nasal, and/or pharyngotracheal trauma or surgery, hospitalizations for pulmonary disorders, dates
- Use of oxygen or ventilation-assisting devices including continuous or bilevel positive airway pressure machines (CPAP or BiPAP, respectively)
- Chronic pulmonary diseases: tuberculosis (date, treatment, compliance), bronchitis, emphysema, bronchiectasis, asthma, cystic fibrosis
- Other chronic disorders: cardiac, cancer, blood clotting disorders
- Testing: allergy, pulmonary function tests, tuberculin and fungal skin tests, chest imaging
- Immunization against *Streptococcus pneumoniae*, influenza

FAMILY HISTORY

- Tuberculosis
- Cystic fibrosis
- Emphysema
- Allergy, asthma, atopic dermatitis
- Malignancy
- Bronchiectasis
- Bronchitis
- Clotting disorders (risk of pulmonary embolism)

CLINICAL PEARL

Chest Pain

Chest pain does not generally originate in the heart when

- There is a constant achiness that lasts all day.
- It does not radiate.
- It is made worse by pressing on the precordium.
- It is a fleeting, needle-like jab that lasts only a second or two.
- It is situated in the shoulders or between the shoulder blades in the back.

Think of the heart but, importantly, also, in such circumstances, of other possibilities in the chest and its environs.

CLINICAL PEARL

Pain From Cocaine

If an adult—especially a young adult—or an adolescent complains of severe, acute chest pain, ask about drug use, particularly cocaine. This situation will not occur often, but the possibility exists that drug use is causing the pain. Cocaine can cause tachycardia, hypertension, coronary arterial spasm (with infarction), and pneumothorax with severe acute chest pain being the common result.

CLINICAL PEARL

The Sequence of Steps

The sequence of steps in examination of the chest and lungs is traditional: inspection, palpation, percussion, and auscultation. None of these techniques alone will provide adequate information for the accurate definition of a pathologic process; the integration of all four, together with the history, often will. Listening to the lungs without also inspecting and palpating the chest will deny you the chance to interpret your findings in the most accurate way. Dullness on percussion, for example, is present in both pleural effusion and lobar pneumonia. Breath sounds are absent in the former and may be bronchial in the latter. On palpation you will often find that tactile fremitus is absent when an effusion exists and is increased with lobar pneumonia. The differentiation of these conditions may well be established on a complete physical examination.

PERSONAL AND SOCIAL HISTORY

- Employment: nature of work, extent of physical and emotional effort and stress, environmental hazards, exposure to chemicals, animals, vapors, dust, pulmonary irritants (e.g., asbestos), allergens, use of protective devices
- Home environment: location, possible allergens, type of heating, use of air conditioning, humidifier, ventilation, use of smoke and carbon monoxide detectors in the home
- Tobacco use: type of tobacco (cigarettes, cigars, pipe, smokeless), duration and amount (Pack years = Number of years of smoking × Number of packs smoked per day), age started, efforts to quit smoking with factors influencing success or failure, the extent of smoking by others at home or at work (second-hand smoking)
- Exposure to respiratory infections, influenza, tuberculosis
- Nutritional status: weight loss or obesity
- Use of herbal or other remedies
- Regional or travel exposures (e.g., tuberculosis [TB] infection in India, China, Indonesia, South Africa, and Nigeria; histoplasmosis in southeastern and midwestern United States; schistosomiasis in east and southwest Asia, Africa, and the Caribbean)
- Hobbies: owning pigeons, parrots, or other animals, woodworking or welding
- Use of alcohol or recreational drugs (e.g., cocaine, inhaled methamphetamine)
- Exercise tolerance: amount of exercise, diminished ability to perform up to expectations

INFANTS AND CHILDREN

- Low birth weight: prematurity, history of intubation, duration of ventilation assistance, respiratory distress syndrome, bronchopulmonary dysplasia, transient tachypnea of the newborn
- Coughing or difficulty breathing of sudden onset, possible aspiration of small object, toy, or food
- Possible ingestion of kerosene, antifreeze or hydrocarbons in household cleaners
- Apneic episodes: associated perioral cyanosis, breath-holding, post-tussive emesis, history of sudden infant death in sibling
- Swallowing dysfunction or other neuromuscular disorders, recurrent spitting up and choking, recurrent pneumonia (possible gastroesophageal reflux)
- History of pneumococcal and influenza vaccination

PREGNANT WOMEN

- Weeks of gestation or estimated date of conception (EDC)
- Presence of multiple fetuses, polyhydramnios, or other conditions in which a larger uterus displaces the diaphragm upward
- Exercise type and energy expenditure
- Exposure to and frequency of respiratory infections, annual influenza immunization

OLDER ADULTS

- Exposure to and frequency of respiratory infections, history of pneumococcal vaccination and annual influenza immunization
- Effects of weather on respiratory efforts and occurrence of infections
- Immobilization or marked sedentary habits
- Difficulty swallowing
- Alteration in daily living habits or activities as a result of respiratory symptoms
- Because older adults are at risk for chronic respiratory diseases (lung cancer, chronic bronchitis, emphysema, and tuberculosis), reemphasize the following:
  - Smoking history
  - Cough, dyspnea on exertion, or breathlessness
  - Blood-tinged or yellowish/greenish sputum
  - Fatigue
  - Significant weight changes
  - Fever, night sweats

EQUIPMENT

- Marking pen
- Centimeter ruler and tape measure
- Stethoscope with bell and diaphragm (for infants, you need a smaller stethoscope)
- Drapes

EXAMINATION AND FINDINGS

INSPECTION

Have the patient sit upright, if possible without support, unclothed to the waist. Clothing of any kind is a barrier. A drape should cover the patient when full exposure is not necessary. The room and stethoscope should be comfortably warm, and a bright tangential light is needed to highlight chest movement. Positioning the patient so that the light source comes at different angles may accentuate findings that are more subtle and otherwise difficult to detect, such as minimal pulsations or retractions, or the presence of deformity (e.g., minimal pectus excavatum). If the patient is in bed and mobility is limited, you should have access to both sides of the bed. Do not hesitate to raise and lower the bed as needed.

Note the shape and symmetry of the chest from both the back and the front, the costal angle, the angle of the ribs, and the intercostal spaces. The bony framework is obvious, the clavicles prominent superiorly, the sternum usually rather flat and free of an abundance of overlying tissue. (Box 13-3 lists thoracic landmarks to use as you record findings.) The chest will not be absolutely symmetric, but one side can be used as a comparison for the other. The AP diameter of the chest is ordinarily less than the lateral diameter, at times by as much as half (Fig. 13-8).

Barrel chest (Fig. 13-9) results from compromised respiration as in, for example, chronic asthma, emphysema, or cystic fibrosis. The ribs are more horizontal, the spine is

BOX 13-3

THORACIC LANDMARKS

In conjunction with the anatomic landmarks of the chest, the following imaginary lines on the surface will help localize the findings on physical examination (Fig. 13-10):

1. *Midsternal line:* vertically down the midline of the sternum
2. *Right and left midclavicular lines*: parallel to the midsternal line, beginning at midclavicle; the inferior borders of the lungs generally cross the sixth rib at the midclavicular line
3. *Right and left anterior axillary lines:* parallel to the midsternal line, beginning at the anterior axillary folds
4. *Right and left midaxillary lines:* parallel to the midsternal line, beginning at the midaxilla
5. *Right and left posterior axillary lines:* parallel to the midsternal line, beginning at the posterior axillary folds
6. *Vertebral line:* vertically down the spinal processes
7. *Right and left scapular lines:* parallel to the vertebral line, through the inferior angle of the scapula when the patient is erect

The spinous process of the seventh cervical vertebra is readily palpated. The thoracic vertebrae can then be counted down from that point (Fig. 13-11).

FIGURE 13-8
Thorax of healthy adult male. Note that the anteroposterior diameter is less than the lateral diameter.

FIGURE 13-9
Barrel chest. Note increase in the anteroposterior diameter.

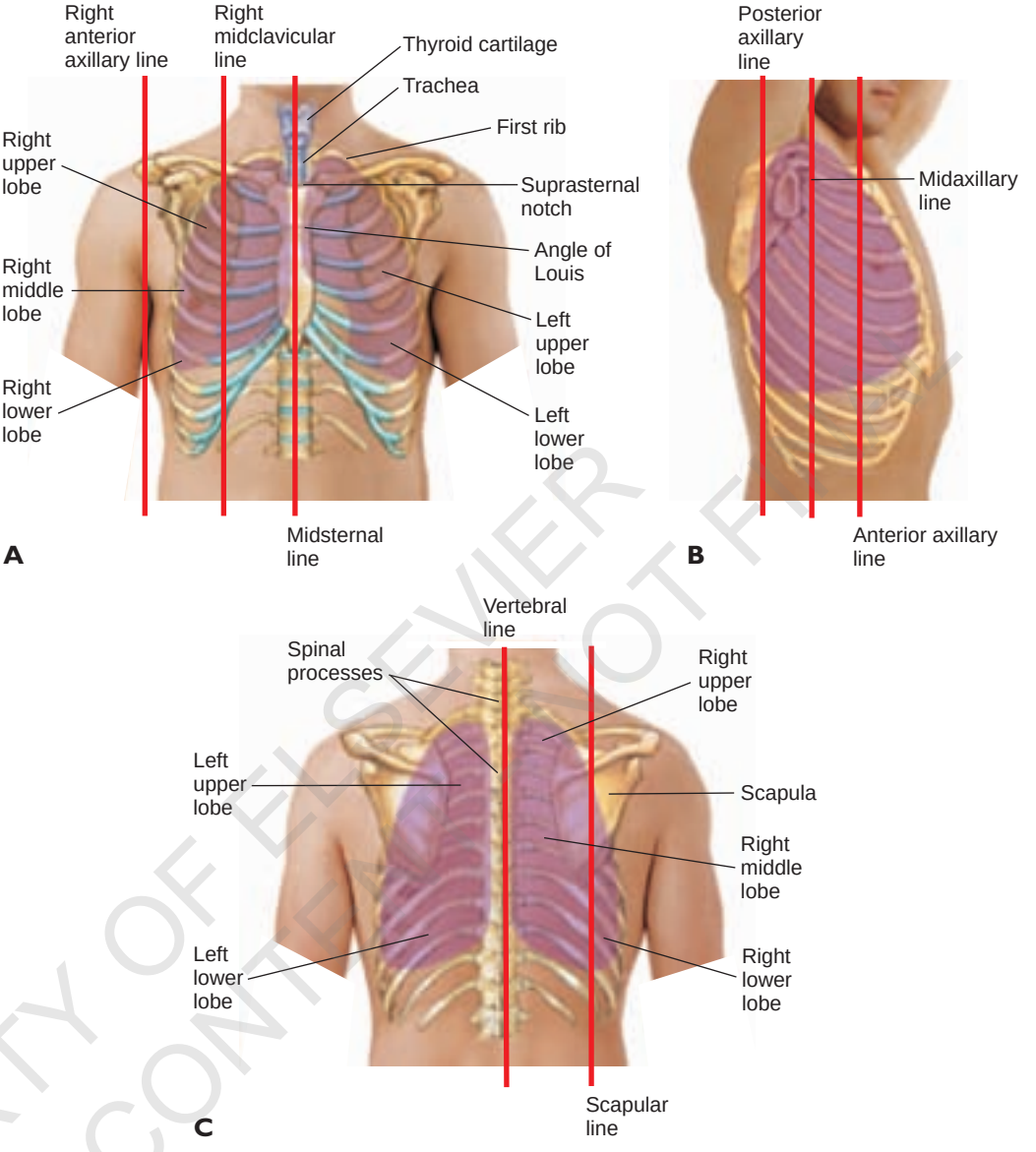


FIGURE 13-10
Thoracic landmarks. **A**, Anterior thorax. **B,** Right lateral thorax. **C,** Posterior thorax.

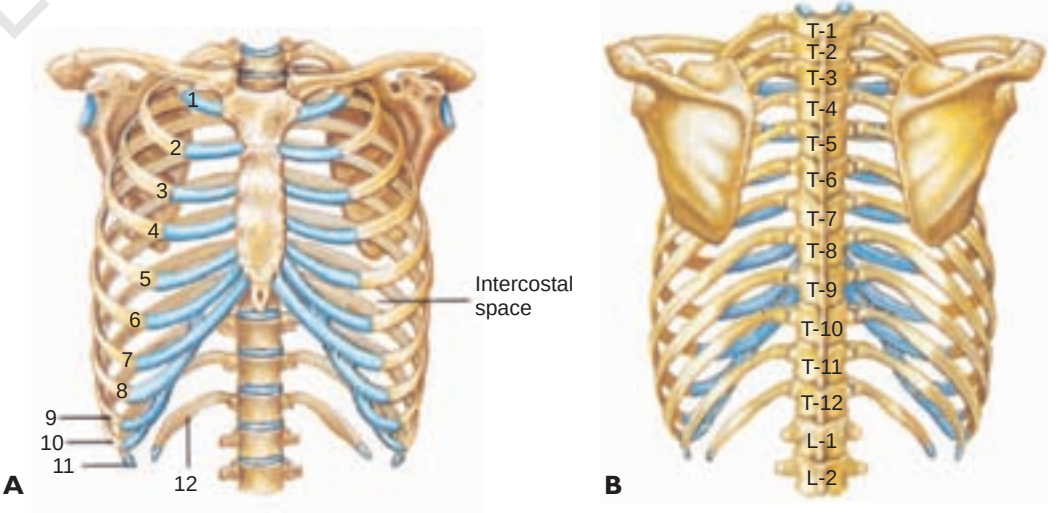


FIGURE 13-11
Rib cage. **A,** Anterior view. **B,** Posterior view.

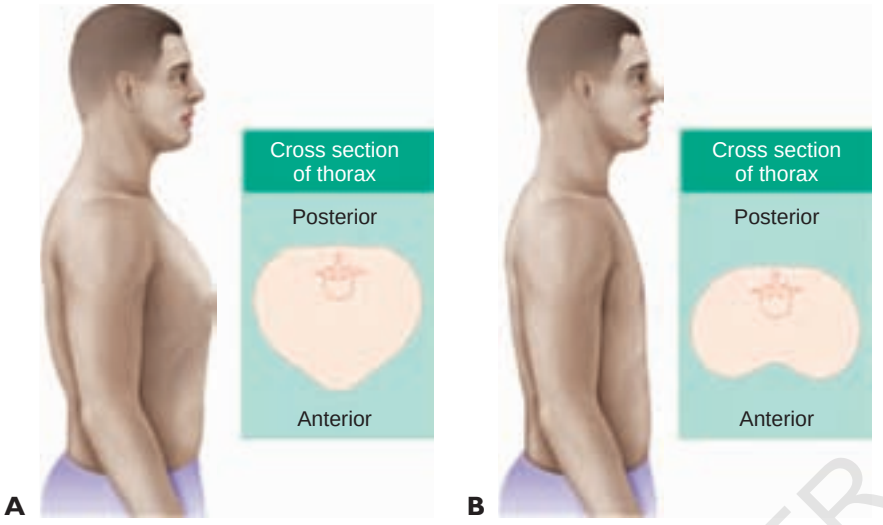


FIGURE 13-12
A, Unilateral pectus carinatum (pigeon chest) in an 18-year-old. **B,** Pectus excavatum (funnel chest) in a young child. Note the child's poor posture, potbelly, and sunken chest.

at least somewhat kyphotic, and the sternal angle is more prominent. The trachea may be posteriorly displaced. Ordinarily, the AP diameter should be less than the lateral diameter. The relationship is expressed as the "thoracic ratio" and is expected to be about 0.70 to 0.75. It does increase with age; however, when the AP diameter approaches or equals the lateral diameter (a ratio of 1.0 or even greater), there is most often a chronic condition present.

Other changes in chest wall contour may be the result of structural problems in the spine, rib cage, or sternum. The spine may be deviated either posteriorly (kyphosis) or laterally (scoliosis) (see Figs. 21-20, *B,* and 21-77).

Two common structural problems are pigeon chest (pectus carinatum), which is a prominent sternal protrusion, and funnel chest (pectus excavatum), which is an indentation of the lower sternum above the xiphoid process (Fig. 13-12).

Inspect the skin, nails, and lips, noting whether cyanosis or pallor is present. These may be clues to respiratory or cardiac disorder. Smell the breath; intrathoracic infection may make it malodorous. Note whether there are supernumerary nipples; these may be a clue to other congenital abnormalities. Look for any superficial venous patterns over the chest, which may be a sign of heart disorders or vascular obstruction. The underlying fat and relative prominence of the ribs give some clue to general nutrition.

Respiratory Patterns

Determine the respiratory rate. The rate should be 12 to 20 respirations per minute; the ratio of respirations to heartbeats is approximately 1:4. Do not tell the patient that you are going to count the pulse, to prevent the patient from varying the rate. Count the respiratory rate after palpating the pulse, just as if you were counting the pulse rate for a longer time. Respiratory rates can vary in the different waking and sleep states. The normal rate of respirations (breaths per minute) depends on a number of factors, including the age of the individual and the degree of exertion. Noting the behavior of the patient relative to the rate is often helpful.

Note the pattern (or rhythm) of respiration and the way in which the chest moves (Fig. 13-13). Expansion of the chest should be bilaterally symmetric. Expect the patient to breathe easily, regularly, and without apparent distress. The pattern of breathing should be even, neither too shallow nor too deep. Note any variations in respiratory rate.

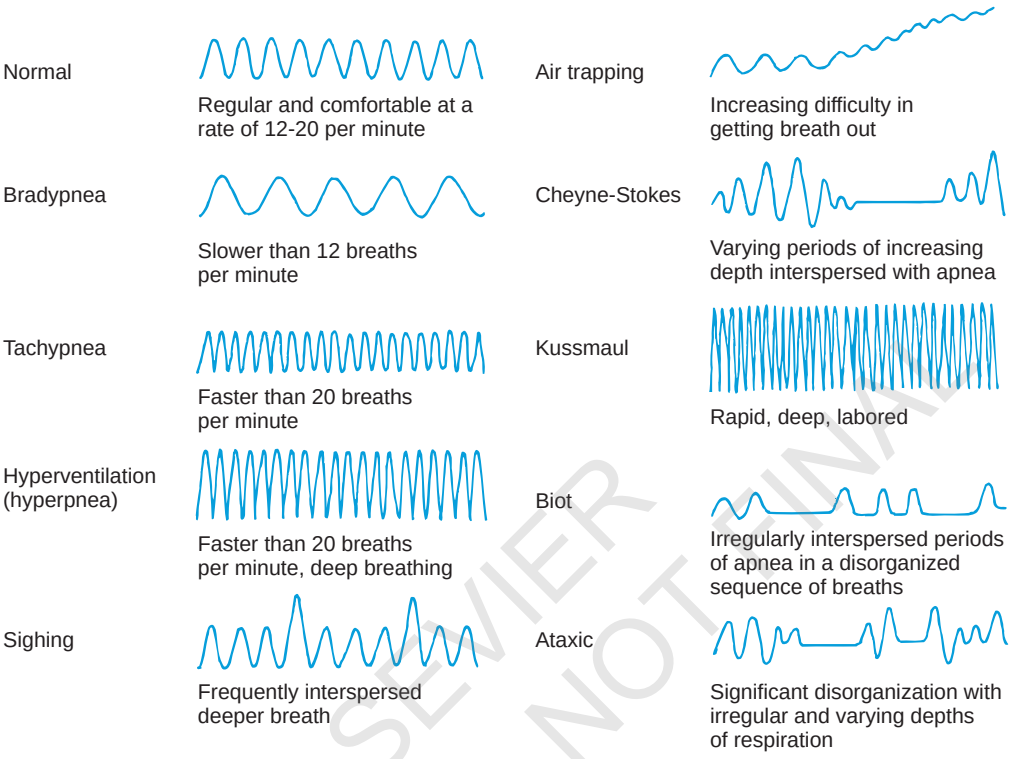


FIGURE 13-13
Patterns of respiration. The horizontal axis indicates the relative rates of these patterns. The vertical swings of the lines indicate the relative depth of respiration.

RISK FACTORS

RESPIRATORY DISABILITY: BARRIERS TO COMPETENT FUNCTION

- Gender: Greater in men, but the difference between the sexes diminishes with advancing age
- Age: Increases inexorably with advancing age
- Family history of asthma, cystic fibrosis, tuberculosis and other contagious disease, neurofibromatosis
- Smoking
- Sedentary lifestyle or forced immobilization
- Occupational exposure to asbestos, dust, or other pulmonary irritants and toxic inhalants
- Extreme obesity
- Difficulty swallowing for any reason
- Weakened chest muscles for any reason
- History of frequent respiratory infections

The normal resting adult respiratory rate is 12 to 20 breaths/minute. Tachypnea is a persistent respiratory rate above this in an adult. Double check to be sure that the respiratory rate is persistent. Rapid, shallow breathing may occur during hyperventilation or simply as a self-conscious response to your observation. It is often a symptom of protective splinting from pain of a broken rib or pleurisy. Massive liver enlargement or abdominal ascites may prevent descent of the diaphragm and produce a similar pattern. *Bradypnea,* a rate slower than 12 respirations per minute, may indicate neurologic or electrolyte disturbance, infection, or a sensible response to protect against the pain of pleurisy or other irritative phenomena. It may also indicate a splendid level of cardiorespiratory fitness.

Note any variations in respiratory rhythm. It may be difficult to discern abnormalities unless they are quite obvious (Box 13-4). Hyperventilation can be due to breathing rapidly

BOX 13-4

INFLUENCES ON THE RATE AND DEPTH OF BREATHING

The rate and depth of breathing will:

Increase With	Decrease With
Acidosis (metabolic)	Alkalosis (metabolic)
Central nervous system lesions (pons)	Central nervous system lesions (cerebrum)
Anxiety	Myasthenia gravis
Aspirin poisoning	Narcotic overdoses
Oxygen need (hypoxemia)	Obesity (extreme)
Pain	

BOX 13-5

APNEA

Apnea, the absence of spontaneous respiration, may have its origin in the respiratory system and, as well, in a variety of central nervous system and cardiac abnormalities. Common contributors include seizures, central nervous system trauma or hypoperfusion, a variety of infections of the respiratory passageway, drug ingestions, and obstructive sleep disorders.

Primary apnea	A self-limited condition, and not uncommon after a blow to the head. It is especially noted immediately after the birth of a newborn, who will breathe spontaneously when sufficient carbon dioxide accumulates in the circulation.
Secondary apnea	Breathing stops and it will not begin spontaneously unless resuscitative measures are immediately instituted. Any event that severely limits the absorption of oxygen into the bloodstream will lead to secondary apnea.
Reflex apnea	When irritating and nausea-provoking vapors or gases are inhaled, there can be an involuntary, temporary halt to respiration.
Sleep apnea	Characterized by periods of an absence of breathing and oxygenation during sleep. With obstruction airflow is not maintained through the nose and mouth.
Apneustic breathing	Characterized by a long inspiration and what amounts to expiration apnea. The neural center for control is in the pons. When it is affected, breathing can become gasping because inspirations are prolonged and expiration constrained.
Periodic apnea of the newborn	A normal condition characterized by an irregular pattern of rapid breathing interspersed with brief periods of apnea that one usually associates with rapid eye movement sleep.

(*tachypnea*), breathing deeply *(hyperpnea),* or both. Exercise and anxiety can cause hyperpnea, but so can central nervous system and metabolic disease. *Kussmaul breathing,* always deep and most often rapid, is the eponym applied to the respiratory effort associated with metabolic acidosis. *Hypopnea,* on the other hand, refers to abnormally shallow respirations (e.g., when pleuritic pain limits excursion).

A regular periodic pattern of breathing, with intervals of apnea followed by a crescendo/decrescendo sequence of respiration, is called *periodic breathing* or *Cheyne-Stokes respiration.* Children and older adults may breathe in this pattern during sleep, but otherwise it occurs in patients who are seriously ill, particularly those with brain damage at the cerebral level or with drug-associated respiratory compromise (Box 13-5).

An occasional deep, audible sigh that punctuates an otherwise regular respiratory pattern is associated with emotional distress or an incipient episode of more severe hyperventilation. Sighs also occur in normal respiration.

If the pulmonary tree is seriously obstructed for any reason, inspired air has difficulty overcoming the resistance and getting out. *Air trapping* is the result of a prolonged but inefficient expiratory effort. The rate of respiration increases in order to compensate; as this happens, the effort becomes more shallow, the amount of trapped air increases, and the lungs inflate. This can lead to a barrel chest

Biot respiration consists of somewhat irregular respirations varying in depth and interrupted by intervals of apnea, but lacking the repetitive pattern of periodic respiration. On occasion, the respirations may be regular, but the apneic periods may occur in an irregular pattern. Biot respiration usually is associated with severe and persistent increased intracranial pressure, respiratory compromise resulting from drug poisoning, or brain damage at the level of the medulla. It may be referred to as *ataxic* in its more extreme expression.

Observing Respiration

Inspect the chest wall movement during respiration. Again, different angles of illumination will aid inspection and help delineate chest wall movement and possible deformities. Expansion should be symmetric, without apparent use of accessory muscles. Chest asymmetry can be associated with unequal expansion and respiratory compromise caused by a collapsed lung or limitation of expansion by extrapleural air, fluid, or a mass. Unilateral or bilateral bulging can be a reaction of the ribs and interspaces to respiratory obstruction. A prolonged expiration and bulging on expiration are probably caused by outflow obstruction or the valvelike action of compression by a tumor, aneurysm, or enlarged heart. When this happens, the costal angle widens beyond 90 degrees.

Retractions are when the chest wall seems to cave in at the sternum, between the ribs, at the suprasternal notch, above the clavicles, and at the lowest costal margins. This suggests an obstruction to inspiration at any point in the respiratory tract. As intrapleural pressure becomes increasingly negative, the musculature "pulls back" in an effort to overcome blockage. Any significant obstruction makes the retraction observable with each inspiratory effort. The degree and level of retraction depend on the extent and level of obstruction (Box 13-6). When the obstruction is high in the respiratory tree (e.g., with tracheal or laryngeal involvement), breathing is characterized by stridor. With *paradoxic breathing,* on inspiration the lower thorax is drawn in, and on expiration, the opposite occurs. This develops when negative intrathoracic pressure is transmitted to the abdomen by a weakened, poorly functioning diaphragm; obstructive airway disease; or during sleep, in the event of upper airway obstruction.

A foreign body in a bronchus (usually the right because of its larger diameter and more vertical placement) causes unilateral retraction, but the suprasternal notch is not involved. Retraction of the lower chest occurs with asthma and bronchiolitis.

CLINICAL PEARL

Clubbing

Clubbing is usually symmetric and painless. Although it suggests significant disease, it may also be congenital.

Looking for Clues at the Periphery

Observe the lips and nails for cyanosis, the lips for pursing, the fingers for clubbing, and the alae nasi for flaring. Any of these peripheral clues suggests pulmonary or cardiac difficulty. Pursing of the lips is an accompaniment of increased expiratory effort. Patients learn without being taught that it reduces the effort of dyspnea. Clubbing, enlargement of the terminal phalanges of the fingers and/or toes is associated, for example, with chronic fibrotic changes within the lung, emphysema, lung cancer, the cyanosis of congenital heart disease, or cystic fibrosis. Flaring of the alae nasi during inspiration is a sign of air hunger.

PALPATION

Palpate the thoracic muscles and skeleton, feeling for pulsations, areas of tenderness, bulges, depressions, masses, and unusual movement. Expect bilateral symmetry and some elasticity

BOX 13-6

IS THE AIRWAY PATENT OR OBSTRUCTED?

Determining the patency of the upper airway is essential to a complete evaluation of pulmonary status. When is the upper airway obstructed?

- When there is:
  - Inspiratory stridor (with an I:E ratio of more than 2:1)
  - A hoarse cough or cry
  - Flaring of the alae nasi
  - Retraction at the suprasternal notch
- Severely so, when:
  - Stridor is inspiratory and expiratory.
  - Cough is barking.
  - Retractions also involve the subcostal and intercostal spaces.
  - Cyanosis is obvious even with supplemental oxygen.
- When the obstruction is above the glottis:
  - Stridor tends to be quieter.
  - The voice is muffled.
  - Swallowing is more difficult.
  - Cough is not a factor.
  - The head and neck may be awkwardly positioned to preserve the airway (e.g., extended with retropharyngeal abscess; head to the affected side with peritonsillar abscess).
- When the obstruction is below the glottis:
  - Stridor tends to be louder, more rasping.
  - The voice is hoarse.
  - Swallowing is not affected.
  - Cough is harsh, barking.
  - Positioning of the head is not a factor.

of the rib cage, but the sternum and xiphoid should be relatively inflexible and the thoracic spine rigid.

Crepitus, a crackly or crinkly sensation, can be both palpated and heard—a gentle, bubbly feeling. It indicates air in the subcutaneous tissue from a rupture somewhere in the respiratory system or by infection with a gas-producing organism. It may be localized (e.g., over the suprasternal notch and base of the neck) or cover a wider area potentially involving the arms and face with the associated swelling mimicking an allergic reaction. Crepitus always requires attention.

A palpable, coarse, grating vibration, usually on inspiration, suggests a *pleural friction rub* caused by inflammation of the pleural surfaces. Think of it as the feel of leather rubbing on leather.

To evaluate thoracic expansion during respiration, stand behind the patient and place your thumbs along the spinal processes at the level of the tenth rib, with your palms lightly in contact with the posterolateral surfaces (Fig. 13-14). Watch your thumbs diverge during quiet and deep breathing. A loss of symmetry in the movement of the thumbs suggests a problem on one or both sides. A barrel-chested patient with chronic obstructive pulmonary disease may not demonstrate this. The chest is so inflated that it cannot expand further and your hands may even come together a bit.

Note the quality of the *tactile fremitus,* the palpable vibration of the chest wall that results from speech or other verbalizations. Fremitus is best felt parasternally at the second intercostal space at the level of the bifurcation of the bronchi. There is great variability depending on the intensity and pitch of the voice and the structure and thickness of the chest wall. In addition, the scapulae obscure fremitus.

FIGURE 13-14
Palpating thoracic expansion. The thumbs are at the level of the tenth rib.

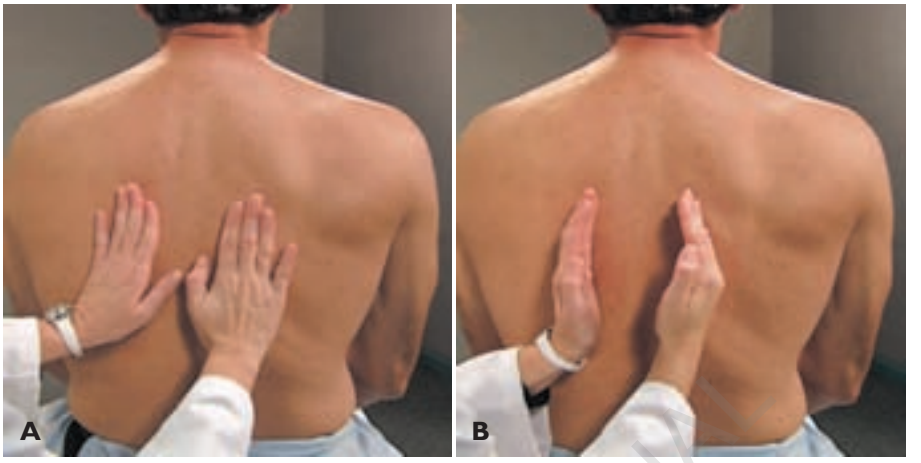


FIGURE 13-15
Two methods for evaluating tactile fremitus. **A,** With palmar surface of both hands. **B,** With ulnar aspect.

Evidence-Based Practice in Physical Examination

Is There a Pleural Effusion?

Based on the review of a number of studies, dullness to percussion and tactile fremitus are the most useful findings for pleural effusion. Dullness to chest percussion makes the probability of a pleural effusion more likely. When the pretest probability of pleural effusion is low, the absence of reduced tactile vocal fremitus makes pleural effusion less.

From Wong, 2009.

Ask the patient to recite a few numbers or say a few words ("99" is a favorite, as is "Mickey Mouse," depending perhaps on the age) while you systematically palpate the chest with the palmar surfaces of the fingers or with the ulnar aspects of the hand. Use a firm, light touch, establishing even contact. For comparison, palpate both sides simultaneously and symmetrically; or use one hand, quickly alternating between the two sides. Move about the patient, palpating each area carefully: right side to left side (Fig. 13-15). Some examiners prefer to use their dominant hand; moving it back and forth to make comparisons.

Decreased or absent fremitus may be caused by excess air in the lungs or may indicate emphysema, pleural thickening or effusion, massive pulmonary edema, or bronchial obstruction. Increased fremitus, often coarser or rougher in feel, occurs in the presence of fluids or a solid mass within the lungs and may be caused by lung consolidation, heavy but nonobstructive bronchial secretions, compressed lung, or tumor. Gentle, more tremulous fremitus than expected occurs with some lung consolidations and some inflammatory and infectious processes.

Examining the Trachea

Note the position of the trachea. Place an index finger in the suprasternal notch and move it gently, side to side, along the upper edges of each clavicle and in the spaces above to the inner borders of the sternocleidomastoid muscles. These spaces should be equal on both sides, and the trachea should be in the midline directly above the suprasternal notch. This can also be determined by palpating with both thumbs simultaneously (Fig. 13-16). A slight, barely noticeable deviation to the right is not unusual.

FIGURE 13-16
Palpating to evaluate midline position of the trachea.

TABLE 13-1 Percussion Tones Heard Over the Chest

Type of Tone	Intensity	Pitch	Duration	Quality
Resonant	Loud	Low	Long	Hollow
Flat	Soft	High	Short	Very dull
Dull	Medium	Medium to high	Medium	Dull thud
Tympanic	Loud	High	Medium	Drumlike
Hyperresonant*	Very loud	Very low	Longer	Booming

See Chapter 3 for definitions and a more complete discussion of these tones.
**Hyperresonance is an abnormal sound, the result of air trapping (e.g., in obstructive lung disease).*

The trachea may be deviated because of problems within the chest and may, on occasion, seem to pulsate. Volume loss (from fibrosis or atelectasis such as due to tumor or adenopathy) pulls the trachea toward the affected lung. Thyroid enlargement or pleural effusion may cause the trachea to deviate away from the affected side. Pneumothorax can make the trachea go either way depending on whether there is a tension pneumothorax; where the deviation is away from the affected side or simply a collapsed lung where the trachea deviates to the affected side. Anterior mediastinal tumors may push it posteriorly; with mediastinitis, the trachea may be pushed forward. A palpable pull out of midline with respiration is called a "tug."

CLINICAL PEARL

Clue to a Mediastinal Mass

An anterior mediastinal mass may compress the trachea and compromise respiration. Patients may develop the harsh sound of stridor with more difficulty breathing. Instinctively, the patient may sit up and lean forward in an attempt to relieve the compression—that action is a clue to the possibility of such a mass.

PERCUSSION

Percussion tones heard over the chest, as elsewhere, are described in Chapter 3 and summarized in Figure 13-17 and Table 13-1. You can percuss directly or indirectly, as described in Chapter 3. Remember that the heavier the stroke you use, the more likely you are to miss a transitional area from resonance to dullness. Tap sharply and consistently from the wrist but do not bang on your finger.

Compare all areas bilaterally, using one side as a control for the other. The following sequence serves as one model. First, examine the back with the patient sitting with head bent forward and arms folded in front. This moves the scapulae laterally, exposing more of the lung. Then ask the patient to raise the arms overhead while you percuss the lateral and anterior chest. For all positions, percuss at 4- to 5-cm intervals over the intercostal spaces, moving systematically from superior to inferior and medial to lateral (Figs. 13-18 and 13-19). This sequence is one of many that you may follow. Adopt the one most comfortable for you and use it consistently. Resonance, the expected sound, can usually be heard over all areas of the lungs. Hyperresonance associated with hyperinflation may indicate emphysema, pneumothorax, or asthma. Dullness or flatness suggests pneumonia, atelectasis, pleural effusion, pneumothorax, or asthma. Tympany is the sound usually associated with percussion over the abdomen.

CLINICAL PEARL

A Woman's Chest

The examination of a woman's chest may be obscured by the breasts. It is permissible, when necessary, to move the breast gently or to ask the patient to do this for you.

Video/Animation
Access an animation on atelectasis on evolve

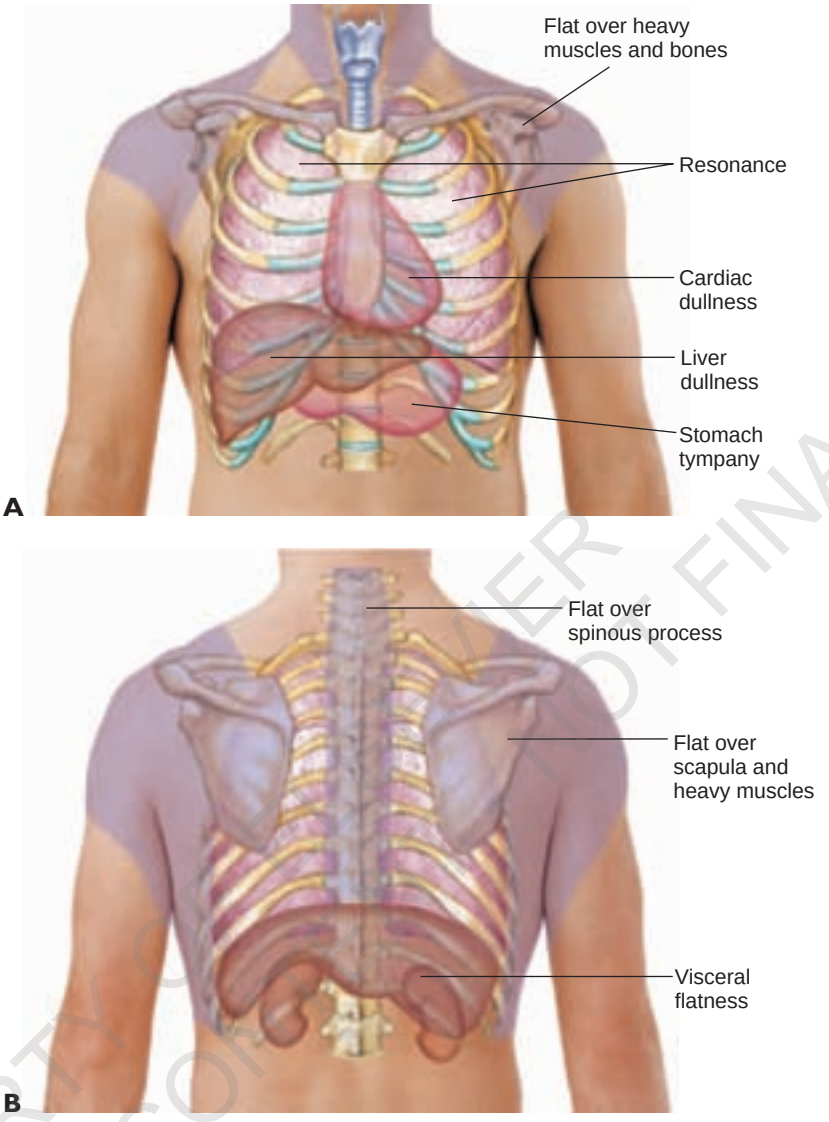


FIGURE 13-17
Percussion tones throughout chest. **A,** Anterior view. **B,** Posterior view.

FIGURE 13-18
A, Direct percussion using ulnar aspect of fist. **B,** Indirect percussion.

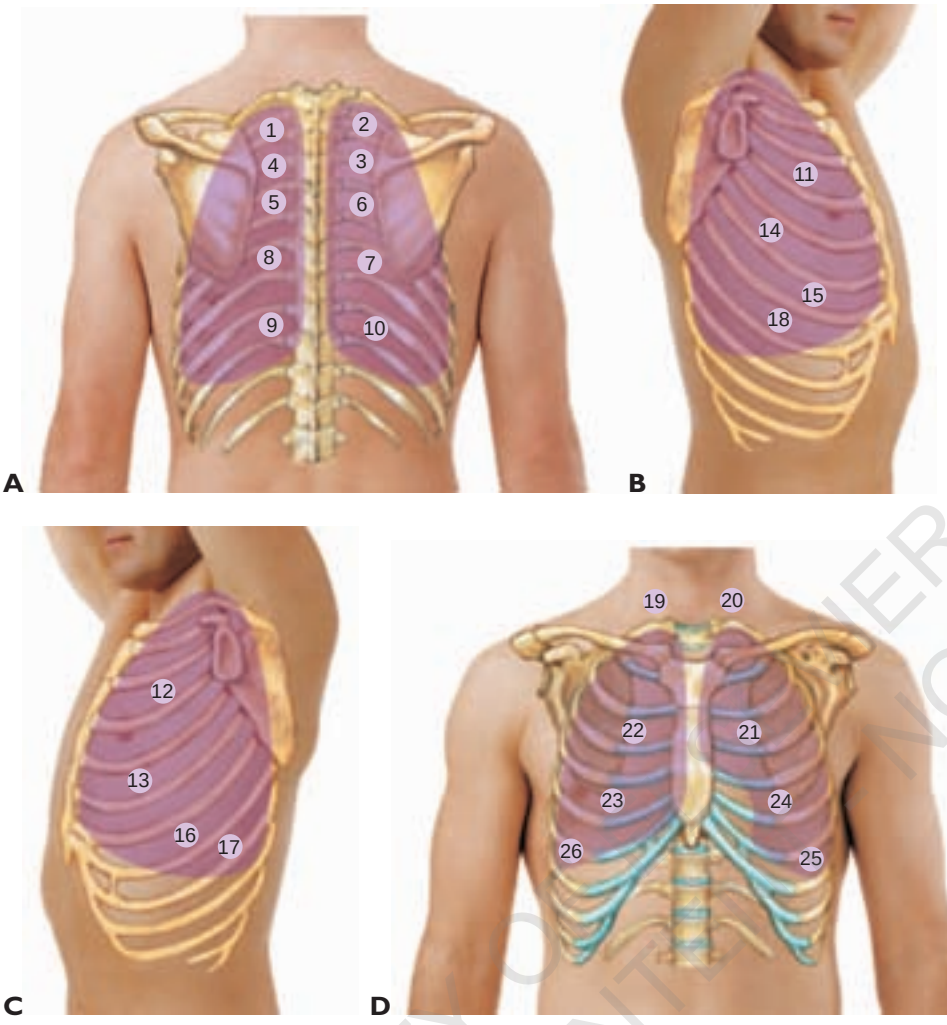


FIGURE 13-19
Suggested sequence for systematic percussion and auscultation of the thorax. **A,** Posterior thorax. **B,** Right lateral thorax. **C,** Left lateral thorax. **D,** Anterior thorax. The pleximeter finger or the stethoscope is moved in the numeric sequence suggested; however, other sequences are possible. It is beneficial to be systematic.

Diaphragmatic Excursion

Measure the diaphragmatic excursion. Its descent may be limited by several types of pathologic processes: pulmonary (e.g., as a result of emphysema), abdominal (e.g., massive ascites, tumor), or superficial pain (e.g., fractured rib). The diaphragm is usually higher on the right than on the left because it sits over the bulk of the liver.

The following steps suggest one approach to measuring the diaphragmatic excursion:

- Ask the patient to take a deep breath and hold it.
- Percuss along the scapular line until you locate the lower border, the point marked by a change in note from resonance to dullness.
- Mark the point with a skin pencil at the scapular line. Allow the patient to breathe, and then repeat the procedure on the other side.
- Ask the patient to take several breaths, to exhale as much as possible, and then to hold (Box 13-7).
- Percuss up from the marked point and make a mark at the change from dullness to resonance. Remind the patient to start breathing. Repeat on the other side.
- Measure and record the distance in centimeters between the marks on each side. The excursion distance is usually 3 to 5 or 6 cm (Fig. 13-20).

Alternatively, you might use strips of tape, or use one hand as a stationary landmark, percussing directly with the other and estimating the distance.

BOX 13-7

BAD BREATH: A POSSIBLE SIGN OF INFECTION

Smell the Breath

Auscultation of the lungs makes it possible (occasionally, even uncomfortably so) to become aware of a patient's breath odor. Bad breath, even when it is not too distinct, is easily noticed. Infection, either acute or chronic, somewhere in the nasal or oral cavity or deep in the lung, can be the source. An especially foul or putrid odor of breath and/or sputum suggests anaerobic respiratory infections, empyema, bronchiectasis, lung abscess, or a particularly insistent bronchitis. Your nose may provide a significant clue:

Sweet, fruity	Diabetic ketoacidosis; starvation ketosis
Fishy, stale	Uremia (trimethylamines)
Ammonia-like	Uremia (ammonia)
Musty fish, clover	Fetor hepaticus: hepatic failure, portal vein thrombosis, portacaval shunts
Foul, feculent	Intestinal obstruction
Foul, putrid	Nasal/sinus pathology: infection, foreign body, cancer; respiratory infections: empyema, lung abscess, bronchiectasis
Halitosis	Tonsillitis, gingivitis, respiratory infections, Vincent angina, gastroesophageal reflux
Cinnamon	Pulmonary tuberculosis

FIGURE 13-20
Measuring diaphragmatic excursion. Excursion distance is usually 3 to 5 cm.

AUSCULTATION

Auscultation with a stethoscope provides important clues to the condition of the lungs and pleura. All sounds can be characterized in the same manner as the percussion notes: intensity, pitch, quality, and duration.

Have the patient sit upright, if possible, and breathe slowly and deeply through the mouth, exaggerating normal respiration. Demonstrate this yourself. Caution the patient to keep a pace consistent with comfort; hyperventilation, which occurs more easily than one might think, may cause faintness, and exaggerated breathing can be tiring, especially for frail patients. Because most pulmonary pathologic conditions patients occur at the lung bases, it is a good idea to examine these first, before fatigue sets in.

The diaphragm of the stethoscope is usually preferable to the bell for listening to the lungs because it transmits the ordinarily high-pitched sounds better and because it provides a

broader area of sound. Place the stethoscope firmly on the skin. When the individual breath sound is being evaluated, there should be no movement of patient or stethoscope except for the respiratory excursion.

To auscultate the back, ask the patient to sit as for percussion, with head bent forward and arms folded in front to enlarge the listening area (Fig. 13-21). Then have the patient sit more erect with arms overhead for auscultating the lateral chest. Finally, ask the patient to sit erect with the shoulders back for auscultation of the anterior chest. As with so much else, the exact sequence you adopt is not as important as using the same sequence each time to ensure that the examination is thorough.

Listen systematically at each position throughout inspiration and expiration, taking advantage of a side-to-side comparison as you move downward from apex to base at intervals of several centimeters. The sounds of the middle lobe of the right lung and the lingula on the left are best heard in the respective axillae.

CLINICAL PEARL

Congestive Heart Failure

If the patient may have congestive heart failure, you should begin auscultation at the base of the lungs to detect crackles that may disappear with continued exaggerated respiration.

Breath Sounds

Breath sounds are made by the flow of air through the respiratory tree. They are characterized by pitch, intensity, quality, and relative duration of their inspiratory and expiratory phases, and are classified as vesicular, bronchovesicular, and bronchial (tubular) (Fig. 13-22, Table 13-2).

Vesicular breath sounds are low-pitched, low-intensity sounds heard over healthy lung tissue. *Bronchovesicular* sounds are heard over the major bronchi and are typically moderate

FIGURE 13-21
Auscultation with a stethoscope.

TABLE 13-2 Characteristics of Normal Breath Sounds

Sound	Characteristics	Findings
Vesicular	Heard over most of lung fields; low pitch; soft and short expirations (see Figs. 13-22 and 13-23); more prominent in a thin person or a child, diminished in the overweight or very muscular patient	
Bronchovesicular	Heard over main bronchus area and over upper right posterior lung field; medium pitch; expiration equals inspiration	
Bronchial/tracheal (tubular)	Heard only over trachea; high pitch; loud and long expirations, sometimes a bit longer than inspiration	

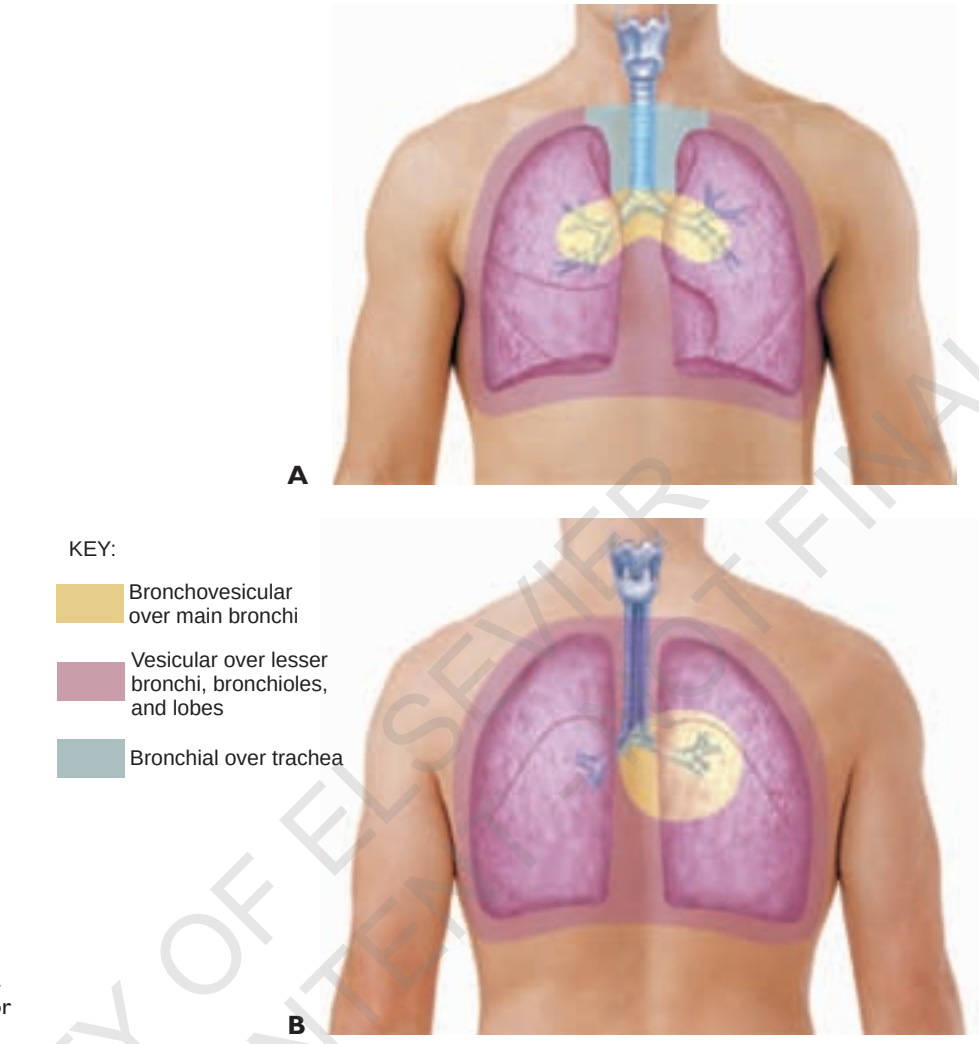


FIGURE 13-22
Expected auscultatory sounds. **A,** Anterior view. **B,** Posterior view.

CLINICAL PEARL

Sickle Cell Disease

Persons with sickle cell disease may have frequent pulmonary problems. Pulmonary infarction and a pulmonary crisis may be suggested by a variety of findings on inspection, palpation, percussion, and auscultation and by an arching of the back as the patient attempts to breathe more comfortably.

in pitch and intensity. The sounds highest in pitch and intensity are the *bronchial* breath sounds, which are ordinarily heard only over the trachea. Both bronchovesicular and bronchial breath sounds are abnormal if they are heard over the peripheral lung tissue.

Breathing that resembles the noise made by blowing across the mouth of a bottle is defined as *amphoric* and is most often heard with a large, relatively stiff-walled pulmonary cavity or a tension pneumothorax with bronchopleural fistula. *Cavernous breathing,* sounding as if coming from a cavern, is commonly heard over a pulmonary cavity in which the wall is rigid.

Breath sounds, dependent in large part for their intensity or the speed with which air enters and leaves the mouth, are relatively more difficult to hear or are absent if fluid or pus has accumulated in the pleural space, if secretions or a foreign body obstructs the bronchi, if the lungs are hyperinflated, or if breathing is shallow from splinting because of pain. Breath sounds are easier to hear when the lungs are consolidated; the mass surrounding the tube of the respiratory tree promotes sound transmission better than do air-filled alveoli.

Most of the abnormal sounds heard during lung auscultation are superimposed on the breath sounds. Extraneous sounds such as the crinkling of chest or back hair must be carefully distinguished from far more significant adventitious sounds. Sometimes it helps to moisten chest hair to minimize this problem. Listening through clothing or patient gowns allows for extraneous sounds. Have your patients bare their skin. The common terms used to describe adventitious sounds are *crackles* (formerly called *rales*), *rhonchi, wheezes,* and *friction rub* (Fig. 13-23). Crackles are discontinuous; rhonchi and wheezes are continuous. Box 13-8 gives a detailed description of adventitious breath sounds.

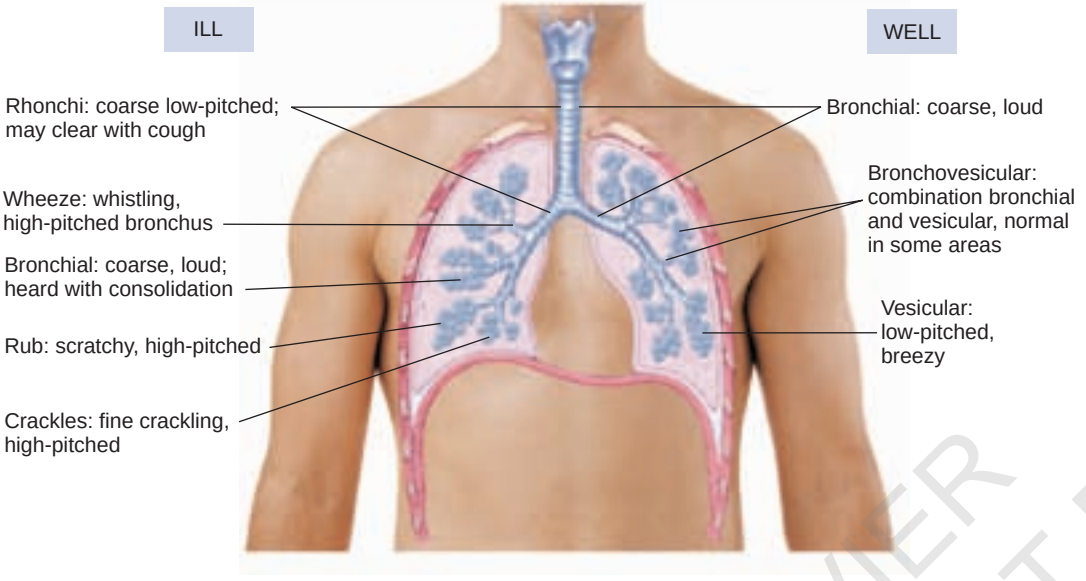


FIGURE 13-23
Schema of breath sounds in the ill and well patient.

BOX 13-8

ADVENTITIOUS BREATH SOUNDS

Fine crackles: high-pitched, discrete, discontinuous crackling sounds heard during the end of inspiration; not cleared by a cough

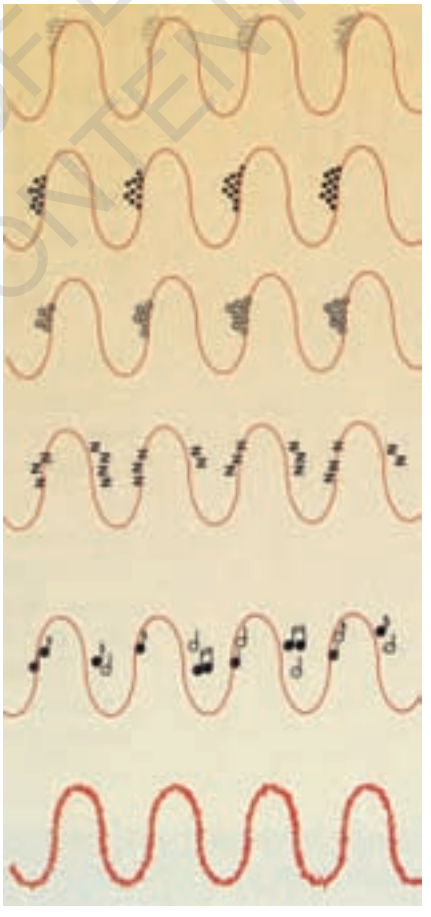
Medium crackles: lower, more moist sound heard during the midstage of inspiration; not cleared by a cough

Coarse crackles: loud, bubbly noise heard during inspiration; not cleared by a cough

Rhonchi (sonorous wheeze): loud, low, coarse sounds like a snore most often heard continuously during inspiration or expiration; coughing may clear sound (usually means mucus accumulation in trachea or large bronchi)

Wheeze (sibilant wheeze): musical noise sounding like a squeak; most often heard continuously during inspiration or expiration; usually louder during expiration

Pleural friction rub: dry, rubbing, or grating sound, usually caused by inflammation of pleural surfaces; heard during inspiration or expiration; loudest over lower lateral anterior surface



Crackles A crackle is an abnormal respiratory sound heard more often during inspiration and characterized by discrete discontinuous sounds, each lasting just a few milliseconds. The individual noise tends to be brief and the interval to the next one similarly brief.

Crackles may be fine, high pitched, and relatively short in duration; or coarse, low pitched, and relatively longer in duration. They are caused by the disruptive passage of air through the small airways in the respiratory tree. High-pitched crackles are described as *sibilant;* the more low-pitched crackles are termed *sonorous.* Crackles with a dry quality, more crisp than gurgling, are apt to occur higher in the respiratory tree. You might listen for crackles at the open mouth. If their origin is in the upper airways, they will be easily heard; if in the lower, not so easily.

Rhonchi *Rhonchi (sonorous wheezes)* are deeper, more rumbling, more pronounced during expiration, more likely to be prolonged and continuous, and less discrete than crackles. They are caused by the passage of air through an airway obstructed by thick secretions, muscular spasm, new growth, or external pressure. The more sibilant, higher-pitched rhonchi arise from the smaller bronchi, as in asthma; the more sonorous, lower-pitched rhonchi arise from larger bronchi, as in tracheobronchitis. All rhonchi may at times be palpable.

It may be difficult to distinguish between crackles and rhonchi. In general, rhonchi tend to disappear after coughing, whereas crackles do not. If such sounds are present, listen to several respiratory excursions: a few with the patient's accustomed effort, a few with deeper breathing, a few before coughing, and a few after.

Wheezes A *wheeze (sibilant wheeze)* is sometimes thought of as a form of rhonchus. It is a continuous, high-pitched, musical sound (almost a whistle) heard during inspiration or expiration. It is caused by a relatively high-velocity air flow through a narrowed or obstructed airway. The longer the wheeze and the higher the pitch, the worse the obstruction. Wheezes may be composed of complex combinations of a variety of pitches or of a single pitch, and they may vary from area to area and minute to minute. If a wheeze is heard bilaterally, it may be caused by the bronchospasm of asthma (reactive airway disease) or acute or chronic bronchitis. Unilateral or more sharply localized wheezing or stridor may occur with a foreign body. A tumor compressing a part of the bronchial tree can create a consistent wheeze or whistle of single pitch at the site of compression.

Other Sounds A *friction rub* occurs outside the respiratory tree. It has a dry, crackly, grating, low-pitched sound and is heard in both expiration and inspiration. It may have a machine-like quality. It may have no significance if heard over the liver or spleen; however, a friction rub heard over the heart or lungs is caused by inflamed, roughened surfaces rubbing together. Over the pericardium, this sound suggests pericarditis; over the lungs, pleurisy. The respiratory rub disappears when the breath is held; the cardiac rub does not.

Mediastinal crunch (Hamman sign) is found with mediastinal emphysema. A great variety of sounds—loud crackles, clicking and gurgling sounds are synchronous with the heartbeat and not particularly so with respiration. These sounds can be more pronounced toward the end of expiration and are easiest to hear when the patient leans to the left or lies down on the left side.

Vocal Resonance

CLINICAL PEARL

Vocal Resonance

The generally lower-pitched voices of men lend an intensity to vocal fremitus that is often greater than that in women.

The spoken voice transmits sounds through the lung fields that may be heard with the stethoscope. Ask the patient to recite numbers, names, or other words. These transmitted sounds are usually muffled and indistinct, and are best heard medially. Pay particular attention to vocal resonance if there are other unexpected findings during any part of the examination of the lungs, such as dullness on percussion or changes in tactile fremitus. The factors that influence tactile fremitus similarly influence vocal resonance.

Greater clarity and increased loudness of spoken sounds are defined as *bronchophony.* If bronchophony is extreme (e.g., in the presence of consolidation of the lungs), even a whisper can be heard clearly and intelligibly through the stethoscope *(whispered pectoriloquy).* When the intensity of the spoken voice is increased and there is a nasal quality (e.g., *e*'s become

stuffy broad *a*'s), the auditory quality is called *egophony*. These auditory changes may be present in any condition that consolidates lung tissue. Conversely, vocal resonance diminishes and loses intensity when there is loss of tissue within the respiratory tree (e.g., with the barrel chest of emphysema).

Coughs

Coughs are a common symptom of a respiratory problem. They are usually preceded by a deep inspiration; this is followed by closure of the glottis and contraction of the chest, abdominal, and even the pelvic muscles, and then a sudden, spasmodic expiration, forcing a sudden opening of the glottis. Air and secretions are exhaled. The causes may be related to localized or more general insults at any point in the respiratory tract. Coughs may be voluntary, but they are usually reflexive responses to an irritant such as a foreign body (microscopic or larger), an infectious agent, or a mass of any sort compressing the respiratory tree. They may also be a clue to an anxiety state.

Staying Well

Never Smoke/Stop Smoking

Chronic obstructive pulmonary disease is, at the moment, the fourth leading cause of death in the United States and this will likely get worse by 2020. The major risk factor is cigarette smoking. Although as many as 20% of people who die from the disease have never smoked, the vital key to prevention is the cessation of smoking or, better yet, never tasting a cigarette. A major risk to the preservation of pulmonary health during late childhood and adolescence is the first experiment with a cigarette. It is our responsibility as care providers to be persistent in our attention to patient education in this regard.

From Rennard, 2004.

Describe a cough according to its moisture, frequency, regularity, pitch and loudness, quality and circumstances. The type of cough may offer some clue to the cause. Although a cough may not have a serious cause, do not ignore it.

Dry or Moist. A moist or productive cough may be caused by infection and can be accompanied by sputum production. A dry or non-productive cough can have a variety of causes (e.g., cardiac problems, allergies), which may be indicated by the quality of its sound.

Onset. An acute onset, particularly with fever, suggests infection; in the absence of fever, a foreign body or inhaled irritants are additional possible causes.

Frequency of Occurrence. Note whether the cough is seldom or often present. An infrequent cough may result from allergens or environmental insults.

Regularity. A regular, paroxysmal cough is heard in pertussis. An irregularly occurring cough may have a variety of causes (e.g., smoking, early congestive heart failure, an inspired foreign body or irritant, or a tumor within or compressing the bronchial tree).

Pitch and Loudness. A cough may be loud and high-pitched or quiet and relatively low-pitched.

Postural Influences. A cough may occur soon after a person has reclined or assumed an erect position (e.g., with a nasal drip or pooling of secretions in the upper airway).

Quality. A dry cough may sound brassy if it is caused by compression of the respiratory tree (as by a tumor) or hoarse if it is caused by croup. Pertussis produces an inspiratory whoop at the end of a paroxysm of coughing in older children and adults.

See Box 13-9 for a summary of expected findings of a healthy chest and lungs.

DIFFERENTIAL DIAGNOSIS

SOME CAUSES OF NOISY BREATHING: STRIDOR, HOARSENESS, WHEEZING, SNORING, GURGLING

The exact nature and location of the stimulus to noisy breathing will determine the type of noise. Snoring and gurgling tend to arise in the nasopharynx; stridor, in the area of the glottis; and wheezing, much lower in the respiratory tree.

Infection

- Peritonsillar abscess
- Retropharyngeal abscess
- Epiglottitis
- Laryngitis
- Tracheitis
- Bronchitis
- Bronchiolitis
- Viral croup

Irritants and Allergens

- Asthma
- Rhinitis
- Angioneurotic edema

Compression (From Outside of the Airway)

- Esophageal cysts or foreign body
- A variety of tumors
- Lymphadenopathy

Congenital Malformation and Abnormalities

- Vascular rings
- Laryngeal webs
- Laryngomalacia
- Tracheomalacia
- Hemangiomas within the upper airway
- Stenosis within the upper airway
- Cystic fibrosis

Acquired Abnormality (at Every Level of the Airway)

- Excessive use of voice
- Nasal polyps
- Hypertrophied adenoids and/or tonsils
- Foreign body, corrosive ingestion
- Intraluminal tumors
- Bronchiectasis
- Burns, thermal injury, smoke inhalation
- Postintubation (e.g., nasogastric tube)

Neurogenic Disorder

- Vocal cord paralysis (also, postsurgical)

BOX 13-9

SUMMARY OF EXPECTED FINDINGS OF THE CHEST AND LUNGS

When the lungs are healthy, the respiratory tree clear, the pleurae unaffected by disease, and the chest wall symmetrically and appropriately structured and mobile, the following characteristics will be found:

- On inspection
  - Symmetry of movement on expansion
  - Absence of retractions
- On palpation
  - Midline trachea without a tug
  - Symmetric, unaccentuated tactile fremitus
- On percussion
  - Range of 3 to 5 cm in the descent of diaphragm
  - Resonant and symmetric percussion notes
- On auscultation
  - Absence of adventitious sounds
  - Vesicular breath sounds, except for bronchovesicular sounds beside the sternum and the more prominent bronchial components in the area of the larger bronchi

SPUTUM

The production of sputum is generally associated with cough. Sputum in more than small amounts and with any degree of consistency always suggests the presence of disease. If the onset is acute, infection is most probable. Once there is some chronicity, the possibility of a significant anatomic change (e.g., tumor, cavitation, or bronchiectasis) becomes apparent. The Differential Diagnosis box below delineates possible pathologic conditions and their accompanying sputum findings.

DIFFERENTIAL DIAGNOSIS

SOME CAUSES OF SPUTUM

Cause	Possible Sputum Characteristics
Bacterial infection	Yellow, green, rust (blood mixed with yellow sputum), clear, or transparent; purulent; blood streaked; mucoid, viscid
Viral infection	Mucoid, viscid; blood streaked (not common)
Chronic infectious disease	All of the above; particularly abundant in the early morning; slight, intermittent blood streaking; occasionally, large amounts of blood*
Carcinoma	Slight, persistent, intermittent blood streaking
Infarction	Blood clotted; large amounts of blood
Tuberculous cavity	Occasional large amounts of blood*

*Remember to ascertain that the blood is not swallowed from a nosebleed.

INFANTS

The examination of the chest and lungs of the newborn follows a sequence similar to that for adults. Inspecting without disturbing the baby is key. Percussion, however, may be unreliable. The examiner's fingers may be too large for a baby's chest, and particularly so for the premature infant.

A newborn's Apgar scores at 1 and 5 minutes after birth tell you a great deal about the infant's condition. An infant whose respirations are inadequate but who is otherwise normal may initially score 1 or even 0 on heart rate, muscle tone, response to a catheter, or color. Depressed respiration often has its origins in the maternal environment during labor, such as sedatives or compromised blood supply to the newborn; or it may result from mechanical obstruction by mucus. Table 13-3 explains the Apgar scoring system. This score requires some subjective judgment and cannot be considered absolute.

TABLE 13-3 Infant Evaluation at Birth—Apgar Scoring System

	0	1	2
Heart rate	Absent	Slow (below 100 beats/min)	Over 100 beats/min
Respiratory effort	Absent	Slow or irregular	Good crying
Muscle tone	Limp	Some flexion of extremities	Active motion
Response to catheter in nostril (tested after oropharynx is clear)	No response	Grimace	Cough or sneeze
Color	Blue or pale	Body pink, extremities blue	Completely pink

Add the scores of the five individual observations to get the full Apgar score. The lower the total, the more likely it is that there is a problem.

Inspect the thoracic cage, noting size and shape; measure the chest circumference, which in the healthy full-term infant is usually about 30 to 36 cm, usually 2 to 3 cm smaller than the head circumference. This difference between the two increases with prematurity. An infant with intrauterine growth retardation will have a relatively smaller chest circumference compared to the head, whereas the infant of a poorly controlled diabetic mother will have a relatively larger chest circumference

The newborn's lung function is particularly susceptible to a number of environmental factors. The pattern of respirations will vary with feeding, and sleep. In the first few hours after birth, the respiratory effort can be depressed by the passive transfer of drugs given to the mother before delivery. Count the respiratory rate for 1 minute. The expected rate varies from 40 to 60 respirations per minute, although a rate of 80 is not uncommon. Babies delivered by cesarean section generally have a more rapid rate than do babies delivered vaginally. Note the regularity of respiration. Babies are obligate nose breathers and, at this age, nasal breathing is common. The more premature an infant at birth, the more likely some irregularity in the respiratory pattern will be present. *Periodic breathing,* a sequence of relatively vigorous respiratory efforts followed by apnea of as long as 10 to 15 seconds, is common. It is cause for concern if the apneic episodes tend to be prolonged and the baby becomes centrally cyanotic (i.e., cyanotic about the mouth, face, and torso). The persistence of periodic breathing episodes in preterm infants is relative to the gestational age of the baby, with the apneic period diminishing in frequency as the baby approaches term status. In the term infant, periodic breathing should wane a few hours after birth.

Coughing is rare in the newborn and should be considered a problem. Sneezing, on the other hand, is frequent and expected—it clears the nose. Hiccups are also frequent, though usually silent, particularly after meals. Frequent hiccupping, however, may suggest seizures, drug withdrawal, or encephalopathy, among other possibilities.

Newborns rely primarily on the diaphragm for their respiratory effort, only gradually adding the intercostal muscles. Infants quite commonly also use the abdominal muscles. Paradoxic breathing (the chest wall collapses as the abdomen distends on inspiration) is common, particularly during sleep.

If the chest expansion is asymmetric, suspect some compromise of the baby's ability to fill one of the lungs (e.g., pneumothorax, atelectasis, or diaphragmatic hernia) (Fig. 13-24).

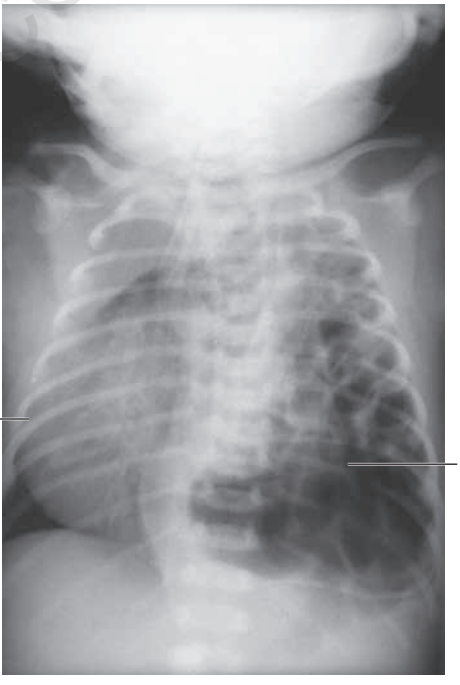


FIGURE 13-24
X-ray film showing diaphragmatic hernia.

Palpate the rib cage and sternum, noting loss of symmetry, unusual masses, or crepitus. Crepitus around a fractured clavicle (with no evidence of pain) is common after a difficult forceps delivery. The newborn's xiphoid process is more mobile and prominent than that of the older child or adult. It has a sharp inferior tip that moves slightly back and forth under your finger.

Listen to the chest. If the baby is crying and restless, it pays to wait for a more quiet moment. Localization of breath sounds is difficult, particularly in the very small chest of the preterm infant. Breath sounds are easily transmitted from one segment of the auscultatory area to another; therefore the absence of sounds in any given area may be difficult to detect. Crackles and rhonchi are commonly heard immediately after birth because fetal fluid has not been completely cleared. Whenever auscultatory findings are asymmetric, suspect a problem—for example, with the aspiration of meconium. Gurgling from the intestinal tract, slight movement, and mucus in the upper airway may all contribute to adventitious sounds, making evaluation difficult. If gastrointestinal gurgling sounds are persistently heard in the chest, one must suspect diaphragmatic hernia, but wide transmission of these sounds can sometimes be deceptive.

Stridor is a high-pitched, piercing sound most often heard during inspiration. It is the result of an obstruction high in the respiratory tree. A compelling sound at any age, it cannot be dismissed as inconsequential, particularly when inspiration (I) may be three to four times longer than expiration (E), giving an I/E ratio of 3:1 or 4:1. When accompanied by a cough, hoarseness, and retraction, stridor signifies a serious problem in the trachea or larynx (e.g., a floppy epiglottis; congenital defects; croup; or an edematous response to an infection, allergen, smoke, chemicals, or aspirated foreign body). Infants who have a narrow tracheal lumen from compression by a tumor, abscess, or double aortic arch can develop stridor. Retraction at the supraclavicular notch and contraction of the sternocleidomastoid muscles indicates significant respiratory distress.

Respiratory grunting is a mechanism by which the infant tries to expel trapped air or fetal lung fluid while trying to retain air and increase oxygen levels. When persistent, it is cause for concern. *Flaring of the alae nasi* is another indicator of respiratory distress at this, or any, age.

CHILDREN

Children use the thoracic (intercostal) musculature for respiration by the age of 6 or 7 years. In young children, obvious intercostal exertion (retractions) on breathing suggests an airway problem (e.g., asthma). Usual respiratory rates for children are listed below. Rates decrease with age with a greater variation in the first 2 years of life and without significant gender difference. Sustained rates that exceed the indicated limits should suggest difficulty (Box 13-10):

BOX 13-10

ASSESSMENT OF RESPIRATORY DISTRESS

Important observations to be made of the respiratory effort include the following:

- Does a loss of synchrony between left and right occur during the respiratory effort? Is there a lag in movement of the chest on one side? If so, consider atelectasis or diaphragmatic hernia.
- Is there stridor? If so, consider croup or epiglottitis?
- Is there retraction at the suprasternal notch intercostally or at the xiphoid process? Do the nares dilate and flare with respiratory effort? If so, consider respiratory distress.
- Is there an audible expiratory grunt? Is it audible with the stethoscope only or without the stethoscope? If so, consider lower airway obstruction or focal atelectasis?

Age	Respirations per Minute
Newborn	30 to 80
1 year	20 to 40
3 years	20 to 30
6 years	16 to 22
10 years	16 to 20
17 years	12 to 20

If the roundness of the young child's chest persists past the second year of life, be concerned about the possibility of a chronic obstructive pulmonary problem such as cystic fibrosis. The persistence of a barrel chest at the age of 5 or 6 years can be ominous.

Seize the opportunity that a crying child presents. A sob is often followed by a deep breath. The sob itself allows the evaluation of vocal resonance and the feel for tactile fremitus; gently use the whole hand, palm and fingers. The crying child may pause occasionally, and the heart sounds may be heard. These pauses may be a bit prolonged as the breath is held, giving the chance to distinguish a murmur from a breath sound.

Children younger than 5 or 6 years may not be able to give enough of an expiration to satisfy you, particularly when you suspect subtle wheezing. Asking them to "blow out" your flashlight or to blow away a bit of tissue in your hand may help bring out otherwise difficult-to-hear end expiratory sounds. It is also easier to hear the breath sounds when the child breathes more deeply after running up and down the hallway.

The child's chest is thinner and ordinarily more resonant than the adult's chest; the intrathoracic sounds are easier to hear, and hyperresonance is common in the young child. With either direct or indirect percussion, it is easy to miss the dullness of an underlying consolidation. If you sense some loss of resonance, give it as much importance as you would give frank dullness in the adolescent or adult. Also, with percussion your pleximeter finger can learn to feel the dull areas, a tactile sense that comes in handy at times with a crying child. The dull areas are sensed as having more resistance than resonant areas because they move less.

Because of the thin chest wall, the breath sounds of the young child may sound louder, harsher, and more bronchial than those of the adult. Bronchovesicular breath sounds may be heard throughout the chest.

PREGNANT WOMEN

Pregnant women experience both structural and ventilatory changes. Dyspnea is common in pregnancy and is usually a result of normal physiologic changes. Overall, the pregnant woman increases her ventilation by breathing more deeply, not more frequently. Asthma can have a varied course, getting worse, getting better, or being unaffected by the pregnancy with about equal frequency.

OLDER ADULTS

The examination procedure for older adults is the same as that for younger adults, although there may be variations in some expected findings. Chest expansion is often decreased. The patient may be less able to use the respiratory muscles because of muscle weakness, general physical disability, or a sedentary lifestyle. Calcification of rib articulations may also interfere with chest expansion, requiring use of accessory muscles. Bony prominences are marked, and there is loss of subcutaneous tissue. The dorsal curve of the thoracic spine is prominent (kyphosis) with flattening of the lumbar curve (Fig. 13-25). The AP diameter of the chest is increased in relation to the lateral diameter.

Older patients may have more difficulty breathing deeply and holding their breath than younger patients, and they may tire more quickly even when well. Adapt the pace and demands of examination to individual needs.

Some older patients may display hyperresonance as a result of increased distensibility of the lungs. This finding must be evaluated in the context of the presence or absence of other symptoms.

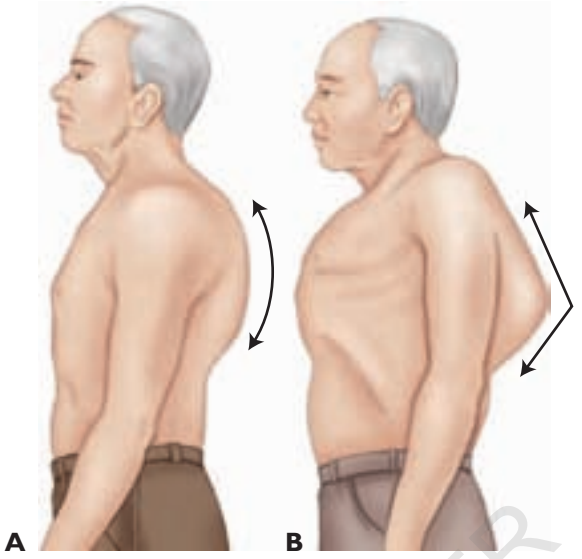


FIGURE 13-25
Pronounced dorsal curvature in older adult. **A,** Kyphosis. **B,** Gibbus (extreme kyphosis).

Sample Documentation

History and Physical Examination

SUBJECTIVE

Chief concern: Cough and fever

History of present illness: Nonproductive cough for past several days. Persistent, worse when lies down. Feels ill. Chest feels "heavy." Feels short of breath. Fever up to 101° F. Taking a nonprescription cough syrup without relief.

OBJECTIVE

Pulse 98, Respiratory rate 24, Temperature 38.2° C, Blood Pressure 110/72

Chest, without kyphosis or other distortion. Thoracic expansion symmetric. Respirations rapid and somewhat labored, not accompanied by retractions or stridor. On palpation, trachea in midline without tug; no friction rubs or tenderness over the ribs or other bony prominences. Over the left base posteriorly, tactile fremitus increased; percussion note dull; on auscultation, crackles were heard and did not clear with cough; breath sounds diminished. Remainder of lung fields clear and free of adventitious sounds, with resonant percussion tones. Diaphragmatic excursion 3 cm bilaterally.

For additional sample documentation, see Chapter 26.

ABNORMALITIES

Physical findings associated with many common conditions are listed in Table 13-4.

TABLE 13-4 Physical Findings Associated With Common Respiratory Conditions*

Condition	Inspection	Palpation	Percussion	Auscultation
Asthma	Tachypnea Nasal flaring Intercostal retractions	Tachycardia Diminished fremitus	Occasional hyperresonance Occasional limited diaphragmatic descent; diaphragmatic level lower	Prolonged expiration Wheezes Diminished lung sounds
Atelectasis	Delayed and/or diminished chest wall movement (respiratory lag), narrowed intercostals spaces on affected side Tachypnea	Diminished fremitus Apical cardiac impulse deviated ipsilaterally Trachea deviated ipsilaterally	Dullness over affected lung	In upper lobe, bronchial breathing, egophony, whispered pectoriloquy In lower lobe, diminished or absent breath sounds Wheezes, rhonchi, and crackles in varying amounts depending on extent of collapse
Bronchiectasis	Tachypnea Respiratory distress Hyperinflation Clubbing (esp. cystic fibrosis)	Few, if any, consistent findings	No unusual findings if there are no accompanying pulmonary disorders	A variety of crackles, usually coarse; and rhonchi, sometimes disappearing after cough
Bronchitis	Occasional tachypnea Occasional shallow breathing Often no deviation from expected findings	Tactile fremitus undiminished	Resonance	Breath sounds may be prolonged Occasional crackles, expiratory wheezes and rhonchi
Chronic obstructive pulmonary disease	Respiratory distress Audible wheezing Cyanosis Distention of neck veins, peripheral edema (in presence of right-sided heart failure) Clubbing, rarely	Somewhat limited mobility of diaphragm Somewhat diminished vocal fremitus	Occasional hyperresonance	Postpertussive rhonchi (sonorous wheezes) and sibilant wheezing Inspirational crackles (best heard with stethoscope held over open mouth) Breath sounds somewhat diminished
Emphysema	Tachypnea Deep breathing Pursed lips Barrel chest Thin, underweight	Apical impulse may not be felt Liver edge displaced downward Diminished fremitus	Hyperresonance Limited descent of diaphragm on inspiration Upper border of liver dullness pushed downward	Diminished breath and voice sounds with occasional prolonged expiration Diminished audibility of heart sounds Only occasional adventitious sounds
Pleural effusion and/ or thickening	Diminished and delayed respiratory movement (lag) on affected side	Diminished and delayed respiratory movement on affected side Cardiac apical impulse shifted contralaterally Trachea shifted contralaterally Diminished fremitus Tachycardia	Dullness to flatness Hyperresonant note in area superior to effusion	Diminished to absent breath sounds Bronchophony, whispered pectoriloquy Egophony and/or crackles in area superior to effusion Occasional friction rub
Pneumonia consolidation	Tachypnea Shallow breathing Flaring of alae nasi Occasional cyanosis Limited movement at times on involved side; splinting	Increased fremitus in presence of consolidation Decreased fremitus in presence of a concomitant empyema or pleural effusion Tachypnea	Dullness if consolidation is great	A variety of crackles with lobar and occasional rhonchi Bronchial breath sounds Egophony, bronchophony, whispered pectoriloquy
Pneumothorax	Tachycardia Cyanosis Respiratory distress Bulging intercostal spaces Respiratory lag on affected side Tracheal deviation with tension pneumothorax	Diminished to absent fremitus Cardiac apical impulse, trachea, and mediastinum shifted contralaterally Diminished to absent tactile fremitus Tachycardia Subcutaneous crepitance from air leaking	Hyperresonance	Diminished to absent breath sounds Succussion splash audible if air and fluid mix Sternal and precordial clicks and crackling (Hamman sign) if air underlies that area Diminished to absent whispered voice sounds

**Physical findings will vary in intensity depending on the severity of the underlying problem and on occasion may not be present in the early stages.*

ASTHMA (REACTIVE AIRWAY DISEASE)

Small airway obstruction due to inflammation and hyperreactive airways.

Pathophysiology

- Acute episodes triggered by allergens, anxiety, cold air, exercise, upper respiratory infections, cigarette smoke, or other environmental agents
- Result in mucosal edema, increased secretions, and bronchoconstriction with increased airway resistance and impeded respiratory flow

History

- Episodes of paroxysmal dyspnea and cough
- Chest pain is common and, with it, a feeling of tightness.
- Episodes may last for minutes, hours, or days.
- May be asymptomatic between episodes

Objective Data

- Tachypnea with wheezing on expiration and inspiration
- Expiration becomes more prolonged with labored breathing, fatigue, and anxious expression as airway resistance increases.
- Hypoxemia by pulse oximetry
- Decreased peak expiratory flow rate

CLINICAL PEARL

Foreign Body

Think about the possibility of a foreign body when a patient, particularly a youngster, presents with wheezing for the first time. The history may not at first offer a clue.

Video/Animation
Access an animation on asthma on Evolve

ATELECTASIS

The incomplete expansion of the lung at birth or the collapse of the lung at any age (Fig. 13-26).

Pathophysiology

- Collapse caused by compression from outside (e.g., exudates, tumors) or resorption of gas from the alveoli in the presence of complete internal obstruction
- Loss of elastic recoil of the lung may be due to thoracic or abdominal surgery, plugging, exudates, or foreign body.

Subjective Data

- Frequently seen in the postoperative setting
- Symptoms of postobstructive pneumonia may develop in the setting of airway obstruction from foreign body or tumor.

Objective Data

- Auscultation dampened or muted in the involved area because the affected area of the lung is airless
- Radiograph may show consolidation associated with a postobstructive pneumonia.

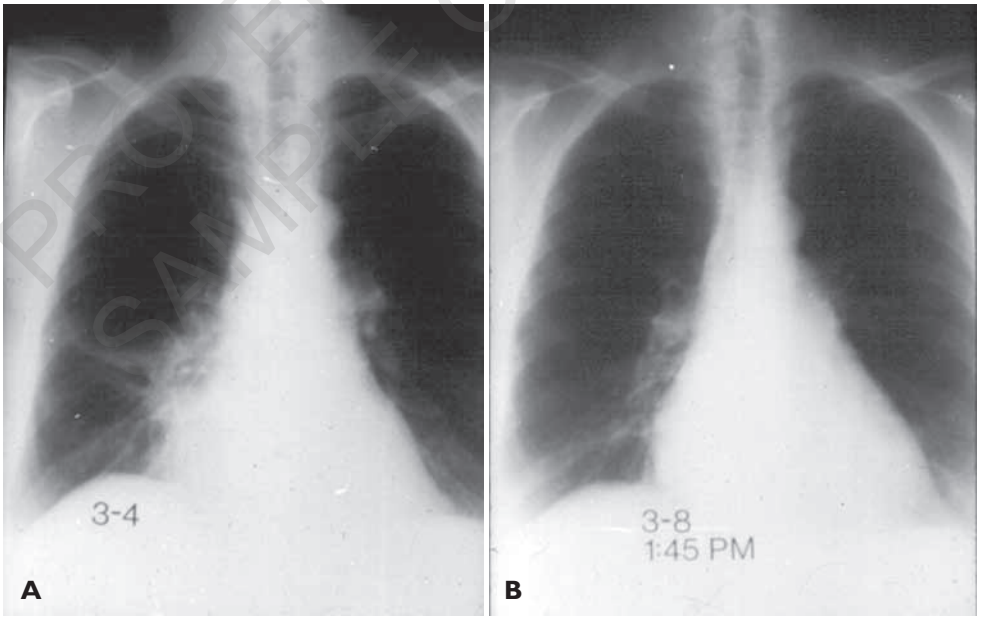


FIGURE 13-26
Atelectasis. *(Modified from Wilson and Thompson, 1990.)*

BRONCHITIS

Inflammation of the large airways.

Pathophysiology

- Inflammation of the bronchial tubes leads to increased mucous secretions (Fig. 13-27).
- Acute bronchitis is usually due to an infection, while chronic bronchitis is usually due to irritant exposure.

Subjective Data

- Acute bronchitis may be accompanied by fever, hacking nonproductive cough, and chest pain.
- In chronic bronchitis, the cough may be productive.

Objective Data

- Minimal auscultation findings with no respiratory distress
- Greater involvement may lead to wheezing or dampened auscultation in the involved areas.

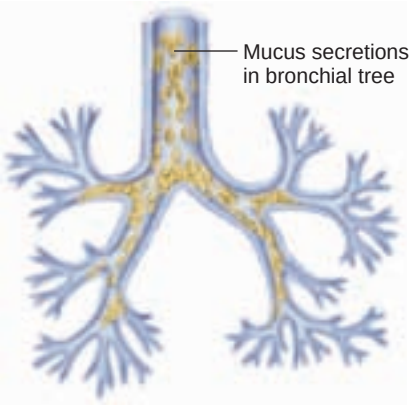


FIGURE 13-27
Acute bronchitis. *(From Wilson and Thompson, 1990.)*

PLEURISY

An inflammatory process involving the visceral and parietal pleura that becomes edematous and fibrinous (Fig. 13-28).

Pathophysiology

- Often the result of pulmonary infections (bacterial or viral) or connective tissue diseases (e.g., lupus).
- Sometimes associated with neoplasm or asbestosis.

Subjective Data

- Usually sudden onset with chest pain when taking a breath (pleuritic)
- Rubbing of the pleural surfaces can be felt by the patient.
- Pain can be referred to the ipsilateral shoulder if the pleural inflammation is close to the diaphragm.

Objective Data

- Respirations are rapid and shallow with diminished breath sounds.
- A pleural friction rub can be auscultated.
- Fever may be present.

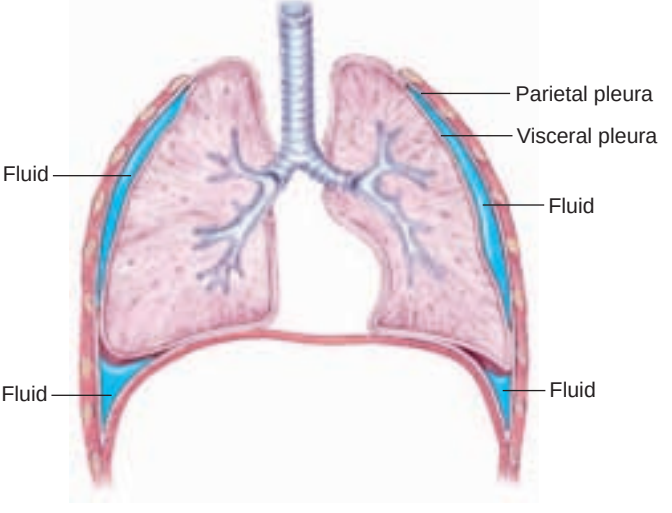


FIGURE 13-28
Pleurisy. *(Modified from Wilson and Thompson, 1990.)*

PLEURAL EFFUSION

Excessive non-purulent fluid in the pleural space (Fig. 13-29).

Pathophysiology

- Sources of fluid vary and include infection, heart failure, renal insufficiency, connective tissue disease, neoplasm, and trauma.

Subjective Data

- Cough with progressive dyspnea is the typical presenting concern.
- Pleuritic chest pain will occur with an inflammatory effusion.

Objective Data

- The findings on auscultation and percussion vary with the amount of fluid present and also with the position of the patient.
- Dullness to percussion and tactile fremitus are the most useful findings for pleural effusion.
- When the fluid is mobile; it will gravitate to the most dependent position.
- In the affected areas, the breath sounds are muted and the percussion note is often hyperresonant in the area above the perfusion.

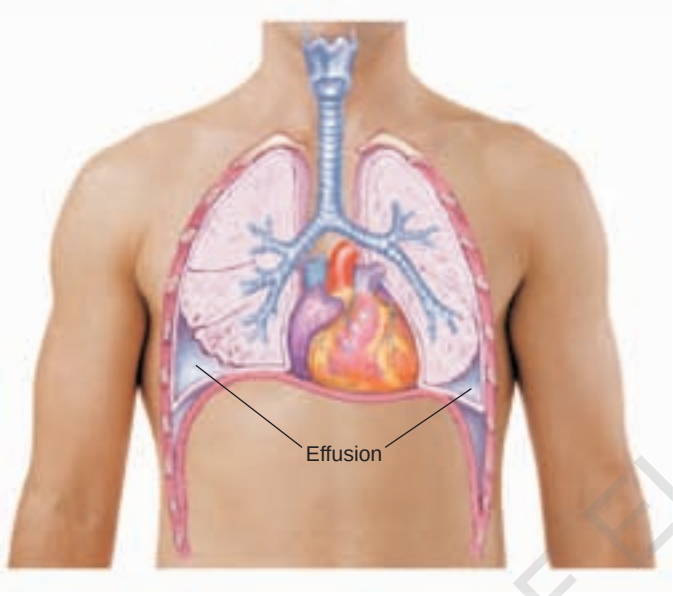


FIGURE 13-29
Pleural effusion. *(Modified from Wilson and Thompson, 1990.)*

EMPYEMA

Purulent exudative fluid collected in the pleural space (Fig. 13-30).

Pathophysiology

- Non–free-flowing purulent fluid collection develops most commonly from adjacent infected or sometimes traumatized tissues.
- May be complicated by pneumonia, simultaneous pneumothorax, or a bronchopleural fistula

Subjective Data

- The patient is often febrile and tachypneic, with cough and chest pain, and appears ill.
- Progressive dyspnea develops.
- Cough may produce blood or sputum.

Objective Data

- Breath sounds are distant or absent in the affected area.
- Percussion note is dull and vocal fremitus is absent.

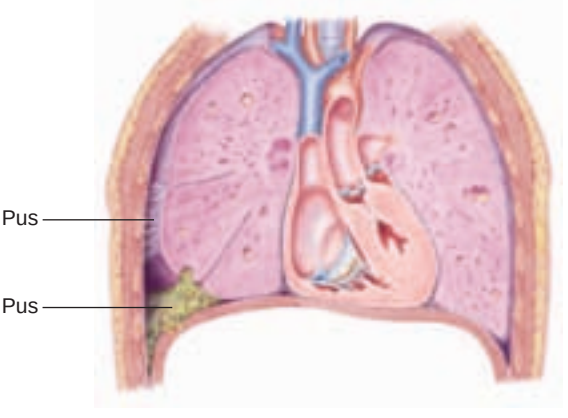


FIGURE 13-30
Empyema. *(Modified from Wilson and Thompson, 1990.)*

LUNG ABSCESS

A well-defined, circumscribed mass defined by inflammation, suppuration, and subsequent central necrosis (Fig. 13-31).

Pathophysiology

- Aspiration of food or infected material from upper respiratory or dental sources of infection are most common causes.
- It may elude diagnosis for a some time.

Subjective Data

- Patient is usually obviously ill with malaise, fever, and shortness of breath.

Objective Data

- Percussion note is dull and the breath sounds distant or absent over the affected area.
- Pleural friction rub may be auscultated.
- Cough may produce purulent, foul-smelling sputum.

FIGURE 13-31
Lung abscess. *(Modified from Wilson and Thompson, 1990.)*

PNEUMONIA

An inflammatory response of the bronchioles and alveoli to an infective agent (bacterial, fungal, or viral) (Fig. 13-32).

Pathophysiology

- Acute infection of the pulmonary parenchyma may be due to a variety of organisms, which depend in part on the setting in which the pneumonia was acquired (community vs. hospital).
- The infection and concomitant inflammatory exudates lead to lung consolidation.

Subjective Data

- Rapid onset (hours to days) of cough, pleuritic chest pain, and dyspnea
- Sputum production is common with bacterial infection.
- Chills, fever, rigors, and nonspecific abdominal symptoms of nausea and vomiting may be present.
- Involvement of the right lower lobe can stimulate the tenth and eleventh thoracic nerves to cause right lower quadrant pain and simulate an abdominal process.

Objective Data

- Febrile, tachypneic, and tachycardic
- Crackles and rhonchi are common with diminished breath sounds.
- Egophony, bronchophony, and whisper pectoriloquy
- Dullness to percussion occurs over the area of consolidation.

CLINICAL PEARL

Pneumonia

In children particularly, but also in adults, audible crackles are not necessary to give evidence of pneumonia. Flaring of the alae nasi, tachypnea, and a possibly productive cough in the absence of crackles and out of proportion to other clinical findings should alert you to the possibility of acute bacterial pneumonia.

FIGURE 13-32
Lobar pneumonia (right upper lobe). *(Modified from Wilson and Thompson, 1990.)*

INFLUENZA

A viral infection of the lung. While this is normally an upper respiratory infection, due to alterations in the epithelial barrier, the infected host is more susceptible to secondary bacterial infections (Fig. 13-33).

Pathophysiology

- When mild, it may seem to be just a cold; however, the aged, the very young, and the chronically ill are particularly susceptible.
- Entire respiratory tract may be overwhelmed by interstitial inflammation and necrosis extending throughout the bronchiolar and alveolar tissue.

Subjective Data

- Characterized by cough, fever, malaise, headache, coryza, and mild sore throat, typical of the common cold.
- Significant respiratory distress can develop, leading to high morbidity.

Objective Data

- Crackles, rhonchi, and tachypnea are common.

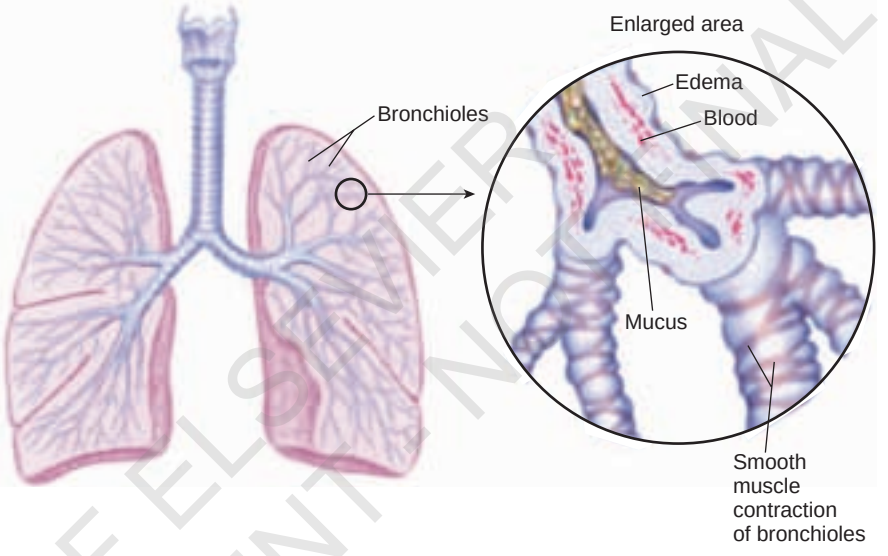


FIGURE 13-33
Influenza. *(Modified from Wilson and Thompson, 1990.)*

TUBERCULOSIS

A chronic infectious disease that most often begins in the lung but may then have widespread manifestations (Fig. 13-34).

Pathophysiology

- The tubercle bacillus is inhaled from the airborne moisture of the coughs and sneezes of infected persons, infecting the recipient's lung.
- Latent period is when the organism entrenches itself .
- There is always the potential for a post-primary spread locally or throughout the body.

Subjective Data

- Latent period: asymptomatic, some regional lymph nodes may be involved
- Active infection: fever, cough, weight loss, night sweats
- History of travel to region with endemic tuberculosis or close contact with infected person

Objective Data

- Latent disease: no pulmonary findings
- Active disease: consolidation and/or pleural effusion may develop with corresponding findings and cough with blood-streaked sputum
- Positive tuberculin skin test

FIGURE 13-34
Tuberculosis. *(Modified from Wilson and Thompson, 1990.)*

PNEUMOTHORAX

The presence of air or gas in the pleural cavity (Fig. 13-35).

Pathophysiology

- May result from trauma or may occur spontaneously, perhaps because of rupture of a congenital or acquired bleb
- In *tension pneumothorax*, air leaks continually into the pleural space, resulting in a potentially life-threatening emergency from increasing pressure in the pleural space.

Subjective Data

- Minimal collections of air may easily be without symptoms at first, particularly because spontaneous pneumothorax paradoxically has its onset most often when the patient is at rest.
- Larger collections provoke dyspnea and chest pain.

Objective Data

- The breath sounds over the pneumothorax are distant.
- A mediastinal shift with tracheal deviation can be seen with a tension pneumothorax.

CLINICAL PEARL

Minimal Pneumothorax

An unexplained but persistent tachycardia may be a clue to a minimal pneumothorax that will not otherwise be detected on physical examination.

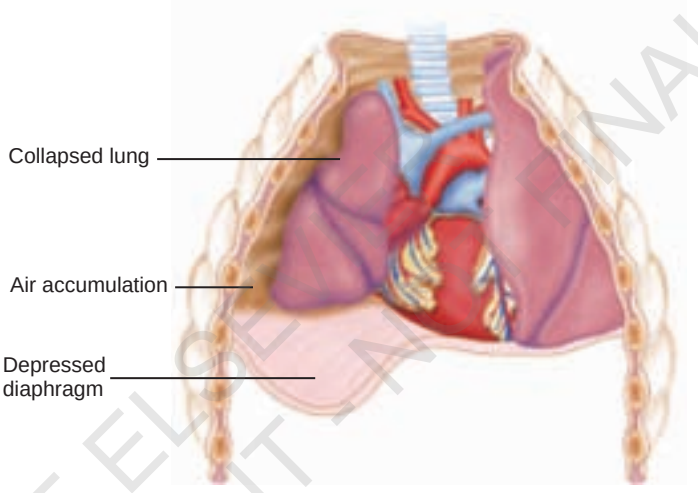


FIGURE 13-35
Pneumothorax.

HEMOTHORAX

The presence of blood in the pleural cavity (Fig. 13-36).

Pathophysiology

- May be the result of trauma or invasive medical procedures (e.g., thoracentesis, central line placement or attempt, pleural biopsy)
- When air is present with the blood; this is called a *hemopneumothorax.*

Subjective Data

- Dyspnea and symptoms of hypovolemia may develop depending on the degree and acuity of blood loss and decreased pulmonary function.

Objective Data

- Breath sounds will be distant or absent if blood predominates.
- Percussion note will be dull.

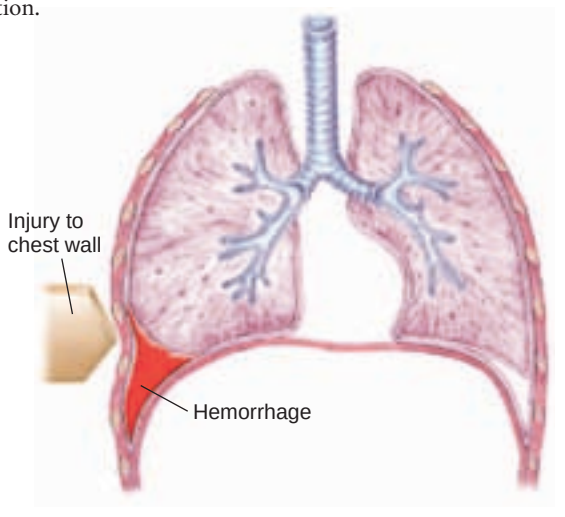


FIGURE 13-36
Hemothorax. *(Modified from Wilson and Thompson, 1990.)*

LUNG CANCER

Generally refers to bronchogenic carcinoma, a malignant tumor that evolves from bronchial epithelial structures (Fig. 13-37).

Pathophysiology

- Etiologic agents include tobacco smoke, asbestos, ionizing radiation, and other inhaled carcinogenic agents.

Subjective Data

- May cause cough, wheezing, a variety of patterns of emphysema and atelectasis, pneumonitis, and hemoptysis
- Peripheral tumors without airway obstruction may be asymptomatic.

Objective Data

- Findings are based on the extent of the tumor and the patterns of its invasion and metastasis.
- With airway obstruction, a postobstructive pneumonia can develop with consolidation.
- A malignant pleural effusion may develop with corresponding findings.

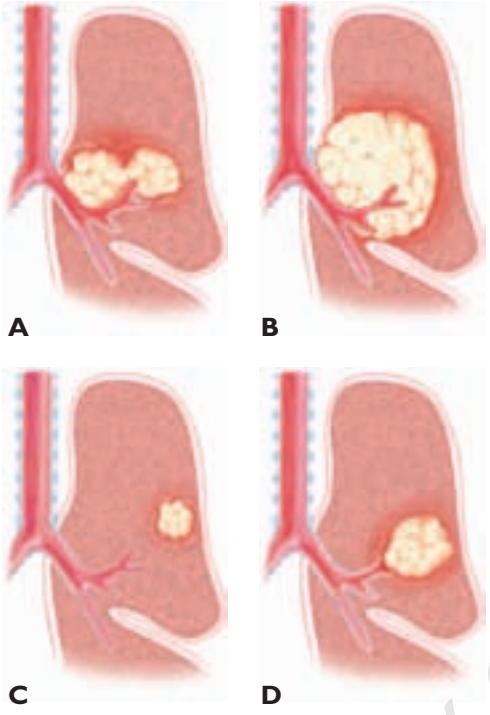


FIGURE 13-37
Cancer of the lung. **A,** Squamous (epidermoid) cell carcinoma. **B,** Small cell (oat cell) carcinoma. **C,** Adenocarcinoma. **D,** Large cell carcinoma.

COR PULMONALE

An acute or chronic condition involving right-sided heart failure (Fig. 13-38).

Pathophysiology

- In acute phase, the right side of the heart is dilated and fails, most often as a direct result of pulmonary embolism.
- In chronic cor pulmonale, gradual hypertrophy of the right ventricle progresses until ultimate heart failure.

Subjective Data

- Dyspnea, fatigue, lightheadedness and potentially syncope, are related to the developing pulmonary hypertension.

Objective Data

- Right-sided heart failure with a right ventricular heave
- Elevated jugular venous pulsation and lower extremity edema

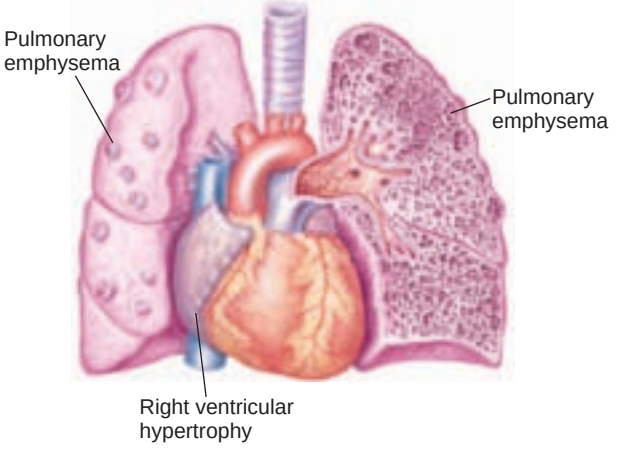


FIGURE 13-38
Cor pulmonale. Notice extensive pulmonary emphysema and right ventricular hypertrophy. *(Modified from Wilson and Thompson, 1990.)*

PULMONARY EMBOLISM

The embolic occlusion of pulmonary arteries is a relatively common condition that is very difficult to diagnose.

Pathophysiology

- Risk factors include, among others, age older than 40 years, a history of venous thromboembolism, surgery with anesthesia longer than 30 minutes, heart disease, cancer, fracture of the pelvis and leg bones, obesity, and acquired or genetic thrombophilia.

Subjective Data

- Pleuritic chest pain with or without dyspnea is a major clue to embolism.

Objective Data

- There may be a low-grade fever or an isolated tachycardia.
- Hypoxia by pulse oximetry may be evident.

Video/Animation
Access animation on a pulmonary embolism on Evolve

INFANTS, CHILDREN, AND ADOLESCENTS

RESPIRATORY DISTRESS SYNDROME

The preterm infant has great difficulty breathing.

Pathophysiology

- Develops in preterm infants due to surfactant deficiency

Subjective Data

- More frequently seen with decreasing gestational age, maternal diabetes, and acute asphyxia

Objective Data

- Tachypnea, retractions, grunting, and cyanosis

DIAPHRAGMATIC HERNIA

The result of an imperfectly structured diaphragm, occurs once in slightly more than 2000 live births (see Fig. 13-24).

Pathophysiology

- It is on the left side at least 90% of the time; the liver is not there to get in the way.

Subjective Data

- The degree of respiratory distress can be slight or very severe depending on the extent to which the bowel has invaded the chest through the defect.

Objective Data

- Bowel sounds are heard in the chest with a flat or scaphoid abdomen.
- The heart is usually displaced to the right.

CYSTIC FIBROSIS

An autosomal recessive disorder of exocrine glands involving the lungs, pancreas, and sweat glands (Fig. 13-39).

Pathophysiology

- Thick mucus causes progressive clogging of the bronchi and bronchioles.
- Bronchiectasis results with cyst formation and subsequent pulmonary infection.
- Many states now screen for this by checking for genetic mutations of *CFTR* (cystic fibrosis transmembrane conductance regulator).

Subjective Data

- Cough with sputum is a hallmark in children younger than 5 years.
- Salt loss in sweat is distinctive such that a parent may notice that the child's skin tastes unusually salty.
- There may be a history of malabsorbtion, poor weight gain, or intestinal obstruction.

Objective Data

- Bronchiectasis with the associated findings
- Low body mass due to malabsorption
- Pulmonary dysfunction leads to clubbing, pulmonary hypertension, and cor pulmonale.

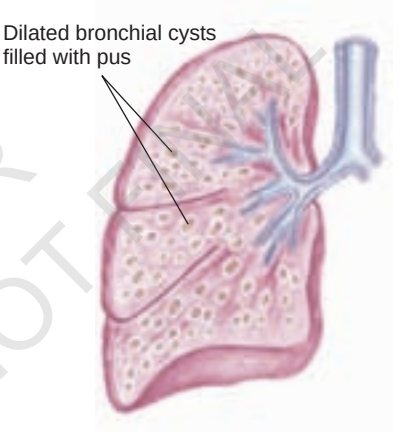


FIGURE 13-39
Cystic fibrosis. *(Modified from Wilson and Thompson, 1990.)*

EPIGLOTTITIS

An acute, life-threatening infection involving the epiglottis and surrounding tissues (Fig. 13-40, *A*).

Pathophysiology

- While immunization against Haemophilus influenza type B has greatly reduced the incidence in this country, its gravity and its occurrence worldwide mandates the attention we give it

Subjective Data

- Begins suddenly and progresses rapidly without cough, often to full obstruction of the airway and can result in death
- May occur at any age but occurs most often in children between the ages of 3 and 7

Objective Data

- Child sits straight up with neck extended and head held forward, appearing very anxious and ill, unable to swallow, and drooling from an open mouth.
- High fever with beefy red epiglottis

CROUP

A syndrome that generally results from infection with a variety of viral agents, particularly the parainfluenza viruses occurring most often in children from about 1½ to 3 years of age.

Pathophysiology

- The inflammation is subglottic and may involve areas beyond the larynx (laryngotracheobronchitis) (see Fig. 13-40, *B*).
- An aspirated foreign body may mimic croup on occasion.

Subjective Data

- An episode frequently begins in the evening, often after the child has gone to sleep.
- The child awakens suddenly, often very frightened, with a harsh, barklike cough.

Objective Data

- Labored breathing, retraction, hoarseness, and inspiratory stridor are characteristic.
- Fever does not always accompany croup. The child does not have the toxic, drooling facies of persons with epiglottitis.

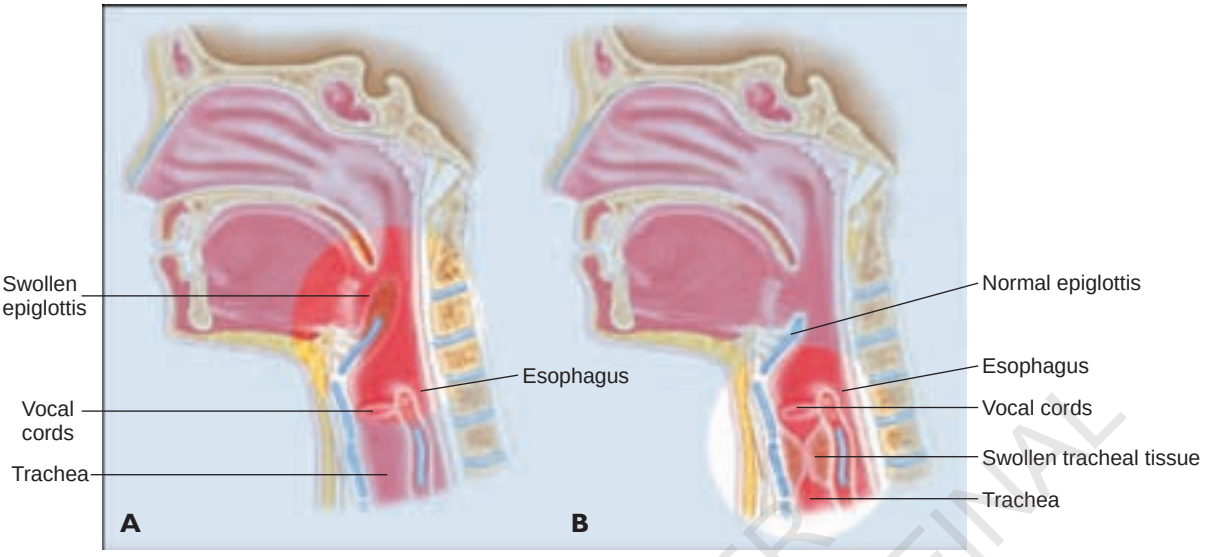


FIGURE 13-40
Croup syndrome. **A,** Acute epiglottitis. **B,** Laryngotracheobronchitis.

TRACHEOMALACIA

A lack of rigidity or a floppiness of the trachea or airway.

Pathophysiology
- Trachea to change in response to the varying pressures of inspiration and expiration.
- Tends to be benign and self-limited with increasing age
- Need to eliminate the possibilities of fixed lesions (e.g., a vascular lesion), tracheal stenosis, or even a foreign body.

Subjective Data
- "Noisy breathing" or wheezing in infancy is often inspiratory stridor.

Objective Data
- Stridor, wheezing, and findings of respiratory distress develop with airway collapse or severe compromise.

BRONCHIOLITIS

Bronchiolar (small airway) inflammation leading to hyperinflation of the lungs occurring most often in infants younger than 6 months.

Pathophysiology
- Usual cause is respiratory syncytial virus.

Subjective Data
- Expiration becomes difficult, and the infant appears anxious and tachypneic.

Objective Data
- Breaths are rapid and short with generalized retractions and perioral cyanosis developing.
- Lung hyperinflation leads to an increased AP diameter of the thoracic cage and hyperresonant percussion.

OLDER ADULTS

CHRONIC OBSTRUCTIVE PULMONARY DISEASE

COPD is a nonspecific designation that includes a group of respiratory problems in which coughs, chronic and often excessive sputum production, and dyspnea are prominent features. Ultimately, an irreversible expiratory airflow obstruction occurs. Chronic bronchitis, bronchiectasis, and emphysema are the main conditions that are included in this group. One need not

be an older adult, of course, to have one of these problems. Most patients, however, are certainly not young, and most patients have been smokers. A careful history will reveal a legacy of episodes of coughs and sputum and limited tolerance for exercise.

EMPHYSEMA

A condition in which the lungs lose elasticity and alveoli enlarge in a way that disrupts function (Fig. 13-41).

Pathophysiology

- Most patients have an extensive smoking history.
- Chronic bronchitis is a common precursor leading to dilation of the air spaces beyond the terminal bronchioles and rupture of alveolar walls, permanently hyperinflating the lung.
- Alveolar gas is trapped, essentially in expiration, and gas exchange is seriously compromised.

Subjective Data

- Dyspnea is common even at rest, requiring supplemental oxygen when severe.
- Cough is infrequent without much production of sputum.

Objective Data

- Chest may be barrel shaped, and scattered crackles or wheezes may be heard.
- Overinflated lungs are hyperresonant on percussion.
- Inspiration is limited with a prolonged expiratory effort (i.e., longer than 4 or 5 onds) to expel air.

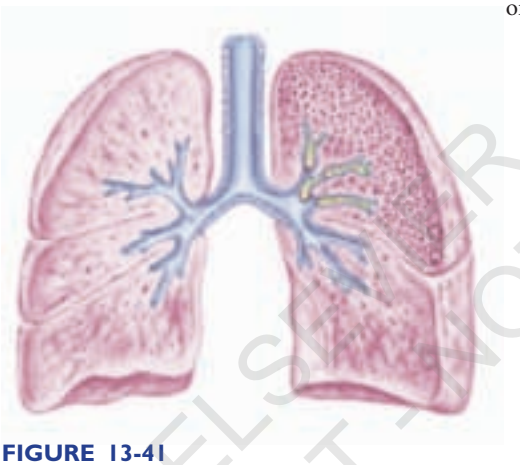


FIGURE 13-41
Chronic obstructive pulmonary disease with lobar emphysema. *(Modified from Wilson and Thompson, 1990.)*

BRONCHIECTASIS

Chronic dilation of the bronchi or bronchioles is caused by repeated pulmonary infections and bronchial obstruction (Fig. 13-42).

Pathophysiology

- Frequently seen in cystic fibrosis
- Malfunction of bronchial muscle tone and loss of elasticity

Subjective Data

- The cough and expectoration are most often the major clues.
- Severe hemoptysis may occur.

Objective Data

- Tachypnea and clubbing
- Crackles and rhonchi, sometimes disappearing after cough

FIGURE 13-42
Bronchiectasis. *(Modified from Wilson and Thompson, 1990.)*

CHRONIC BRONCHITIS

Large airway inflammation, usually a result of chronic irritant exposure, is more commonly a problem for patients older than 40.

Pathophysiology

- Large airways are chronically inflamed, leading to mucus production.
- Smoking is prominent in the history with many of these patients being emphysematous.
- Recurrent bacterial infections are common.

Subjective Data

- Dyspnea may be present although not severe.
- Cough and sputum production are impressive.

Objective Data

- Wheezing and crackles
- Hyperinflation with decreased breath sounds and a flattened diaphragm
- Severe chronic bronchitis may result in right ventricular failure with dependent edema.