ANATOMY AND PHYSIOLOGY

Study the anatomy of the chest wall, identifying the structures illustrated. Note that an interspace between two ribs is numbered by the rib above it.

- Manubrium of sternum
- Body of sternum
- Suprasternal notch
- Sternal angle
- 2nd rib
- 2nd rib interspace
- 2nd costal cartilage
- Cardiac notch of left lung
- Costochondral junctions
- Xyphoid process
- Costal angle
**Locating Findings on the Chest.** Describe abnormalities of the chest in two dimensions: along the vertical axis and around the circumference of the chest.

To make vertical locations, you must be able to count the ribs and interspaces. The sternal angle, also termed the angle of Louis, is the best guide: place your finger in the hollow curve of the suprasternal notch, then move your finger down about 5 cm to the horizontal bony ridge joining the manubrium to the body of the sternum. Then move your finger laterally and find the adjacent 2nd rib and costal cartilage. From here, using two fingers, you can “walk down the interspaces,” one space at a time, on an oblique line illustrated by the red numbers below. Do not try to count interspaces along the lower edge of the sternum; the ribs there are too close together. In a woman, to find the interspaces either displace the breast laterally or palpate a little more medially than illustrated. Avoid pressing too hard on tender breast tissue.

Note that the costal cartilages of the first seven ribs articulate with the sternum; the cartilages of the 8th, 9th, and 10th ribs articulate with the costal cartilages just above them. The 11th and 12th ribs, the “floating ribs,” have no anterior attachments. The cartilaginous tip of the 11th rib can usually be felt laterally, and the 12th rib may be felt posteriorly. On palpation, costal cartilages and ribs feel identical.
Posteriorly, the 12th rib is another possible starting point for counting ribs and interspaces: it helps locate findings on the lower posterior chest and provides an option when the anterior approach is unsatisfactory. With the fingers of one hand, press in and up against the lower border of the 12th rib, then “walk up” the interspaces numbered in red below, or follow a more oblique line up and around to the front of the chest.

The inferior tip of the scapula is another useful bony marker—it usually lies at the level of the 7th rib or interspace.

The spinous processes of the vertebrae are also useful anatomic landmarks. When the neck is flexed forward, the most protruding process is usually the vertebra of C7. If two processes are equally prominent, they are C7 and T1. You can often palpate and count the processes below them, especially when the spine is flexed.

To locate findings around the circumference of the chest, use a series of vertical lines, shown in the next three illustrations. The midsternal and vertebral lines are precise; the others are estimated. The midclavicular line drops vertically from the midpoint of the clavicle. To find it, you must identify both ends of the clavicle accurately (see p. 469). The anterior and posterior axillary lines drop vertically from the anterior and posterior axillary folds, the muscle masses that border the axilla. The midaxillary line drops from the apex of the axilla.
Lungs, Fissures, and Lobes. The lungs and their fissures and lobes can be mentally pictured on the chest wall. Anteriorly, the apex of each lung rises about 2 cm to 4 cm above the inner third of the clavicle. The lower border of the lung crosses the 6th rib at the midclavicular line and the 8th rib at the midaxillary line. (Because ribs slant, a fairly horizontal line can drop a rib or more as it passes across the chest.) Posteriorly, the lower border of the lung lies at about the level of the T10 spinous process. On inspiration, it descends farther.

Each lung is divided roughly in half by an oblique (major) fissure. This fissure may be approximated by a string that runs from the T3 spinous process...
obliquely down and around the chest to the 6th rib at the midclavicular line. The right lung is further divided by the horizontal (minor) fissure. Anteriorly, this fissure runs close to the 4th rib and meets the oblique fissure in the midaxillary line near the 5th rib.

The right lung is thus divided into upper, middle, and lower lobes. The left lung has only two lobes, upper and lower.
**Locations on the Chest.** Be familiar with general anatomic terms used to locate chest findings, such as:

- Supraclavicular—above the clavicles
- Infraclavicular—below the clavicles
- Interscapular—between the scapulae
- Infrascapular—below the scapula
- Bases of the lungs—the lowermost portions
- Upper, middle, and lower lung fields

You may then infer what part(s) of the lung(s) are affected by an abnormal process. Signs in the right upper lung field, for example, almost certainly originate in the right upper lobe. Signs in the right middle lung field laterally, however, could come from any of three different lobes.

**The Trachea and Major Bronchi.** Breath sounds over the trachea and bronchi have a different quality than breath sounds over the lung parenchyma. Be sure you know the location of these structures. The trachea bifurcates into its mainstem bronchi at the levels of the sternal angle anteriorly and the T4 spinous process posteriorly.

**The Pleurae.** The pleurae are serous membranes that cover the outer surface of each lung, the *visceral pleura*, and also line the inner rib cage and upper surface of the diaphragm, the *parietal pleura*. Their smooth opposing surfaces, lubricated by pleural fluid, allow the lungs to move easily within the rib cage during inspiration and expiration. The *pleural space* is the potential space between visceral and parietal pleurae.
Breathing. Breathing is largely an automatic act, controlled in the brainstem and mediated by the muscles of respiration. The dome-shaped diaphragm is the primary muscle of inspiration. When it contracts, it descends in the chest and enlarges the thoracic cavity. At the same time it compresses the abdominal contents, pushing the abdominal wall outward. Muscles in the rib cage and neck expand the thorax during inspiration, especially the parasternals, which run obliquely from sternum to ribs, and the scalenes, which run from the cervical vertebrae to the first two ribs.

During inspiration, as these muscles contract, the thorax expands. Intra-thoracic pressure decreases, drawing air through the tracheobronchial tree into the alveoli, or distal air sacs, and expanding the lungs. Oxygen diffuses into the blood of adjacent pulmonary capillaries, and carbon dioxide diffuses from the blood into the alveoli.

After inspiratory effort stops, the expiratory phase begins. The chest wall and lungs recoil, the diaphragm relaxes and rises passively, air flows outward, and the chest and abdomen return to their resting positions.

Normal breathing is quiet and easy—barely audible near the open mouth as a faint whish. When a healthy person lies supine, the breathing movements of the thorax are relatively slight. In contrast, the abdominal movements are usually easy to see. In the sitting position, movements of the thorax become more prominent.

During exercise and in certain diseases, extra work is required to breathe, and accessory muscles join the inspiratory effort. The sternomastoids are the most important of these, and the scalenes may become visible. Abdominal muscles assist in expiration.
As people age, their capacity for exercise decreases. The chest wall becomes stiffer and harder to move, respiratory muscles may weaken, and the lungs lose some of their elastic recoil. The speed of breathing out with maximal effort gradually diminishes. Skeletal changes associated with aging may accentuate the dorsal curve of the thoracic spine, producing kyphosis and increasing the anteroposterior diameter of the chest. The resulting “barrel chest,” however, has little effect on function.

Complaints of chest pain or chest discomfort raise the specter of heart disease, but often arise from structures in the thorax and lung as well. To assess this symptom, you must pursue a dual investigation of both thoracic and cardiac causes. Sources of chest pain are listed below. For this important symptom, you must keep all of these in mind.

- The myocardium
- The pericardium
- The aorta
- The trachea and large bronchi
- The parietal pleura
- The chest wall, including the musculoskeletal system and skin
- The esophagus
- Extrathoracic structures such as the neck, gallbladder, and stomach.

This section focuses on pulmonary complaints, including general questions about chest symptoms, dyspnea, wheezing, cough, and hemoptyis. For
health history questions about exertional chest pain, palpitations, orthopnea, paroxysmal nocturnal dyspnea, and edema, see Chapter 7, The Cardiovascular System.

Your initial questions should be as broad as possible. “Do you have any discomfort or unpleasant feelings in your chest?” As you proceed to the full history, ask the patient to point to where the pain is in the chest. Watch for any gestures as the patient describes the pain. You should elicit all seven attributes of this symptom (see p. 27) to distinguish among the various causes of chest pain.

Lung tissue itself has no pain fibers. Pain in lung conditions such as pneumonia or pulmonary infarction usually arises from inflammation of the adjacent parietal pleura. Muscle strain from prolonged recurrent coughing may also be responsible. The pericardium also has few pain fibers—the pain of pericarditis stems from inflammation of the adjacent parietal pleura. (Chest pain is commonly associated with anxiety, too, but the mechanism remains obscure.)

Dyspnea is a nonpainful but uncomfortable awareness of breathing that is inappropriate to the level of exertion. This serious symptom warrants a full explanation and assessment, since dyspnea commonly results from cardiac or pulmonary disease.

Ask “Have you had any difficulty breathing?” Find out when the symptom occurs, at rest or with exercise, and how much effort produces onset. Because of variations in age, body weight, and physical fitness, there is no absolute scale for quantifying dyspnea. Instead, make every effort to determine its severity based on the patient’s daily activities. How many steps or flights of stairs can the patient climb before pausing for breath? What about work such as carrying bags of groceries, mopping the floor, or making the bed? Has dyspnea altered the patient’s lifestyle and daily activities? How? Carefully elicit the timing and setting of dyspnea, any associated symptoms, and relieving or aggravating factors.

Most patients with dyspnea relate shortness of breath to their level of activity. Anxious patients present a different picture. They may describe difficulty taking a deep enough breath, or a smothering sensation with inability to get enough air, along with paresthesias, or sensations of tingling or “pins and needles” around the lips or in the extremities.

Wheeze are musical respiratory sounds that may be audible both to the patient and to others.

Cough is a common symptom that ranges in significance from trivial to ominous. Typically, cough is a reflex response to stimuli that irritate re-
ceptors in the larynx, trachea, or large bronchi. These stimuli include mucus, pus, and blood, as well as external agents such as dusts, foreign bodies, or even extremely hot or cold air. Other causes include inflammation of the respiratory mucosa and pressure or tension in the air passages from a tumor or enlarged peribronchial lymph nodes. Although cough typically signals a problem in the respiratory tract, it may also be cardiovascular in origin.

For complaints of cough, a thorough assessment is in order. Ask whether the cough is dry or produces *sputum*, or phlegm. Ask the patient to describe the volume of any sputum and its color, odor, and consistency.

To help patients quantify volume, a multiple-choice question may be helpful . . . “How much do you think you cough up in 24 hours; a teaspoon, tablespoon, a quarter cup, half cup, cupful?” If possible, ask the patient to cough into a tissue; inspect the phlegm and note its characteristics. The symptoms associated with a cough often lead you to its cause.

*Hemoptysis* is the coughing up of blood from the lungs; it may vary from blood-streaked phlegm to frank blood. For patients reporting hemoptysis, assess the volume of blood produced as well as the other sputum attributes; ask about the related setting and activity and any associated symptoms.

Before using the term “hemoptysis,” try to confirm the source of the bleeding by both history and physical examination. Blood or blood-streaked material may originate in the mouth, pharynx, or gastrointestinal tract and is easily mislabeled. When vomited, it probably originates in the gastrointestinal tract. Occasionally, however, blood from the nasopharynx or the gastrointestinal tract is aspirated and then coughed out.
Despite declines in smoking over the past several decades, more than 27% of Americans age 12 and older still smoke. All adults, pregnant women, parents, and adolescents who smoke should be counseled regularly to stop smoking. Smoking has been definitively linked to significant pulmonary, cardiovascular, and neoplastic disease, and accounts for one out of every five deaths in the United States. It is considered the leading cause of preventable death. Nonsmokers exposed to smoke are also at increased risk for lung cancer, ear and respiratory infection, asthma, low birthweight, and residential fires. Smoking exposes patients not only to carcinogens, but also to nicotine, an addictive drug. Be especially alert to smoking by teenagers, the age group when tobacco use often begins, and by pregnant women, who may continue smoking during pregnancy.

The disease risks of smoking drop significantly within a year of smoking cessation. Effective interventions include targeted messages by clinicians, group counseling, and use of nicotine-replacement therapies. Clinicians are advised to adopt the four “As”:

- Ask about smoking at each visit.
- Advise patients regularly to stop smoking in a clear personalized message.
- Assist patients to set stop dates and provide educational materials for self-help.
- Arrange for follow-up visits to monitor and support progress.

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**Preview: Recording the Physical Examination—The Thorax and Lungs**

Note that initially you may use sentences to describe your findings; later you will use phrases. The style below contains phrases appropriate for most write-ups. Unfamiliar terms are explained in the next section, Techniques of Examination.

“Thorax is symmetric with good expansion. Lungs resonant. Breath sounds vesicular; no rales, wheezes, or rhonchi. Diaphragms descend 4 cm bilaterally.”

**OR**

“Thorax symmetric with moderate kyphosis and increased anteroposterior (AP) diameter, decreased expansion. Lungs are hyperresonant. Breath sounds distant with delayed expiratory phase and scattered expiratory wheezes. Fremitus decreased; no bronchophony, egophony, or whispered pectoriloquy. Diaphragms descend 2 cm bilaterally.”

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Combining clinician and group counseling with nicotine replacement therapy is especially effective for highly addicted patients.

Relapses are common and should be expected. Nicotine withdrawal, weight gain, stress, social pressure, and use of alcohol are often cited as explanations. Help patients to learn from these experiences: work with the patient to pinpoint the precipitating circumstances and develop strategies for alternative responses and health-promoting behaviors.

It is helpful to examine the posterior thorax and lungs while the patient is sitting, and the anterior thorax and lungs with the patient supine. Proceed in an orderly fashion: inspect, palpate, percuss, and auscultate. Try to visualize the underlying lobes, and compare one side with the other, so the patient serves as his or her own control. Arrange the patient’s gown so that you can see the chest fully. For women, drape the gown over each half of the anterior chest as you examine the other half. Cover the woman’s anterior chest when you examine the back.

With the patient sitting, examine the posterior thorax and lungs. The patient’s arms should be folded across the chest with hands resting, if possible, on the opposite shoulders. This position moves the scapulae partly out of the way and increases your access to the lung fields. Then ask the patient to lie down.

With the patient supine, examine the anterior thorax and lungs. The supine position makes it easier to examine women because the breasts can be gently displaced. Furthermore, wheezes, if present, are more likely to be heard. (Some authorities, however, prefer to examine both the back and the front of the chest with the patient sitting. This technique is also satisfactory).

For patients unable to sit up without aid, try to get help so that you can examine the posterior chest in the sitting position. If this is impossible, roll the patient to one side and then to the other. Percuss the upper lung, and auscultate both lungs in each position. Because ventilation is relatively greater in the dependent lung, your chances of hearing wheezes or crackles are greater on the dependent side.

Initial Survey of Respiration and the Thorax

Even though you may have already recorded the respiratory rate when you took the vital signs, it is wise to again observe the rate, rhythm, depth, and effort of breathing. A normal resting adult breathes quietly and regularly about
14 to 20 times a minute. An occasional sigh is to be expected. Note whether expiration lasts longer than usual. 

*Always inspect the patient for any signs of respiratory difficulty.*

- **Assess the patient’s color** for cyanosis. Recall any relevant findings from earlier parts of your examination, such as the shape of the fingernails.

- **Listen to the patient’s breathing.** Is there any **audible wheezing**? If so, where does it fall in the respiratory cycle?

- **Inspect the neck.** During inspiration, is there contraction of the sternomastoid or other accessory muscles, or supraclavicular retraction? Is the trachea midline?

Also **observe the shape of the chest.** The anteroposterior (AP) diameter may increase with aging.

## Examination of the Posterior Chest

### INSPECTION

From a midline position behind the patient, note the **shape of the chest** and the **way in which it moves**, including:

- **Deformities or asymmetry**

- **Abnormal retraction of the interspaces during inspiration.** Retraction is most apparent in the lower interspaces. Supraclavicular retraction is often associated.

- **Impaired respiratory movement on one or both sides or a unilateral lag (or delay) in movement.**

### PALPATION

As you palpate the chest, focus on areas of tenderness and abnormalities in the overlying skin, respiratory expansion, and fremitus.

**Identify tender areas.** Carefully palpate any area where pain has been reported or where lesions or bruises are evident.

- **Cyanosis signals hypoxia.** Clubbing of the nails (see p. 110) in chronic obstructive pulmonary disease (COPD) or congenital heart disease

- **Audible stridor, a high-pitched wheeze,** is an ominous sign of airway obstruction in the larynx or trachea.

- **Inspiratory contraction of the sternomastoids at rest signals severe difficulty breathing.** Lateral displacement of the trachea in pneumothorax, pleural effusion, or atelectasis

- **The AP diameter also may increase in COPD.**

See Table 6-4, **Deformities of the Thorax** (p. 239).

- **Retraction in severe asthma, COPD, or upper airway obstruction.**

- **Unilateral impairment or lagging of respiratory movement suggests disease of the underlying lung or pleura.**

- **Intercostal tenderness over inflamed pleura**

- **Bruises over a fractured rib**
Assess any observed abnormalities such as masses or sinus tracts (blind, inflammatory, tubelike structures opening onto the skin).

Test chest expansion. Place your thumbs at about the level of the 10th ribs, with your fingers loosely grasping and parallel to the lateral rib cage. As you position your hands, slide them medially just enough to raise a loose fold of skin on each side between your thumb and the spine.

Ask the patient to inhale deeply. Watch the distance between your thumbs as they move apart during inspiration, and feel for the range and symmetry of the rib cage as it expands and contracts.

Feel for tactile fremitus. Fremitus refers to the palpable vibrations transmitted through the bronchopulmonary tree to the chest wall when the patient speaks. To detect fremitus, use either the ball (the bony part of the palm at the base of the fingers) or the ulnar surface of your hand to optimize the vibratory sensitivity of the bones in your hand. Ask the patient to repeat the words “ninety-nine” or “one-one-one.” If fremitus is faint, ask the patient to speak more loudly or in a deeper voice.

Use one hand until you have learned the feel of fremitus. Some clinicians find using one hand more accurate. The simultaneous use of both hands to compare sides, however, increases your speed and may facilitate detection of differences.

Causes of unilateral decrease or delay in chest expansion include chronic fibrotic disease of the underlying lung or pleura, pleural effusion, lobar pneumonia, pleural pain with associated splinting, and unilateral bronchial obstruction.

Fremitus is decreased or absent when the voice is soft or when the transmission of vibrations from the larynx to the surface of the chest is impeded. Causes include an obstructed bronchus; COPD; separation of the pleural surfaces by fluid (pleural effusion), fibrosis (pleural thickening), air (pneumothorax), or an infiltrating tumor; and also a very thick chest wall.

Although rare, sinus tracts usually indicate infection of the underlying pleura and lung (as in tuberculosis, actinomycosis).
Palpate and compare symmetric areas of the lungs in the pattern shown in the photograph. Identify and locate any areas of increased, decreased, or absent fremitus. Fremitus is typically more prominent in the interscapular area than in the lower lung fields, and is often more prominent on the right side than on the left. It disappears below the diaphragm.

Tactile fremitus is a relatively rough assessment tool, but as a scouting technique it directs your attention to possible abnormalities. Later in the examination you will check any suggested findings by listening for breath sounds, voice sounds, and whispered voice sounds. All these attributes tend to increase or decrease together.

PERCUSSION

Percussion is one of the most important techniques of physical examination. Percussion of the chest sets the chest wall and underlying tissues into motion, producing audible sound and palpable vibrations. Percussion helps you establish whether the underlying tissues are air-filled, fluid-filled, or solid. It penetrates only about 5 cm to 7 cm into the chest, however, and therefore will not help you to detect deep-seated lesions.

The technique of percussion can be practiced on any surface. As you practice, listen for changes in percussion notes over different types of materials or different parts of the body. The key points for good technique, described for a right-handed person, are as follows:

- Hyperextend the middle finger of your left hand, known as the pleximeter finger. Press its distal interphalangeal joint firmly on the surface to be percussed. Avoid surface contact by any other part of the hand, because this dampens out vibrations. Note that the thumb, 2nd, 4th, and 5th fingers are not touching the chest.

- Position your right forearm quite close to the surface, with the hand cocked upward. The middle finger should be partially flexed, relaxed, and poised to strike.
With a quick sharp but relaxed wrist motion, strike the pleximeter finger with the right middle finger, or plexor finger. Aim at your distal interphalangeal joint. You are trying to transmit vibrations through the bones of this joint to the underlying chest wall.

Strike using the tip of the plexor finger, not the finger pad. Your finger should be almost at right angles to the pleximeter. A short fingernail is recommended to avoid self-injury.

Withdraw your striking finger quickly to avoid damping the vibrations you have created.

In summary, the movement is at the wrist. It is directed, brisk yet relaxed, and a bit bouncy.

**Percussion Notes.** With your plexor or tapping finger, use the lightest percussion that produces a clear note. A thick chest wall requires heavier percussion than a thin one. However, if a louder note is needed, apply more pressure with the pleximeter finger (this is more effective for increasing percussion note volume than tapping harder with the plexor finger).

When percussing the lower posterior chest, stand somewhat to the side rather than directly behind the patient. This allows you to place your pleximeter finger more firmly on the chest and your plexor is more effective, making a better percussion note.

When comparing two areas, use the same percussion technique in both areas. Percuss or strike twice in each location. It is easier to detect differences in percussion notes by comparing one area with another than by striking repetitively in one place.
Learn to identify five percussion notes. You can practice four of them on yourself. These notes differ in their basic qualities of sound: intensity, pitch, and duration. Train your ear to distinguish these differences by concentrating on one quality at a time as you percuss first in one location, then in another. Review the table below. Normal lungs are resonant.

<table>
<thead>
<tr>
<th>Percussion Notes and Their Characteristics</th>
<th>Relative Intensity</th>
<th>Relative Pitch</th>
<th>Relative Duration</th>
<th>Example of Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flatness</td>
<td>Soft</td>
<td>High</td>
<td>Short</td>
<td>Thigh</td>
</tr>
<tr>
<td>Dullness</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Liver</td>
</tr>
<tr>
<td>Resonance</td>
<td>Loud</td>
<td>Low</td>
<td>Long</td>
<td>Normal lung</td>
</tr>
<tr>
<td>Hyperresonance</td>
<td>Very loud</td>
<td>Lower</td>
<td>Longer</td>
<td>None normally</td>
</tr>
<tr>
<td>Tympany</td>
<td>Loud</td>
<td>High*</td>
<td>*</td>
<td>Gastric air bubble or puffed-out cheek</td>
</tr>
</tbody>
</table>

* Distinguished mainly by its musical timbre.

While the patient keeps both arms crossed in front of the chest, percuss the thorax in symmetric locations from the apices to the lung bases.

Percuss one side of the chest and then the other at each level, as shown by the numbers below. Omit the areas over the scapulae—the thickness of muscle and bone alters the percussion notes over the lungs. Identify and locate the area and quality of any abnormal percussion note.

Dullness replaces resonance when fluid or solid tissue replaces air-containing lung or occupies the pleural space beneath your percussing fingers. Examples include: lobar pneumonia, in which the alveoli are filled with fluid and blood cells; and pleural accumulations of serous fluid (pleural effusion), blood (hemothorax), pus (empyema), fibrous tissue, or tumor.

Generalized hyperresonance may be heard over the hyperinflated lungs of emphysema or asthma, but it is not a reliable sign. Unilateral hyperresonance suggests a large pneumothorax or possibly a large air-filled bulla in the lung.
Identify the descent of the diaphragms, or diaphragmatic excursion. First, determine the level of diaphragmatic dullness during quiet respiration. Holding the pleximeter finger above and parallel to the expected level of dullness, percuss downward in progressive steps until dullness clearly replaces resonance. Confirm this level of change by percussion near the middle of the hemithorax and also more laterally.

Note that with this technique you are identifying the boundary between the resonant lung tissue and the duller structures below the diaphragm. You are not percussing the diaphragm itself. You can infer the probable location of the diaphragm from the level of dullness.

Now, estimate the extent of diaphragmatic excursion by determining the distance between the level of dullness on full expiration and the level of dullness on full inspiration, normally about 5 cm or 6 cm. This estimate does not correlate well, however, with radiologic assessment of diaphragmatic movement.

Auscultation

Auscultation of the lungs is the most important examining technique for assessing air flow through the tracheobronchial tree. Together with percussion, it also helps the clinician to assess the condition of the surrounding lungs and pleural space. Auscultation involves (1) listening to the sounds generated by breathing, (2) listening for any adventitious (added) sounds, and (3) if abnormalities are suspected, listening to the sounds of the patient’s spoken or whispered voice as they are transmitted through the chest wall.

Breath Sounds (Lung Sounds). You will learn to identify patterns of breath sounds by their intensity, their pitch, and the relative duration of their inspiratory and expiratory phases. Normal breath sounds are:

- Sounds from bedclothes, paper gowns, and the chest itself can generate confusion in auscultation. Hair on the chest may cause cracking sounds. Either press harder or wet the hair. If the patient is cold or tense, you may hear muscle contraction sounds—muffled, low-pitched rumbling or roaring noises. A change in the patient’s position may eliminate this noise. You can
TECHNIQUES OF EXAMINATION

- **Vesicular**, or soft and low pitched. They are heard through inspiration, continue without pause through expiration, and then fade away about one third of the way through expiration.

- **Bronchovesicular**, with inspiratory and expiratory sounds about equal in length, at times separated by a silent interval. Differences in pitch and intensity are often more easily detected during expiration.

- **Bronchial**, or louder and higher in pitch, with a short silence between inspiratory and expiratory sounds. Expiratory sounds last longer than inspiratory sounds.

The characteristics of these three kinds of breath sounds are summarized in the table below. Also shown are the *tracheal* breath sounds—very loud, harsh sounds that are heard by listening over the trachea in the neck.

### Characteristics of Breath Sounds

<table>
<thead>
<tr>
<th>Duration of Sounds</th>
<th>Intensity of Expiratory Sound</th>
<th>Pitch of Expiratory Sound</th>
<th>Locations Where Heard Normally</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicular</td>
<td>Inspiratory sounds last longer than expiratory ones.</td>
<td>Soft</td>
<td>Over most of both lungs</td>
</tr>
<tr>
<td>Bronchovesicular</td>
<td>Inspiratory and expiratory sounds are about equal.</td>
<td>Intermediate</td>
<td>Often in the 1st and 2nd interspaces anteriorly and between the scapulae</td>
</tr>
<tr>
<td>Bronchial</td>
<td>Expiratory sounds last longer than inspiratory ones.</td>
<td>Loud</td>
<td>Over the manubrium, if heard at all</td>
</tr>
<tr>
<td>Tracheal</td>
<td>Inspiratory and expiratory sounds are about equal.</td>
<td>Very loud</td>
<td>Over the trachea in the neck</td>
</tr>
</tbody>
</table>

*The thickness of the bars indicates intensity; the steeper their incline, the higher the pitch.*

Listen to the breath sounds with the diaphragm of a stethoscope after instructing the patient to breathe deeply through an open mouth. Use the pattern suggested for percussion, moving from one side to the other and comparing symmetric areas of the lungs. If you hear or suspect abnormal sounds, auscultate adjacent areas so that you can fully describe the extent of any abnormality. Listen to at least one full breath in each location. Be alert for patient discomfort due to hyperventilation (e.g., light headedness, faintness), and allow the patient to rest as needed.

EXAMPLES OF ABNORMALITIES

reproduce this sound on yourself by doing a Valsalva maneuver (straining down) as you listen to your own chest.

If bronchovesicular or bronchial breath sounds are heard in locations distant from those listed, suspect that air-filled lung has been replaced by fluid-filled or solid lung tissue. See Table 6-5, Normal and Altered Breath and Voice Sounds (p. 240).
Note the *intensity* of the breath sounds. Breath sounds are usually louder in the lower posterior lung fields and may also vary from area to area. If the breath sounds seem faint, ask the patient to breathe more deeply. You may then hear them easily. When patients do not breathe deeply enough or when they have a thick chest wall, as in obesity, breath sounds may remain diminished.

Is there a *silent gap* between the inspiratory and expiratory sounds?

Listen for the *pitch, intensity, and duration of the expiratory and inspiratory sounds*. Are vesicular breath sounds distributed normally over the chest wall? Or are there bronchovesicular or bronchial breath sounds in unexpected places? If so, where are they?

**Adventitious (Added) Sounds.** Listen for any added, or adventitious, sounds that are superimposed on the usual breath sounds. Detection of adventitious sounds—*crackles* (sometimes called *rales*), *wheezes*, and *rhonchi*—is an important part of your examination, often leading to diagnosis of cardiac and pulmonary conditions. The most common kinds of these sounds are described below:

### Adventitious Lung Sounds

**DISCONTINUOUS SOUNDS** (CRACKLES OR RALES) are intermittent, nonmusical, and brief—like dots in time.

- **Fine crackles** (\(\cdots\)) are soft, high pitched, and very brief (5–10 msec).
- **Coarse crackles** (\(\cdots\cdots\)) are somewhat louder, lower in pitch, and not quite so brief (20–30 msec).

**CONTINUOUS SOUNDS** are > 250 msec, notably longer than crackles—like dashes in time—but do not necessarily persist throughout the respiratory cycle. Unlike crackles, they are musical.

- **Wheezes** (\(\cdots\cdots\cdots\)) are relatively high pitched (around 400 Hz or higher) and have a hissing or shrill quality.
- **Rhonchi** (\(\cdots\cdots\cdots\cdots\)) are relatively low pitched (around 200 Hz or lower) and have a snoring quality.

If you hear *crackles*, especially those that do not clear after cough, listen carefully for the following characteristics. These are clues to the underlying condition:

- Loudness, pitch, and duration (summarized as fine or coarse crackles)
- Number (few to many)

Breath sounds may be decreased when air flow is decreased (as by obstructive lung disease or muscular weakness) or when the transmission of sound is poor (as in pleural effusion, pneumothorax, or emphysema).

A gap suggests bronchial breath sounds.

For further discussion and other added sounds, see Table 6-6, Adventitious (Added) Lung Sounds: Causes and Qualities (p. 241).

Crackles may be due to abnormalities of the lungs (pneumonia, fibrosis, early congestive heart failure) or of the airways (bronchitis, bronchiectasis).

Wheezes suggest narrowed airways, as in asthma, COPD, or bronchitis.

Rhonchi suggest secretions in large airways.

Fine late inspiratory crackles that persist from breath to breath suggest abnormal lung tissue.
EXAMPLES OF ABNORMALITIES

- Timing in the respiratory cycle
- Location on the chest wall
- Persistence of their pattern from breath to breath
- Any change after a cough or a change in the patient’s position

In some normal people, crackles may be heard at the lung bases anteriorly after maximal expiration. Crackles in dependent portions of the lungs may also occur after prolonged recumbency.

If you hear wheezes or rhonchi, note their timing and location. Do they change with deep breathing or coughing?

**Transmitted Voice Sounds.** If you hear abnormally located bronchovesicular or bronchial breath sounds, continue on to assess transmitted voice sounds. With a stethoscope, listen in symmetric areas over the chest wall as you:

- Ask the patient to say “ninety-nine.” Normally the sounds transmitted through the chest wall are muffled and indistinct.
- Ask the patient to say “ee.” You will normally hear a muffled long E sound.
- Ask the patient to whisper “ninety-nine” or “one-two-three.” The whispered voice is normally heard faintly and indistinctly, if at all.

**Examination of the Anterior Chest**

The patient, when examined in the supine position, should lie comfortably with arms somewhat abducted. A patient who is having difficulty breathing should be examined in the sitting position or with the head of the bed elevated to a comfortable level.

Clearing of crackles, wheezes, or rhonchi after cough suggests that secretions caused them, as in bronchitis or atelectasis.

Increased transmission of voice sounds suggests that air-filled lung has become airless. See Table 6-5, Normal and Altered Breath and Voice Sounds (p. 240).

Louder, clearer voice sounds are called bronchophony.

When “ee” is heard as “ay,” an E-to-A change (egophony) is present, as in lobar consolidation from pneumonia. The quality sounds nasal.

Louder, clearer whispered sounds are called whispered pectoriloquy.

Persons with severe COPD may prefer to sit leaning forward, with lips pursed during exhalation and arms supported on their knees or a table.
TECHNIQUES OF EXAMINATION

EXAMPLES OF ABNORMALITIES

INSPECTION

Observe the shape of the patient’s chest and the movement of the chest wall. Note:

■ Deformities or asymmetry

■ Abnormal retraction of the lower interspaces during inspiration

■ Local lag or impairment in respiratory movement

PALPATION

Palpation has four potential uses:

■ Identification of tender areas

■ Assessment of observed abnormalities

■ Assessment of chest expansion. Place your thumbs along each costal margin, your hands along the lateral rib cage. As you position your hands, slide them medially a bit to raise loose skin folds between your thumbs. Ask the patient to inhale deeply. Observe how far your thumbs diverge as the thorax expands, and feel for the extent and symmetry of respiratory movement.

See Table 6-4, Deformities of the Thorax (p. 239).

Severe asthma, COPD, or upper airway obstruction

Underlying disease of lung or pleura

Tender pectoral muscles or costal cartilages tend to corroborate, but do not prove, that chest pain has a musculoskeletal origin.

Assessment of tactile fremitus. Compare both sides of the chest, using the ball or ulnar surface of your hand. Fremitus is usually decreased or absent over the precordium. When examining a woman, gently displace the breasts as necessary.
PERCUSSION

Percuss the anterior and lateral chest, again comparing both sides. The heart normally produces an area of dullness to the left of the sternum from the 3rd to the 5th interspaces. Percuss the left lung lateral to it.

Dullness replaces resonance when fluid or solid tissue replaces air-containing lung or occupies the pleural space. Because pleural fluid usually sinks to the lowest part of the pleural space (posteriorly in a supine patient), only a very large effusion can be detected anteriorly.

The hyperresonance of COPD may totally replace cardiac dullness.
In a woman, to enhance percussion, gently displace the breast with your left hand while percussing with the right.

Alternatively, you may ask the patient to move her breast for you.

Identify and locate any area of abnormal percussion note.

With your pleximeter finger above and parallel to the expected upper border of liver dullness, percuss in progressive steps downward in the right mid-clavicular line. Identify the upper border of liver dullness. Later, during the abdominal examination, you will use this method to estimate the size of the liver. As you percuss down the chest on the left, the resonance of normal lung usually changes to the tympany of the gastric air bubble.

The dullness of right middle lobe pneumonia typically occurs behind the right breast. Unless you displace the breast, you may miss the abnormal percussion note.

A lung affected by COPD often displaces the upper border of the liver downward. It also lowers the level of diaphragmatic dullness posteriorly.
AUSCULTATION

Listen to the chest anteriorly and laterally as the patient breathes with mouth open, somewhat more deeply than normal. Compare symmetric areas of the lungs, using the pattern suggested for percussion and extending it to adjacent areas as indicated.

*Listen to the breath sounds,* noting their intensity and identifying any variations from normal vesicular breathing. Breath sounds are usually louder in the upper anterior lung fields. Bronchovesicular breath sounds may be heard over the large airways, especially on the right.

*Identify any adventitious sounds,* time them in the respiratory cycle, and locate them on the chest wall. Do they clear with deep breathing?

If indicated, *listen for transmitted voice sounds.*

**Special Techniques**

**Clinical Assessment of Pulmonary Function.** A simple but informative way to assess the complaint of breathlessness in an ambulatory patient is to walk with the patient down the hall or climb one flight of stairs. Observe the rate, effort, and sound of the patient’s breathing.

**Forced Expiratory Time.** This test assesses the expiratory phase of breathing, which is typically slowed in obstructive pulmonary disease. Ask the patient to take a deep breath in and then breathe out as quickly and completely as possible with mouth open. Listen over the trachea with the diaphragm of a stethoscope and time the audible expiration. Try to get three consistent readings, allowing a short rest between efforts if necessary.

**Identification of a Fractured Rib.** Local pain and tenderness of one or more ribs raise the question of fracture. By anteroposterior compression of the chest, you can help to distinguish a fracture from soft-tissue injury. With one hand on the sternum and the other on the thoracic spine, squeeze the chest. Is this painful, and where?

See Table 6-6, Adventitious (Added) Lung Sounds: Causes and Qualities (p. 241), and Table 6-7, Physical Findings in Selected Chest Disorders (pp. 242–243).

If the patient understands and cooperates in performing the test, a forced expiration time of 6 or more seconds suggests obstructive pulmonary disease.

An increase in the local pain (distant from your hands) suggests rib fracture rather than just soft tissue injury.
### TABLE 6-1  Chest Pain

<table>
<thead>
<tr>
<th>Problem</th>
<th>Process</th>
<th>Location</th>
<th>Quality</th>
<th>Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cardiovascular</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Angina Pectoris</strong></td>
<td>Temporary myocardial ischemia, usually secondary to coronary atherosclerosis</td>
<td>Retrosternal or across the anterior chest, sometimes radiating to the shoulders, arms, neck, lower jaw, or upper abdomen</td>
<td>Pressing, squeezing, tight, heavy, occasionally burning</td>
<td>Mild to moderate, sometimes perceived as discomfort rather than pain</td>
</tr>
<tr>
<td><strong>Myocardial Infarction</strong></td>
<td>Prolonged myocardial ischemia, resulting in irreversible muscle damage or necrosis</td>
<td>Same as in angina</td>
<td>Same as in angina</td>
<td>Often but not always a severe pain</td>
</tr>
<tr>
<td><strong>Pericarditis</strong></td>
<td>Irritation of parietal pleura adjacent to the pericardium</td>
<td>Precordial, may radiate to the tip of the shoulder and to the neck</td>
<td>Sharp, knifelike</td>
<td>Often severe</td>
</tr>
<tr>
<td><strong>Dissecting Aortic Aneurysm</strong></td>
<td>A splitting within the layers of the aortic wall, allowing passage of blood to dissect a channel</td>
<td>Retrosternal</td>
<td>Crushing</td>
<td>Severe</td>
</tr>
<tr>
<td><strong>Pulmonary Tracheobronchitis</strong></td>
<td>Inflammation of trachea and large bronchi</td>
<td>Upper sternal or on either side of the sternum</td>
<td>Burning</td>
<td>Mild to moderate</td>
</tr>
<tr>
<td><strong>Pleural Pain</strong></td>
<td>Inflammation of the parietal pleura, as from pleurisy, pneumonia, pulmonary infarction, or neoplasm</td>
<td>Chest wall overlying the process</td>
<td>Sharp, knifelike</td>
<td>Often severe</td>
</tr>
<tr>
<td><strong>Gastrointestinal and other</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Reflex Esophagitis</strong></td>
<td>Inflammation of the esophageal mucosa by reflux of gastric acid</td>
<td>Retrosternal, may radiate to the back</td>
<td>Burning, may be squeezing</td>
<td>Mild to severe</td>
</tr>
<tr>
<td><strong>Diffuse Esophageal Spasm</strong></td>
<td>Motor dysfunction of the esophageal muscle</td>
<td>Retrosternal, may radiate to the back, arms, and jaw</td>
<td>Usually squeezing</td>
<td>Mild to severe</td>
</tr>
<tr>
<td><strong>Chest Wall Pain</strong></td>
<td>Variable, often unclear</td>
<td>Often below the left breast or along the costal cartilages; also elsewhere</td>
<td>Stabbing, sticking, or dull, aching</td>
<td>Variable</td>
</tr>
<tr>
<td><strong>Anxiety</strong></td>
<td>Unclear</td>
<td>Precordial, below the left breast, or across the anterior chest</td>
<td>Stabbing, sticking, or dull, aching</td>
<td>Variable</td>
</tr>
</tbody>
</table>

Note: Remember that chest pain may be referred from extrathoracic structures such as the neck (arthritis) and abdomen (biliary colic, acute cholecystitis). Pleural pain may be due to abdominal conditions such as subdiaphragmatic abscess.
<table>
<thead>
<tr>
<th>Timing</th>
<th>Factors That Aggravate</th>
<th>Factors That Relieve</th>
<th>Associated Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usually 1–3 min but up to 10 min. Prolonged episodes up to 20 min</td>
<td>Exertion, especially in the cold; meals; emotional stress. May occur at rest</td>
<td>Rest, nitroglycerin</td>
<td>Sometimes dyspnea, nausea, sweating</td>
</tr>
<tr>
<td>20 min to several hr</td>
<td></td>
<td></td>
<td>Nausea, vomiting, sweating, weakness</td>
</tr>
<tr>
<td>Persistent</td>
<td>Breathing, changing position, coughing, lying down, sometimes swallowing</td>
<td>Sitting forward may relieve it.</td>
<td>Of the underlying illness</td>
</tr>
<tr>
<td>Persistent</td>
<td></td>
<td></td>
<td>Of the underlying illness</td>
</tr>
<tr>
<td>Abrupt onset, early peak, persistent for hours or more</td>
<td>Hypertension</td>
<td></td>
<td>Syncope, hemiplegia, paraplegia</td>
</tr>
<tr>
<td>Variable</td>
<td>Coughing</td>
<td></td>
<td>Cough</td>
</tr>
<tr>
<td>Persistent</td>
<td>Breathing, coughing, movements of the trunk</td>
<td>Lying on the involved side may relieve it.</td>
<td>Of the underlying illness</td>
</tr>
<tr>
<td>Variable</td>
<td>Large meal; bending over, lying down</td>
<td>Antacids, sometimes belching</td>
<td>Sometimes regurgitation, dysphagia</td>
</tr>
<tr>
<td>Variable</td>
<td>Swallowing of food or cold liquid; emotional stress</td>
<td>Sometimes nitroglycerin</td>
<td>Dysphagia</td>
</tr>
<tr>
<td>Fleeting to hours or days</td>
<td>Movement of chest, trunk, arms</td>
<td></td>
<td>Often local tenderness</td>
</tr>
<tr>
<td>Fleeting to hours or day</td>
<td>May follow effort, emotional stress</td>
<td></td>
<td>Breathlessness, palpitations, weakness, anxiety</td>
</tr>
<tr>
<td>Problem</td>
<td>Process</td>
<td>Timing</td>
<td></td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Left-Sided Heart Failure <em>(left ventricular failure or mitral stenosis)</em></td>
<td>Elevated pressure in pulmonary capillary bed with transudation of fluid into interstitial spaces and alveoli, decreased compliance (increased stiffness) of the lungs, increased work of breathing</td>
<td>Dyspnea may progress slowly, or suddenly as in acute pulmonary edema.</td>
<td></td>
</tr>
<tr>
<td>Chronic Bronchitis*</td>
<td>Excessive mucus production in bronchi, followed by chronic obstruction of airways</td>
<td>Chronic productive cough followed by slowly progressive dyspnea</td>
<td></td>
</tr>
<tr>
<td>Chronic Obstructive Pulmonary Disease (COPD)*</td>
<td>Overdistention of air spaces distal to terminal bronchioles, with destruction of alveolar septa and chronic obstruction of the airways</td>
<td>Slowly progressive dyspnea; relatively mild cough later</td>
<td></td>
</tr>
<tr>
<td>Asthma</td>
<td>Bronchial hyperresponsiveness involving release of inflammatory mediators, increased airway secretions, and bronchoconstriction</td>
<td>Acute episodes, separated by symptom-free periods. Nocturnal episodes are common.</td>
<td></td>
</tr>
<tr>
<td>Diffuse Interstitial Lung Diseases <em>(such as sarcoidosis, widespread neoplasms, asbestosis, and idiopathic pulmonary fibrosis)</em></td>
<td>Abnormal and widespread infiltration of cells, fluid, and collagen into interstitial spaces between alveoli. Many causes</td>
<td>Progressive dyspnea, which varies in its rate of development with the cause</td>
<td></td>
</tr>
<tr>
<td>Pneumonia</td>
<td>Inflammation of lung parenchyma from the respiratory bronchioles to the alveoli</td>
<td>An acute illness, timing varies with the causative agent</td>
<td></td>
</tr>
<tr>
<td>Spontaneous Pneumothorax</td>
<td>Leakage of air into pleural space through blebs on visceral pleura, with resulting partial or complete collapse of the lung</td>
<td>Sudden onset of dyspnea</td>
<td></td>
</tr>
<tr>
<td>Acute Pulmonary Embolism</td>
<td>Sudden occlusion of all or part of pulmonary arterial tree by a blood clot that usually originates in deep veins of legs or pelvis</td>
<td>Sudden onset of dyspnea</td>
<td></td>
</tr>
<tr>
<td>Anxiety With Hyperventilation</td>
<td>Overbreathing, with resultant respiratory alkalosis and fall in the partial pressure of carbon dioxide in the blood</td>
<td>Episodic, often recurrent</td>
<td></td>
</tr>
</tbody>
</table>

*Chronic bronchitis and chronic obstructive pulmonary disease (COPD) may coexist.
<table>
<thead>
<tr>
<th>Factors That Aggravate</th>
<th>Factors That Relieve</th>
<th>Associated Symptoms</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exertion, lying down</td>
<td>Rest, sitting up, though dyspnea may become persistent</td>
<td>Often cough, orthopnea, paroxysmal nocturnal dyspnea; sometimes wheezing</td>
<td>History of heart disease or its predisposing factors</td>
</tr>
<tr>
<td>Exertion, inhaled irritants, respiratory infections</td>
<td>Expectoration; rest, though dyspnea may become persistent</td>
<td>Chronic productive cough, recurrent respiratory infections; wheezing may develop</td>
<td>History of smoking, air pollutants, recurrent respiratory infections</td>
</tr>
<tr>
<td>Exertion</td>
<td>Rest, though dyspnea may become persistent</td>
<td>Cough, with scant mucoid sputum</td>
<td>History of smoking, air pollutants, sometimes a familial deficiency in alpha-1-antitrypsin</td>
</tr>
<tr>
<td>Variable, including allergens, irritants, respiratory infections, exercise, and emotion</td>
<td>Separation from aggravating factors</td>
<td>Wheezing, cough, tightness in chest</td>
<td>Environmental and emotional conditions</td>
</tr>
<tr>
<td>Exertion</td>
<td>Rest, though dyspnea may become persistent</td>
<td>Often weakness, fatigue. Cough less common than in other lung diseases</td>
<td>Varied. Exposure to one of many substances may be causative.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pleuritic pain, cough, sputum, fever, though not necessarily present</td>
<td>Varied</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pleuritic pain, cough</td>
<td>Often a previously healthy young adult</td>
</tr>
<tr>
<td>More often occurs at rest than after exercise. An upsetting event may not be evident.</td>
<td>Breathing in and out of a paper or plastic bag sometimes helps the associated symptoms.</td>
<td>Sighing, lightheadedness, numbness or tingling of the hands and feet, palpitations, chest pain</td>
<td>Postpartum or postoperative periods; prolonged bed rest; congestive heart failure, chronic lung disease, and fractures of hip or leg; deep venous thrombosis (often not clinically apparent)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Other manifestations of anxiety may be present.</td>
</tr>
</tbody>
</table>
# TABLE 6-3  Cough and Hemoptysis

<table>
<thead>
<tr>
<th>Problem</th>
<th>Cough and Sputum</th>
<th>Associated Symptoms and Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Acute Inflammation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laryngitis</td>
<td>Dry cough (without sputum), may become productive of variable amounts of sputum</td>
<td>An acute, fairly minor illness with hoarseness. Often associated with viral nasopharyngitis</td>
</tr>
<tr>
<td>Tracheobronchitis</td>
<td>Dry cough, may become productive (as above)</td>
<td>An acute, often viral illness, with burning retrosternal discomfort</td>
</tr>
<tr>
<td>Mycoplasma and Viral Pneumonias</td>
<td>Dry hacking cough, often becoming productive of mucoid sputum</td>
<td>An acute febrile illness, often with malaise, headache, and possibly dyspnea</td>
</tr>
<tr>
<td>Bacterial Pneumonias</td>
<td>Pneumococcal: sputum mucoid or purulent; may be blood-streaked, diffusely pinkish, or rusty</td>
<td>An acute illness with chills, high fever, dyspnea, and chest pain. Often is preceded by acute upper respiratory infection. Typically occurs in older alcoholic men</td>
</tr>
<tr>
<td><strong>Chronic Inflammation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postnasal Drip</td>
<td>Chronic cough; sputum mucoid or mucopurulent</td>
<td>Repeated attempts to clear the throat. Postnasal discharge may be sensed by patient or seen in posterior pharynx. Associated with chronic rhinitis, with or without sinusitis</td>
</tr>
<tr>
<td>Chronic Bronchitis</td>
<td>Chronic cough; sputum mucoid to purulent, may be blood-streaked or even bloody</td>
<td>Often longstanding cigarette smoking. Recurrent superimposed infections. Wheezing and dyspnea may develop.</td>
</tr>
<tr>
<td>Bronchiectasis</td>
<td>Chronic cough; sputum purulent, often copious and foul-smelling; may be blood-streaked or bloody</td>
<td>Recurrent bronchopulmonary infections common; sinusitis may coexist</td>
</tr>
<tr>
<td>Pulmonary Tuberculosis</td>
<td>Cough dry or sputum that is mucoid or purulent; may be blood-streaked or bloody</td>
<td>Early, no symptoms. Later, anorexia, weight loss, fatigue, fever, and night sweats</td>
</tr>
<tr>
<td>Lung Abscess</td>
<td>Sputum purulent and foul-smelling; may be bloody</td>
<td>A febrile illness. Often poor dental hygiene and a prior episode of impaired consciousness</td>
</tr>
<tr>
<td>Asthma</td>
<td>Cough, with thick mucoid sputum, especially near end of an attack</td>
<td>Episodic wheezing and dyspnea, but cough may occur alone. Often a history of allergy</td>
</tr>
<tr>
<td>Gastroesophageal Reflux</td>
<td>Chronic cough, especially at night or early in the morning</td>
<td>Wheezing, especially at night (often mistaken for asthma), early morning hoarseness, and repeated attempts to clear the throat. Often a history of heartburn and regurgitation</td>
</tr>
<tr>
<td><strong>Neoplasm</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cancer of the Lung</td>
<td>Cough dry to productive; sputum may be blood-streaked or bloody</td>
<td>Usually a long history of cigarette smoking. Associated manifestations are numerous.</td>
</tr>
<tr>
<td><strong>Cardiovascular Disorders</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left Ventricular Failure or Mitral Stenosis</td>
<td>Often dry, especially on exertion or at night; may progress to the pink frothy sputum of pulmonary edema or to frank hemoptysis</td>
<td>Dyspnea, orthopnea, paroxysmal nocturnal dyspnea</td>
</tr>
<tr>
<td>Pulmonary Emboli</td>
<td>Dry to productive; may be dark, bright red, or mixed with blood</td>
<td>Dyspnea, anxiety, chest pain, fever; factors that predispose to deep venous thrombosis</td>
</tr>
<tr>
<td>Irritating Particles, Chemicals, or Gases</td>
<td>Variable. There may be a latent period between exposure and symptoms.</td>
<td>Exposure to irritants. Eyes, nose, and throat may be affected.</td>
</tr>
</tbody>
</table>

*Characteristics of hemoptysis are printed in red.
TABLE 6-4  ■  Deformities of the Thorax

**Normal Adult**
The thorax in the normal adult is wider than it is deep. Its lateral diameter is larger than its anteroposterior diameter.

**Barrel Chest**
A barrel chest has an increased anteroposterior diameter. This shape is normal during infancy, and often accompanies normal aging and chronic obstructive pulmonary disease.

**Traumatic Flail Chest**
If multiple ribs are fractured, paradoxical movements of the thorax may be seen. As descent of the diaphragm decreases intrathoracic pressure on inspiration, the injured area caves inward; on expiration, it moves outward.

**Funnel Chest (Pectus Excavatum)**
A funnel chest is characterized by a depression in the lower portion of the sternum. Compression of the heart and great vessels may cause murmurs.

**Pigeon Chest (Pectus Carinatum)**
In a pigeon chest, the sternum is displaced anteriorly, increasing the anteroposterior diameter. The costal cartilages adjacent to the protruding sternum are depressed.

**Thoracic Kyphoscoliosis**
In thoracic kyphoscoliosis, abnormal spinal curvatures and vertebral rotation deform the chest. Distortion of the underlying lungs may make interpretation of lung findings very difficult.
The origins of breath sounds are still unclear. According to leading theories, turbulent air flow in the central airways produces the tracheal and bronchial breath sounds. As these sounds pass through the lungs to the periphery, lung tissue filters out their higher-pitched components and only the soft and lower-pitched components reach the chest wall, where they are heard as vesicular breath sounds. Normally, tracheal and bronchial sounds may be heard over the trachea and main-stem bronchi; vesicular breath sounds predominate throughout most of the lungs. When lung tissue loses its air, it transmits high-pitched sounds much better. If the tracheobronchial tree is open, bronchial breath sounds may replace the normal vesicular sounds over airless areas of the lung. This change is seen in lobar pneumonia when the alveoli fill with fluid, red cells, and white cells—a process called consolidation. Other causes include pulmonary edema or hemorrhage. Bronchial breath sounds usually correlate with an increase in tactile fremitus and transmitted voice sounds. These findings are summarized below.

<table>
<thead>
<tr>
<th>Breath Sounds</th>
<th>Normal Air-Filled Lung</th>
<th>Airless Lung, as in Lobar Pneumonia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmitted Voice Sounds</td>
<td>Predominantly vesicular</td>
<td>Bronchial or bronchovesicular over the involved area</td>
</tr>
<tr>
<td>Spoken words muffled and indistinct</td>
<td>Spoken words louder, clearer (bronchophony)</td>
<td></td>
</tr>
<tr>
<td>Spoken “ee” heard as “ee”</td>
<td>Spoken “ee” heard as “ay” (egophony)</td>
<td></td>
</tr>
<tr>
<td>Whispered words faint and indistinct, if heard at all</td>
<td>Whispered words louder, clearer (whispered pectoriloquy)</td>
<td></td>
</tr>
<tr>
<td>Tactile Fremitus</td>
<td>Normal</td>
<td>Increased</td>
</tr>
</tbody>
</table>
### Adventitious (Added) Lung Sounds: Causes and Qualities

<table>
<thead>
<tr>
<th><strong>Crackles</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Crackles have two leading explanations. (1) They result from a series of tiny explosions when small airways, deflated during expiration, pop open during inspiration. This mechanism probably explains the late inspiratory crackles of interstitial lung disease and early congestive heart failure. (2) Crackles result from air bubbles flowing through secretions or lightly closed airways during respiration. This mechanism probably explains at least some coarse crackles.</td>
</tr>
<tr>
<td><em>Late inspiratory crackles</em> may begin in the first half of inspiration but must continue into late inspiration. They are usually fine and fairly profuse, and persist from breath to breath. These crackles appear first at the bases of the lungs, spread upward as the condition worsens, and shift to dependent regions with changes in posture. Causes include interstitial lung disease (such as fibrosis) and early congestive heart failure.</td>
</tr>
<tr>
<td><em>Early inspiratory crackles</em> appear soon after the start of inspiration and do not continue into late inspiration. They are often but not always coarse and are relatively few in number. Expiratory crackles are sometimes associated. Causes include chronic bronchitis and asthma.</td>
</tr>
<tr>
<td><em>Mid-inspiratory and expiratory crackles</em> are heard in bronchiectasis but are not specific for this diagnosis. Wheezes and rhonchi may be associated.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Wheeze and Rhonchi</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheezes occur when air flows rapidly through bronchi that are narrowed nearly to the point of closure. They are often audible at the mouth as well as through the chest wall. Causes of wheezes that are generalized throughout the chest include asthma, chronic bronchitis, COPD, and congestive heart failure (cardiac asthma). In asthma, wheezes may be heard only in expiration or in both phases of the respiratory cycle. Rhonchi suggest secretions in the larger airways. In chronic bronchitis, wheezes and rhonchi often clear with coughing.</td>
</tr>
<tr>
<td>Occasionally in severe obstructive pulmonary disease, the patient is no longer able to force enough air through the narrowed bronchi to produce wheezing. The resulting <em>silent chest</em> should raise immediate concern and not be mistaken for improvement.</td>
</tr>
<tr>
<td>A persistent localized wheeze suggests a partial obstruction of a bronchus, as by a tumor or foreign body. It may be inspiratory, expiratory, or both.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Stridor</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>A wheeze that is entirely or predominantly inspiratory is called <em>stridor</em>. It is often louder in the neck than over the chest wall. It indicates a partial obstruction of the larynx or trachea, and demands immediate attention.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Pleural Rub</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Inflamed and roughened pleural surfaces grate against each other as they are momentarily and repeatedly delayed by increased friction. These movements produce creaking sounds known as a <em>pleural rub</em> (or pleural friction rub).</td>
</tr>
<tr>
<td>Pleural rubs resemble crackles acoustically, although they are produced by different pathologic processes. The sounds may be discrete, but sometimes are so numerous that they merge into a seemingly continuous sound. A rub is usually confined to a relatively small area of the chest wall, and typically is heard in both phases of respiration. When inflamed pleural surfaces are separated by fluid, the rub often disappears.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Mediastinal Crunch (Hamman’s Sign)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>A <em>mediastinal crunch</em> is a series of precordial crackles synchronous with the heart beat, not with respiration. Best heard in the left lateral position, it is due to mediastinal emphysema (pneumomediastinum).</td>
</tr>
</tbody>
</table>
**TABLE 6-7 Physical Findings in Selected Chest Disorders**

The black boxes in this table suggest a framework for clinical assessment. Start with the three boxes under Percussion Note: resonant, dull, and hyperresonant. Then move from each of these to other boxes that emphasize some of the key differences among various conditions. The changes described vary with the extent and severity of the disorder. Abnormalities deep in the chest usually produce fewer signs than superficial ones, and may cause no signs at all. Use the table for the direction of typical changes, not for absolute distinctions.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Percussion Note</th>
<th>Trachea</th>
<th>Breath Sounds</th>
<th>Adventitious Sounds</th>
<th>Tactile Fremitus and Transmitted Voice Sounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Resonant</td>
<td>Midline</td>
<td>Vesicular, except perhaps bronchovesicular and bronchial sounds over the large bronchi and trachea respectively</td>
<td>None, except perhaps a few transient inspiratory crackles at the bases of the lungs</td>
<td>Normal</td>
</tr>
<tr>
<td>Chronic Bronchitis</td>
<td>Resonant</td>
<td>Midline</td>
<td>Vesicular (normal)</td>
<td>None; or scattered coarse crackles in early inspiration and perhaps expiration; or wheezes or rhonchi</td>
<td>Normal</td>
</tr>
<tr>
<td>Left-Sided Heart Failure (Early)</td>
<td>Resonant</td>
<td>Midline</td>
<td>Vesicular</td>
<td>Late inspiratory crackles in the dependent portions of the lungs; possibly wheezes</td>
<td>Normal</td>
</tr>
<tr>
<td>Consolidation</td>
<td>Dull over the airless area</td>
<td>Midline</td>
<td>Bronchial over the involved area</td>
<td>Late inspiratory crackles over the involved area</td>
<td>Increased over the involved area, with bronchophony, epiphony, and whispered pectoriloquy</td>
</tr>
</tbody>
</table>
### Atelectasis (Lobar Obstruction)

When a plug in a mainstem bronchus (as from mucus or a foreign object) obstructs airflow, affected lung tissue collapses into an airless state.

- **Physical Findings**
  - **Dull over the airless area**
  - May be shifted toward involved side
  - **Usually absent when bronchial plug persists.**
  - Exceptions include right upper lobe atelectasis, where adjacent tracheal sounds may be transmitted.
  - None
  - **Usually absent when the bronchial plug persists.**
  - In exceptions, e.g., right upper lobe atelectasis, may be increased

### Pleural Effusion

Fluid accumulates in the pleural space, separates air-filled lung from the chest wall, blocking the transmission of sound.

- **Dull to flat over the fluid**
- **Shifted toward opposite side in a large effusion**
- **Decreased to absent, but bronchial breath sounds may be heard near top of large effusion.**
- None, except a possible pleural rub
- **Decreased to absent, but may be increased toward the top of a large effusion**

### Pneumothorax

When air leaks into the pleural space, usually unilaterally, the lung recoils from the chest wall. Pleural air blocks transmission of sound.

- **Hyperresonant or tympanic over the pleural air**
- **Shifted toward opposite side if much air**
- **Decreased to absent over the pleural air**
- None, except a possible pleural rub
- **Decreased to absent over the pleural air**

### Chronic Obstructive Pulmonary Disease (COPD)

Slowly progressive disorder in which the distal air spaces enlarge and lungs become hyperinflated. Chronic bronchitis is often associated.

- **Diffusely hyperresonant**
- **Midline**
- **Decreased to absent**
- **None, or the crackles, wheezes, and rhonchi of associated chronic bronchitis**
- **Decreased**

### Asthma

Widespread narrowing of the tracheobronchial tree diminishes airflow to a fluctuating degree. During attacks, airflow decreases further and lungs hyperinflate.

- **Resonant to diffusely hyperresonant**
- **Midline**
- **Often obscured by wheezes**
- **Wheezes, possibly crackles**
- **Decreased**