be percussed. The level of the diaphragms on each side should be observed. The percussion note should be compared on the two sides starting at the apex and moving down, including the posterior, anterior, and lateral aspects. A pleural effusion, consolidation, mass, or elevated diaphragm can cause dullness to percussion; a pneumothorax or hyperinflation can cause hyperresonance.

Auscultation of the lungs is performed to evaluate the quality of the breath sounds and to detect extra sounds not heard in normal lungs. Normal breath sounds have two qualities, vesicular and bronchial. Bronchial breath sounds are heard over the central airways and are louder and coarser than vesicular breath sounds, which are heard at the periphery and base of the lungs. Bronchovesicular sounds are a combination of the two and are heard over medium-sized airways. Bronchial sounds have a longer inhaled component, whereas vesicular sounds have a much longer expiratory component and are much softer. Bronchial breath sounds and bronchovesicular breath sounds at the periphery of the lungs are abnormal and may be caused by underlying consolidation. In the setting of consolidation, increased transmission of vocal sounds, called *whispered pectoriloquy,* occurs; *egophony,* in which the spoken letter *e* sounds like an *a* over the area of consolidation, is heard and sometimes compared with the bleating of a goat.

Abnormal or extrapulmonary sounds are crackles, wheezes, and rubs. Crackles can be coarse rattles or fine, Velcro-like sounds. Mucus in the airways or the opening of large- and medium-sized airways often causes coarse crackles. In bronchiectasis, the crackles are altered with coughing. Fine crackles, heard during inspiration and caused by the opening of collapsed alveoli, are most common at the bases. Crackles are heard in pulmonary edema and interstitial fibrosis.

Wheezing is a higher-pitched sound, and when heard locally, it suggests large airway obstruction. The wheezing of patients with asthma or congestive heart failure is lower in pitch and heard diffusely over all lung fields. Localized wheezing can be heard in conditions such as pulmonary embolism, obstruction of a bronchus by a tumor, and foreign-body aspiration.

A rub is a pleural sound caused by inflamed pleural surfaces rubbing together. A rub has been described as the sound of pieces of leather rubbing against each other. Rubs are often evanescent and depend on the amount of fluid in the pleural space. Often, pleuritic chest pain and a rub develop after large-volume thoracentesis.

A crunching sound timed with the cardiac cycle, called *Hamman's crunch* or *Hamman's sign,* is heard in patients with a pneumomediastinum. The complete absence of breath sounds on one side should cause the examiner to think of pneumothorax, hydrothorax, or hemothorax; obstruction of a main stem bronchus; or surgical or congenital absence of the lung.

EVALUATION

The clinician should be able to develop a differential diagnosis based on a detailed history and a thorough physical examination. The preliminary differential diagnosis is the basis for ordering a battery of tests, recognizing that these tests may reveal disorders not considered in the initial assessment. The objective of this extended evaluation is twofold: to confirm a diagnosis or discard other disorders and to assess the severity of the lung derangement.

Patients with a suggested lung disorder should undergo pulmonary function testing (see Chapter 15). Spirometry evaluates airflow and helps to distinguish between the obstructive pattern characteristic of COPD, asthma, and related disorders and the restrictive pattern observed in fibrosing lung disease. Spirometry also provides information regarding the severity of the physiologic derangement.

Lung volume measurements are helpful in assessing hyperinflation or confirming a restrictive process. Measuring the diffusing capacity of the lung for carbon monoxide (DLCO) provides information about alterations in gas-exchanging capability. Further assessment of gas exchange can be obtained by the determination of oxygen saturation using pulse oximetry.

Information regarding oxygenation and acid-base status is obtained from arterial blood gas determination. A 6-minute walk test can evaluate oxygenation during exertion; through this test, patients are often found to require supplemental oxygen for the first time. Other, more specialized tests (e.g., bronchoprovocation, cardiopulmonary stress testing, polysomnography) may be required, depending on the circumstances.

Imaging studies of the chest are extremely useful in evaluating lung structure. The chest radiograph provides information about the lung parenchyma and pleura, the cardiac silhouette, mediastinal structures, and body habitus. Examining old chest radiographic images is essential for assessing progression of disease.

Computed tomography (CT) provides more accurate information about the pulmonary and mediastinal structures, and it is essential in the assessment of interstitial lung disease, lung masses, and other disorders. Together with ventilation-perfusion scanning and pulmonary angiography, CT is one of the many tools available to evaluate the lung vasculature. Positron emission tomography is used to assess metabolic activity of lung masses and can suggest a diagnosis of malignancy.

Standard blood tests such as the blood counts and blood chemistry point to specific disorders or may provide information about the severity of a lung disorder (e.g., polycythemia in chronic hypoxemia, leukocytosis in lung infection). Some specialized tests should be reserved for specific diagnoses such as connective tissue disorders (e.g., rheumatoid factor, antinuclear antibodies) or hypersensitivity pneumonitis (hypersensitivity profile).

Together with the history and physical examination, these tests are useful for narrowing a diagnosis to establish a specific plan of treatment. The plan can often be created in a single visit. However, patients frequently require several visits to a clinician. During these follow-up visits, the physician assesses progression of disease, patient compliance with therapy, and response to management.

If noninvasive tests do not allow a diagnosis of the problem, more invasive tests may be necessary. Fiberoptic or rigid bronchoscopy allows direct visualization of the airways and acquisition of valuable clinical samples for study. Transthoracic percutaneous needle aspiration or navigational bronchoscopy is useful in evaluating peripheral lung lesions. Ultimately, surgery may be required to obtain tissue through open or video-assisted thoracoscopically guided lung biopsy.