EVALUATION OF LUNG FUNCTION

Pulmonary function tests evaluate one or more major aspects of the respiratory system. Accurate measurements of lung volumes, airway function, and gas exchange require a pulmonary function testing laboratory. Pulmonary function tests are commonly used to aid in the diagnosis of disease and assess disease severity. In addition, they are helpful in monitoring the course of disease, assessing the risk for surgical procedures, and measuring the effects of varied environmental exposures. The response to bronchodilators or other forms of treatment also can be assessed with serial pulmonary function tests (Table 15-1). Accurate interpretation of pulmonary function tests requires the appropriate reference standards. Variables that affect the predicted standards include age, height, gender, race, and hemoglobin concentration.

Spirometry, the simplest means of measuring lung function, can be performed in an office practice. A spirometer is an apparatus that measures inspiratory and expiratory volumes. Flow rates can be calculated from tracings of volume versus time. Typically, vital capacity (VC) is measured as the difference between a full inspiration to total lung capacity (TLC) and a full exhalation to residual volume (RV) (Fig. 15-19). Flow rates are measured after the patient is instructed to forcefully exhale from TLC to RV. Such a forced expiratory maneuver allows one to calculate the forced expiratory volume in 1 second (FEV_1) and the forced vital capacity (FVC) (Fig. 15-20). A value that is 80% to 120% of the predicted value is considered normal for FVC. Normally, people can exhale more than 75% to 80% of their FVC in the first second, and the majority of the FVC can be exhaled in 3 seconds. The ratio of FEV_1/FVC is normally greater than 0.80.

TABLE 15-1 INDICATIONS FOR PULMONARY FUNCTION TESTING

Evaluation of signs and symptoms: Shortness of breath Exertional dyspnea Chronic cough Screening of at-risk populations Monitoring of pulmonary drug toxicity	Follow-up after abnormal study results: Chest radiograph Electrocardiogram Arterial blood gases Hemoglobin Preoperative assessment: Assess severity Follow response to therapy Determine further treatment goals Assess disability

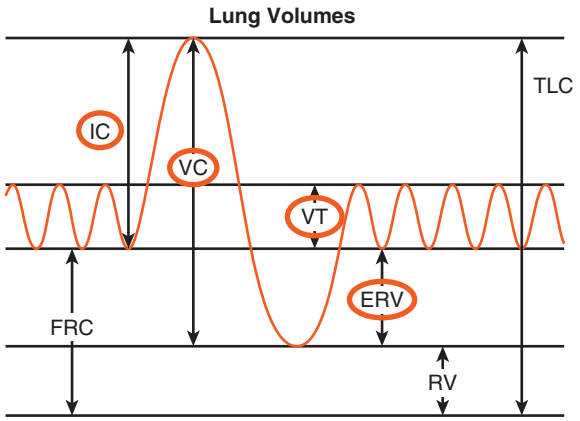

FIGURE 15-19 Lung volumes and capacities. Although spirometry can measure vital capacity and its subdivisions *(red circles)*, calculation of residual volume (RV) requires measurement of functional residual capacity (FRC) by one of the following techniques: body plethysmography, helium dilution, or nitrogen washout. IC, Inspiratory capacity; ERV, expiratory reserve volume; TLC, total lung capacity; VC, vital capacity; VT, tidal volume.

Spirometry can reveal abnormalities that are classified into two patterns: obstructive and restrictive. Obstructive impairments are defined by a low FEV_1/FVC ratio. Diseases that are characterized by an obstructive pattern include asthma, chronic bronchitis, emphysema, bronchiectasis, cystic fibrosis, and some central airway lesions. The reduction in FEV_1 (expressed as % predicted FEV_1) is used to determine the severity of airflow obstruction (E-Fig. 15-2). Peak expiratory flow rate (PEFR) can be measured as the maximal expiratory flow rate obtained during spirometry or when using a handheld peak flowmeter. The lower the PEFR, the more significant the obstruction. The peak flowmeter can be used at home or in the emergency department to evaluate the presence of obstruction. Severe attacks of asthma, for example, are usually associated with PEFRs of less than 200 L/minute (normal, 500 to 600 L/minute). A restrictive pattern is characterized by loss of lung volume. With spirometry, both the FVC and the FEV_1 are reduced, so the FEV_1/FVC ratio remains normal. The restrictive pattern must be confirmed by measurements of lung volumes.

Lung volumes are measured by body plethysmography or by dilution of an inert gas such as helium. Lung volumes that can be measured with these techniques include FRC, TLC, and RV (see Fig. 15-19). As described earlier, FRC is the lung volume at which the inward elastic recoil of the lung equals the outward elastic recoil of the chest wall. Changes in FRC reflect abnormalities in lung elastic recoil. Diseases associated with increased elastic recoil (e.g., pulmonary fibrosis) are associated with a reduction in FRC, whereas those with decreased recoil (e.g., emphysema) are associated with an increase in FRC. TLC is the amount of air remaining in the thorax after a maximal inspiration. It is determined by the balance of the forces generated by the respiratory muscles to expand the respiratory system and the elastic recoil of the respiratory system. Restrictive lung disease is defined as a TLC less than 80% predicted, whereas values of TLC greater than 120% predicted are consistent with hyperinflation. The lower the % predicted TLC, the more severe the restrictive impairment.

Restriction may be caused by disorders of the lung, chest wall, respiratory muscles, or pleural space. Lung diseases that cause pulmonary fibrosis cause a restrictive pattern because of the increased elastic recoil of the respiratory system. Diseases of the chest wall, such as kyphoscoliosis, obesity, or ankylosing spondylitis, can also cause restriction by reducing the elasticity of the chest wall. Weakness of the respiratory muscles causes restriction by reducing the force available to inflate the respiratory system. Myasthenia gravis, amyotrophic lateral sclerosis, diaphragm paralysis, and Guillain-Barré syndrome can be associated with weakness sufficient to cause restrictive lung disease. Finally, space-occupying lesions involving the pleural space, such as