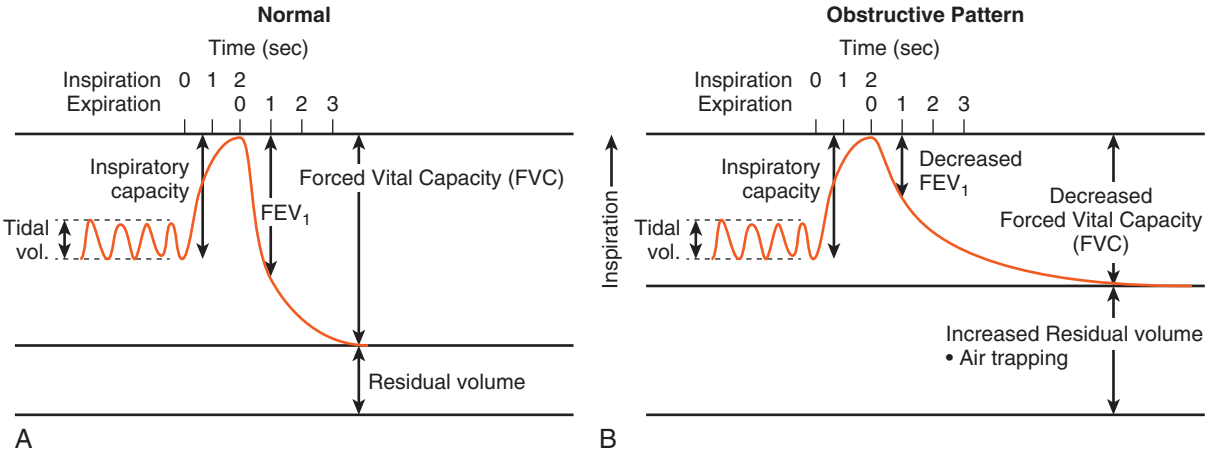

FIGURE 15-20 Spirometry in a normal individual (**A**) and in a patient with obstructive lung disease (**B**). FEV_1 represents the forced expiratory volume in 1 second, and FVC represents the forced vital capacity. The FEV_1/FVC ratio is normally greater than 0.80. With obstruction, the FEV_1/FVC ratio is less than 0.70.

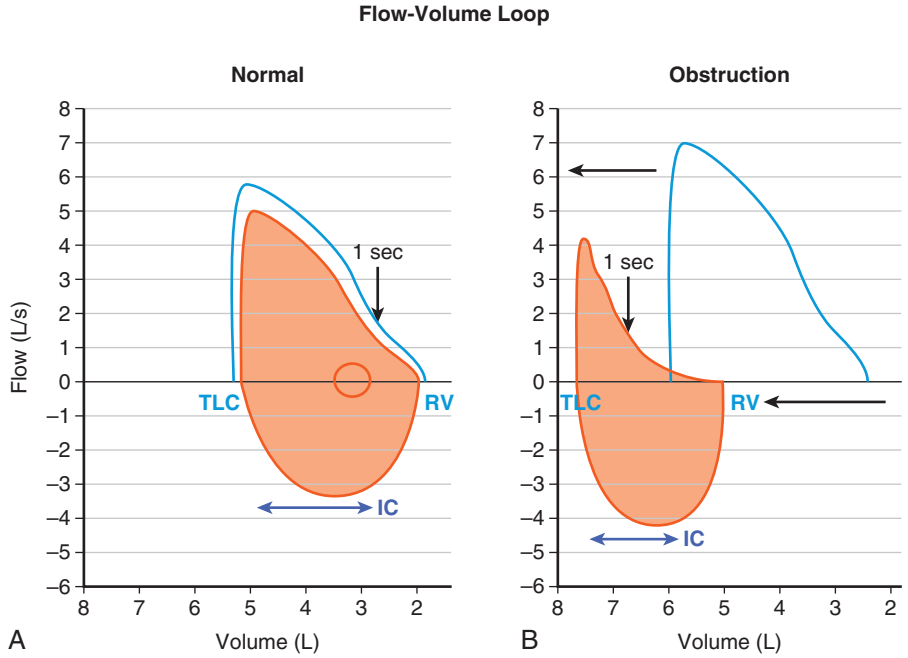

FIGURE 15-21 The maximum expiratory flow and volume curve in a normal individual (**A**) and in an individual with obstructive lung disease (in this case, COPD) (**B**). Hyperinflation and air trapping *(arrows)* push the total lung capacity (TLC) and residual volume (RV) to the left (i.e., toward higher lung volumes). In addition, characteristic scalloping of the expiratory limb of the flow-volume curve develops. IC, Inspiratory capacity.

pleural effusions, pneumothorax, or pleural tumors, can cause restriction. Occasionally, RV and FRC may be elevated with no increase in TLC. This pattern, referred to *air trapping*, and can be seen with COPD or asthma.

The forced expiratory maneuver can be analyzed in terms of flow and volume by construction of a flow-volume loop (Fig. 15-21). Flow-volume loops are useful to identify obstructive and restrictive patterns. The characteristic appearance of obstructive impairment is concavity ("scooping") of the expiratory loop, whereas with restrictive impairments, the loops have a normal shape but are reduced in size. In addition, flow-volume loops are the primary means of identifying upper airway obstruction. Upper airway obstruction is characterized by a truncated (clipped) inspiratory or expiratory loop. A fixed obstruction produces clipping of both inspiratory and expiratory loops. Variable intrathoracic upper airway obstruction exhibits clipping of the expiratory loop, whereas variable extrathoracic obstruction exhibits clipping of the inspiratory loop (Fig. 15-22).

Bronchoprovocation Testing

Bronchoprovocation testing is typically used to determine the presence or absence of hyperreactive airways disease. Some individuals with a clinical suspicion of asthma have normal expiratory flow rates and lung volumes. Bronchoprovocation testing in these individuals can be important to identify hyperreactive airways disease and support the diagnosis of asthma. Methacholine is a cholinergic agonist that causes bronchoconstriction. During the bronchoprovocation test, the subject inhales