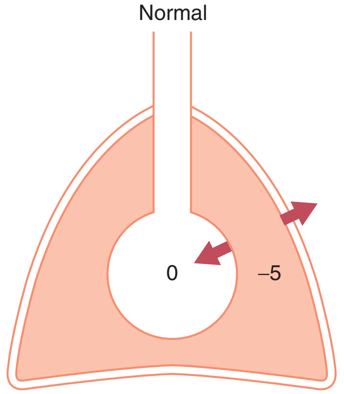

FIGURE 15-5 Schematic diagram of the lung and chest wall at functional residual capacity (FRC). The *arrows* show that the expanding elastic force of the chest wall equals the collapsing elastic force of the lung. The intrapleural pressure is –5 at FRC because both forces are tugging on the pleural space in opposite directions.

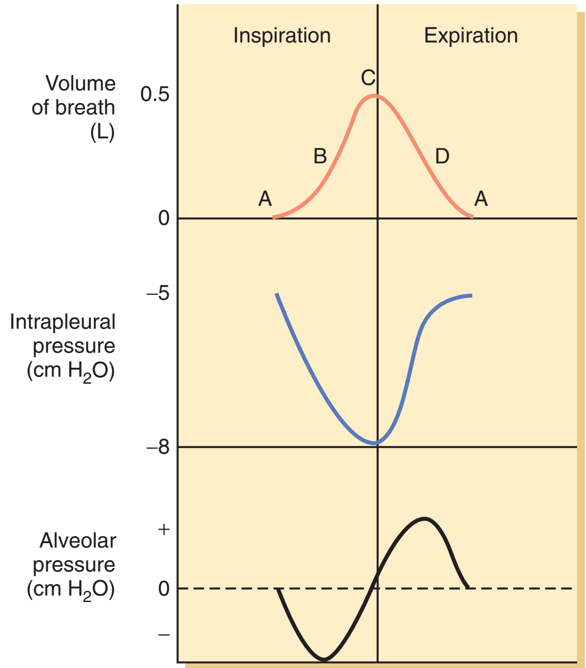

FIGURE 15-6 Volume, intrapleural pressure, and alveolar pressure during a normal breathing cycle. The letters correspond to the various phases of the cycle: *A,* end-expiration; *B,* inspiration; *C,* end-inspiration; and *D,* expiration. Alveolar pressure is biphasic, with zero crossings at times of no flow (i.e., end-expiration and end-inspiration). Intrapleural pressure remains subatmospheric throughout.

During a typical breath, inspiratory muscle contraction lowers the intrapleural pressure, which in turn lowers the intra-alveolar pressure. Once alveolar pressure becomes subatmospheric, air can flow from the mouth through the airways to the alveoli. At the end of inspiration, the inspiratory muscles are turned off, and the lungs and chest wall recoil passively back to their equilibrium states. This passive recoil of the respiratory system causes alveolar pressure to become positive throughout expiration until the resting position of the lung and chest wall are reestablished and alveolar pressure once again equals atmospheric pressure. During quiet breathing, pleural pressure is always subatmospheric, whereas alveolar pressure oscillates below and above zero (atmospheric) pressure (Fig. 15-6).

The major inspiratory muscle is the diaphragm. Others include the sternocleidomastoid muscles, the scalenus muscles, the parasternals, and the external intercostals. Diaphragm contraction results in expansion of the lower rib cage and compression of the intra-abdominal contents. The latter action results in expansion of the abdominal wall. The expiratory muscles consist of the internal intercostal muscles and the abdominal muscles. Expiratory flows can be enhanced by recruiting the expiratory muscles; this occurs during exercise or with cough.

To inflate the respiratory system, the inspiratory muscles must overcome two types of forces: the elastic forces imposed by the lung and the chest wall (elastic loads) and the resistive forces related to airflow (resistive loads). The elastic loads on the inspiratory muscles result from the respiratory system's tendency to resist stretch. The elastic forces are volume dependent; that is, the respiratory system becomes more difficult to stretch at volumes greater than the functional residual capacity (FRC) and more difficult to compress at volumes lower than the FRC. The elastic forces can be characterized by examining the relationship between lung volume and recoil pressure (Fig. 15-7). When either deflated or inflated, the lung and chest wall have characteristic recoil pressures. The slope of the relationship between lung volume and elastic recoil pressure of the chest wall or lung represents the *compliance* of each structure. The sum of the chest wall and lung recoil pressures represents the recoil pressure of the total respiratory system.

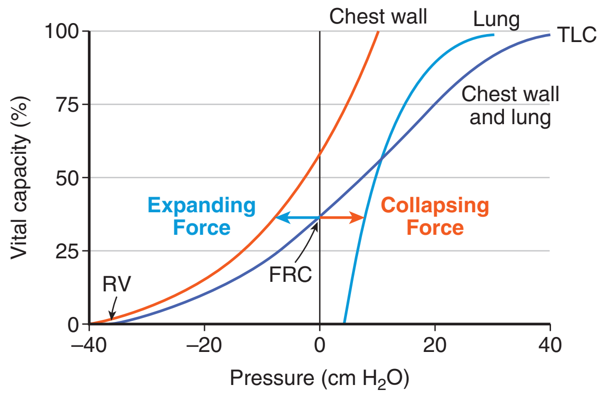

FIGURE 15-7 Volume-pressure relationship of the respiratory system and its components, the lung and chest wall. Respiratory system recoil pressure at any volume is the sum of the lung and chest wall recoil pressures. Forces creating negative pressures expand the respiratory system, whereas forces creating positive pressures collapse the respiratory system. The slope of the volume-pressure curve represents the compliance of each structure. FRC, Functional residual capacity; RV, residual volume; TLC, total lung capacity.

The elastic properties of the lung are related to two factors: the elastic behavior of collagen and elastin in the lung parenchyma and the surface tension in the alveolus at the air-liquid interface. Both factors contribute equally to lung elastic recoil. A surface-active substance called *surfactant* is produced by type II alveolar cells and lines the alveoli. This substance consists primarily of phospholipids. It lowers the surface tension of the air-liquid interface, making it easier to inflate the lung. The lungs are stiff (less compliant) and difficult to inflate in diseases that