39.2C: Lung Volumes and Capacities

Lung volumes measure the amount of air for a specific function, while lung capacities are the sum of two or more volumes.

Learning Objectives

• Distinguish between lung volume and lung capacity

Key Points

• The lung volumes that can be measured using a spirometer include tidal volume (TV), expiratory reserve volume (ERV), and inspiratory reserve volume (IRV).

• Residual volume (RV) is a lung volume representing the amount of air left in the lungs after a forced exhalation; this volume cannot be measured, only calculated.

• The lung capacities that can be calculated include vital capacity (ERV+TV+IRV), inspiratory capacity (TV+IRV), functional residual capacity (ERV+RV), and total lung capacity (RV+ERV+TV+IRV).

Key Terms

• tidal volume: the amount of air breathed in or out during normal respiration

• residual volume: the volume of unexpended air that remains in the lungs following maximum expiration

• spirometry: the measurement of the volume of air that a person can move into and out of the lungs
Lung Volumes and Capacities

Different animals exhibit different lung capacities based on their activities. For example, cheetahs have evolved a much higher lung capacity than humans in order to provide oxygen to all the muscles in the body, allowing them to run very fast. Elephants also have a high lung capacity due to their large body and their need to take up oxygen in accordance with their body size.

Human lung size is determined by genetics, gender, and height. At maximal capacity, an average lung can hold almost six liters of air; however, lungs do not usually operate at maximal capacity. Air in the lungs is measured in terms of lung volumes and lung capacities. Volume measures the amount of air for one function (such as inhalation or exhalation) and capacity is any two or more volumes (for example, how much can be inhaled from the end of a maximal exhalation).

Lung Volumes

The volume in the lung can be divided into four units: tidal volume, expiratory reserve volume, inspiratory reserve volume, and residual volume. Tidal volume (TV) measures the amount of air that is inspired and expired during a normal breath. On average, this volume is around one-half liter, which is a little less than the capacity of a 20-ounce drink bottle. The expiratory reserve volume (ERV) is the additional amount of air that can be exhaled after a normal exhalation. It is the reserve amount that can be exhaled beyond what is normal. Conversely, the inspiratory reserve volume (IRV) is the additional amount of air that can be inhaled after a normal inhalation. The residual volume (RV) is the amount of air that is left after expiratory reserve volume is exhaled. The lungs are never completely empty; there is always some air left in the lungs after a maximal exhalation. If this residual volume did not exist and the lungs emptied completely, the lung tissues would stick together. The energy necessary to re-inflate the lung could be too great to overcome. Therefore, there is always some air remaining in the lungs. Residual volume is also important for preventing large fluctuations in respiratory gases (O₂ and CO₂). The residual volume is the only lung volume that cannot be measured directly because it is impossible to completely empty the lung of air. This volume can only be calculated rather than measured.

Lung volumes are measured by a technique called spirometry. An important measurement taken during spirometry is the forced expiratory volume (FEV), which measures how much air can be forced out of the lung over a specific period, usually one second (FEV1). In addition, the forced vital capacity (FVC), which is the total amount of air that can be forcibly exhaled, is measured. The ratio of these values (FEV1/FVC ratio) is used to diagnose lung diseases including asthma, emphysema, and fibrosis. If the FEV1/FVC ratio is high, the lungs are not compliant (meaning they are stiff and
unable to bend properly); the patient probably has lung fibrosis. Patients exhale most of the lung volume very quickly. Conversely, when the FEV1/FVC ratio is low, there is resistance in the lung that is characteristic of asthma. In this instance, it is difficult for the patient to get the air out of his or her lungs. It takes a long time to reach the maximal exhalation volume. In either case, breathing is difficult and complications arise.

Lung Capacities

The lung capacities are measurements of two or more volumes. The vital capacity (VC) measures the maximum amount of air that can be inhaled or exhaled during a respiratory cycle. It is the sum of the expiratory reserve volume, tidal volume, and inspiratory reserve volume. The inspiratory capacity (IC) is the amount of air that can be inhaled after the end of a normal expiration. It is, therefore, the sum of the tidal volume and inspiratory reserve volume. The functional residual capacity (FRC) includes the expiratory reserve volume and the residual volume. The FRC measures the amount of additional air that can be exhaled after a normal exhalation. The total lung capacity (TLC) is a measurement of the total amount of air that the lung can hold. It is the sum of the residual volume, expiratory reserve volume, tidal volume, and inspiratory reserve volume.