Respiratory system

Compliance

Compliance is the ability of the lungs and thorax to expand. It is defined as the change in volume per unit change in the respiratory pressure. Determination of compliance is useful as it is the measure of stiffness of lungs. Stiffer the lungs, less is the compliance.

- Compliance is the volume increase in lungs per unit increase in the intra-alveolar pressure:

1. Compliance of lungs and thorax together: 130 ml/1 cm H_2O pressure

2. Compliance of lungs alone: 220 ml/1 cm H_20 pressure.

- Compliance is the volume increase in lungs per unit decrease in the intrapleural pressure:

1. Compliance of lungs and thorax together 100 m/1 cm H_2O pressure

2. Compliance of lungs alone- 200 ml/1 cm H_2O pressure.

Thus, if lungs are removed from thorax, the expansibility (compliance) of lungs alone doubled. It is because of the absence of the inertia and the restriction exerted by the structures of thoracic cage, which interfere with expansion of lungs.

The work of breathing

It is the work done by the respiratory muscles during breathing to overcome the resistance in the thorax and respiratory tract. During the respiratory processes, inspiration is active process and the expiration is a passive process. So, during quiet breathing, the respiratory muscles perform the work only during inspiration and not during expiration.

The energy obtained during the work of breathing is utilized to overcome three types of resistance

1. Airway resistance

2. Elastic resistance of lungs and thorax (compliance work).

3. Non-elastic viscous resistance (tissue resistance work).

The air in lung is classified into two divisions:

1. Lung volumes

2. Lung capacities

Pulmonary function tests are carried out mostly by using spirometer. The graphical recording of lung volumes and capacities is called spirogram.

Lung volume

Lung volumes are the static volumes of air breathed by an individual. The lung volumes are of four types:

1. Tidal volume (TV)

Tidal volume is the volume of air breathed in and out of lungs in a single normal quiet respiration. Tidal volume signifies the normal depth of breathing. Normal value- 500 mL (0.5 L).

2. Inspiratory reserve volume (IRV)

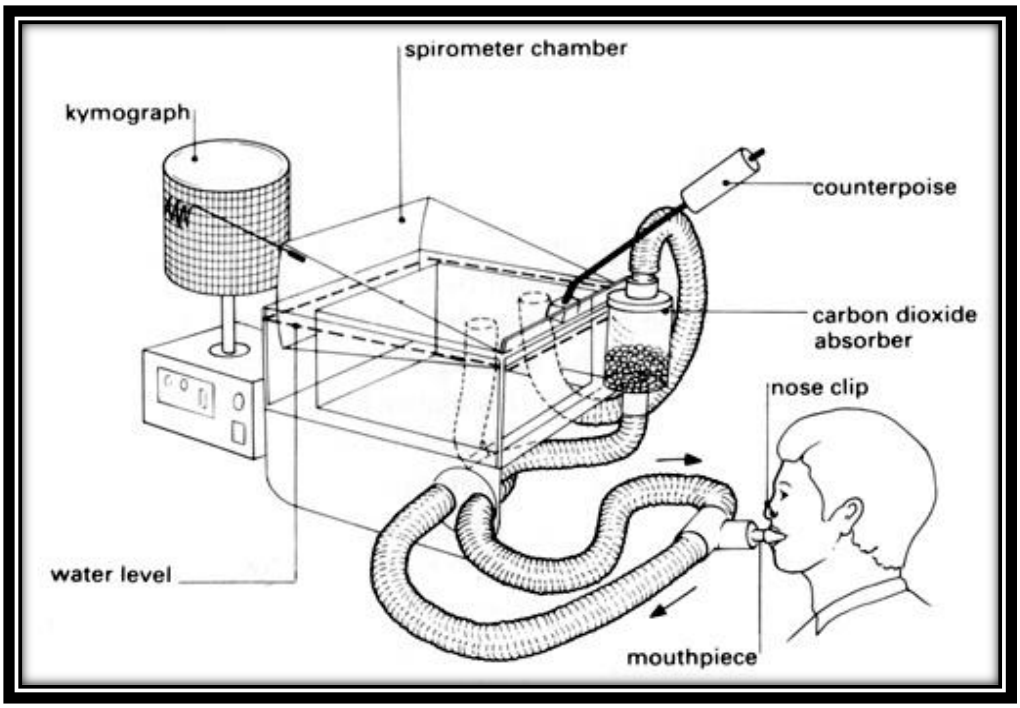
Inspiratory reserve volume is an additional volume of air that can be inspired forcefully after the end of normal inspiration. Normal value 3300 mL (3.3 L).

3. Expiratory reserve volume (ERV)

Expiratory reserve volume is the additional volume of air that can be expired out forcefully, after normal expiration Normal value 1000 mL (1 L)

4. Residual volume (RV)

Residual volume is the volume of air remaining in the lungs even after forced expiration. Normally, lungs cannot be emptied completely even by forceful expiration. Some quantity of air always remains in the lungs even after the forced expiration. Normal value- 1200 mL (1.2 L)



Lung capacity

Lung capacities are the combination of two or more lung volumes. Lung capacities are of four types:

1. Inspiratory capacity (IC)

Inspiratory capacity is the maximum volume of air that is inspired after normal expiration (end expiratory position). It includes tidal volume and inspiratory reserve volume

IC= TV+IRV=500+3300- 3800 mL

2. Vital capacity (VC)

It is the maximum volume of air that can be expelled out forcefully after a deep (maximal) inspiration. Vital capacity includes inspiratory reserve volume, tidal volume and expiratory reserve volume.

VC= IRV+ TV+ERV= 3300+500+1000= 4800 mL.

3. Functional residual capacity (FRC)

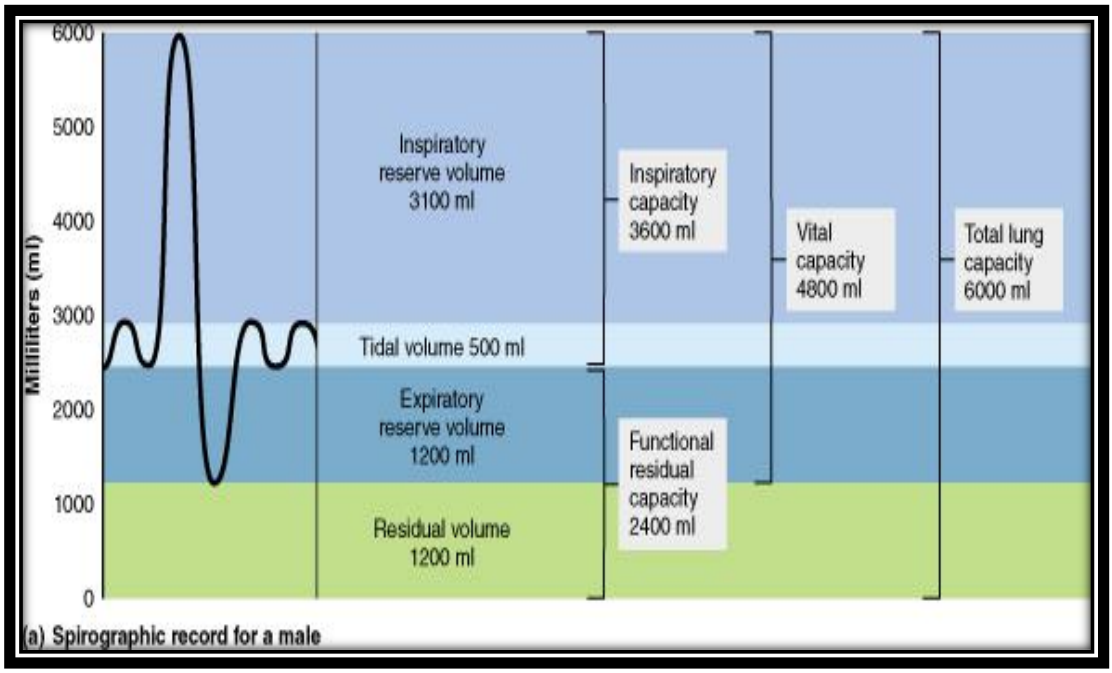
It is the volume of air remaining in the lungs after normal expiration (after normal tidal expiration). Functional residual capacity includes expiratory reserve volume and residual volume

FRC=ERV+RV=1000 +1200=2200 mL

4. Total lung capacity (TLC)

Total lung capacity is the volume of air present in the lungs after a deep (maximal) inspiration. It includes all the volumes.

TLC= IRV+TV+ERV+RV=3300+500+1000 +1200=6000 mL



Ventilation

Pulmonary ventilation

It is the volume of air moving in and out of lungs per minute in quiet breathing. It is also called respiratory minute volume (RMV).

Normal value and calculation

Normal value of pulmonary ventilation is 6 L/minute. It is the product of tidal volume (TV) and the rate of respiration (RR). It is calculated by the formula: **Pulmonary ventilation=Tidal volume x Respiratory rate**

=500 mL x 12/minute

=6,000mL=6 L/minute

Factors affecting pulmonary ventilation:

1. Surface tension of alveolar fluid

Surfactant (Pulmonary surfactant is a surface acting material that decreases the surface tension on the alveolar membrane).

2. Lung compliance

- Elasticity
- Surface tension

3. Airway resistance.

Alveolar ventilation

Alveolar ventilation is the amount of air utilized for gaseous exchange every minute. Alveolar ventilation is different from pulmonary ventilation. In pulmonary ventilation, 6 L of air moves in and out of lungs in every minute. But the whole volume of air is not utilized for exchange of gases. The volume of air subjected for exchange of gases is the alveolar ventilation. The air trapped in the respiratory passage (dead space) does not take part in gaseous exchange.

Normal value of alveolar ventilation is 4,200 mL (4.2 L)/ minute

Dead space

Dead space is defined as the part of the respiratory tract, where gaseous exchange does not take place. The air present in the dead space is called dead space air.

Dead space is of two types:

I. Anatomical dead space.

II. Physiological dead space.

Physiological Dead Space

Physiological dead space includes the anatomical dead space volumes: plus two additional

1. The air in the alveoli, which are nonfunctioning. some of the respiratory diseases, alveoli do not function because of dysfunction or destruction of alveolar membrane
2. The air in the alveoli, which do not receive adequate blood flow. Gaseous exchange does not take place during inadequate blood supply

Normal value and measurement of dead space

Under normal conditions, the physiological dead space is equal to anatomical dead space. It is because, all the alveoli are functioning and all alveoli receive adequate blood flow in normal conditions. The volume of normal dead space is 150 ml.

In respiratory disorders, which affect the pulmonary blood flow or the alveoli, the dead space increases. It is associated with reduction in alveolar ventilation. The dead space is measured by single breath nitrogen washout method.