Respiratory pressures

Two types of pressures are exerted in the thoracic cavity and the lungs during the process of respiration:

1. Intrapleural pressure or intrathoracic pressure.
2. Intra-alveolar pressure or intrapulmonary pressure.

Intrapleural pressure

It is the pressure existing in pleural cavity, that is, in between the visceral and parietal layers of pleura. It is exerted by the suction of the fluid that lines the pleural cavity. It is also called intrathoracic pressure since it is exerted in the whole of thoracic cavity. Intrapleural pressure is always negative.

- ***Importance of Intrapleural Pressure*:**
  1) Throughout the respiratory cycle intrapleural pressure remains lower than intra-alveolar pressure; this keeps the lungs always inflated.
  2) It prevents the collapsing tendency of lungs.
  3) It causes dilatation of vena cava and larger veins in thorax.

Intra-alveolar pressure

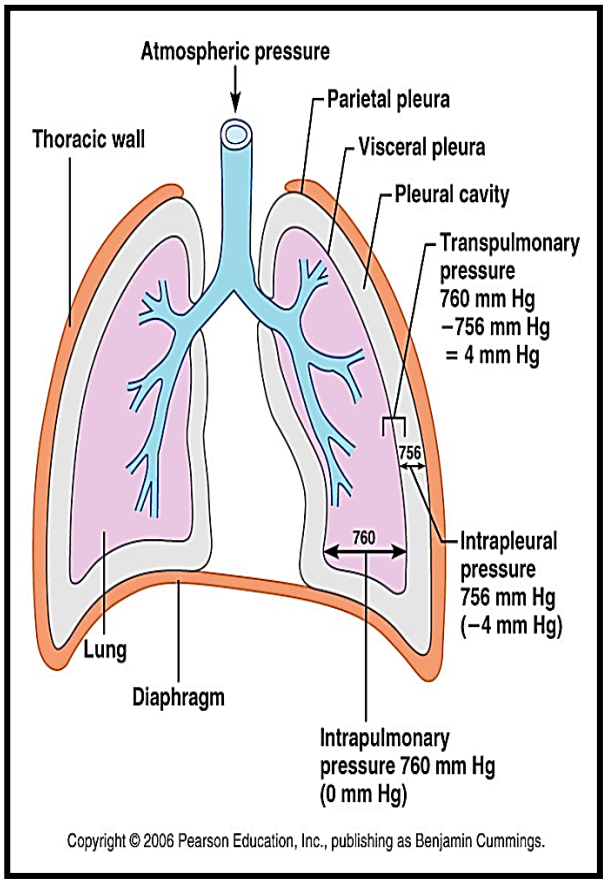
It is the pressure existing in the alveoli of the lungs. Normally, intra-alveolar pressure becomes negative during inspiration and positive during expiration.

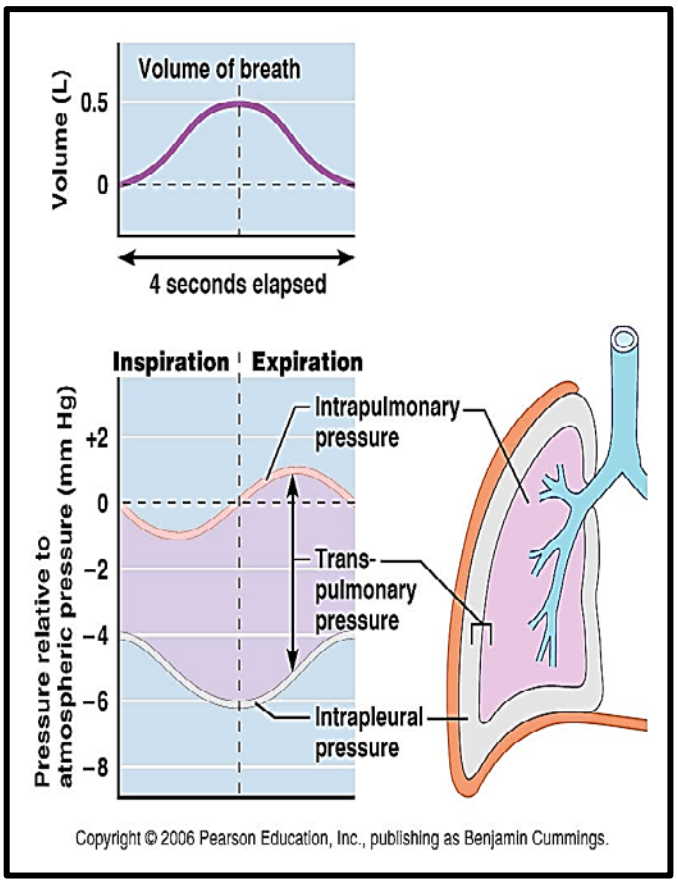
- ***Importance of Intra-alveolar Pressure***
  1) It causes flow of air in and out of alveoli. During inspiration, the intra-alveolar pressure becomes negative, so the atmospheric air enters the alveoli. And, during expiration, the air is expelled out of alveoli
  2) It also helps in the exchange of gases between the alveolar air and the blood.

1- Transpulmonary Pressure

It is the difference between intra-alveolar pressure and intrapleural pressure.

Changes in respiratory pressures during inspiration and expiration '0' indicate the normal atmospheric pressure (760 mm Hg).





Factors causing collapsing tendency of lungs

Two factors are responsible for the collapsing tendency of lungs

1. Elastic property of lung tissues which show constant recoiling tendency and try to collapse the lungs.
2. Surface tension exerted on the surface of the alveolar membrane by the fluid secreted from alveolar epithelium.

Fortunately, there are some factors which save the lungs from collapsing.

Factors preventing collapsing tendency of lungs

Two factors preventing collapsing tendency of lungs. In spite of the elastic property of the lungs and the surface tension in the alveoli of lungs, the collapsing tendency of lungs is prevented by two factors:

1. Intrapleural pressure which is always negative. Because of negativity, it keeps the lungs expanded and prevents the collapsing tendency of lungs produced by the elastic tissues.
2. Surfactant secreted in alveolar epithelium. It is surface acting materials that decrease surface tension on the alveolar membrane and prevents the collapsing tendency produced by surface tension.

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.

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

Variation in Compliance

Compliance decreases in pathological conditions such as:

1. Deformities of thorax.
2. Paralysis of respiratory muscles.
3. Pleural effusion.
4. Fibrosis
5. Abnormal thorax.

Compliance increases in physiological and pathological conditions.

1. In old age, lung compliance increases due to loss of elastic property of lung tissues.
2. In emphysema, lung compliance increases because of damage of alveolar membrane.

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.

During normal quiet breathing, all respiratory muscle contraction occurs during inspiration; expiration is almost entirely a passive process caused by elastic recoil of the lungs and chest cage. Thus, under resting conditions, the respiratory muscles normally perform "work" to cause inspiration but not to cause expiration.

The resistance and work of breathing

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

1. **Airway resistance (airway resistance work)**

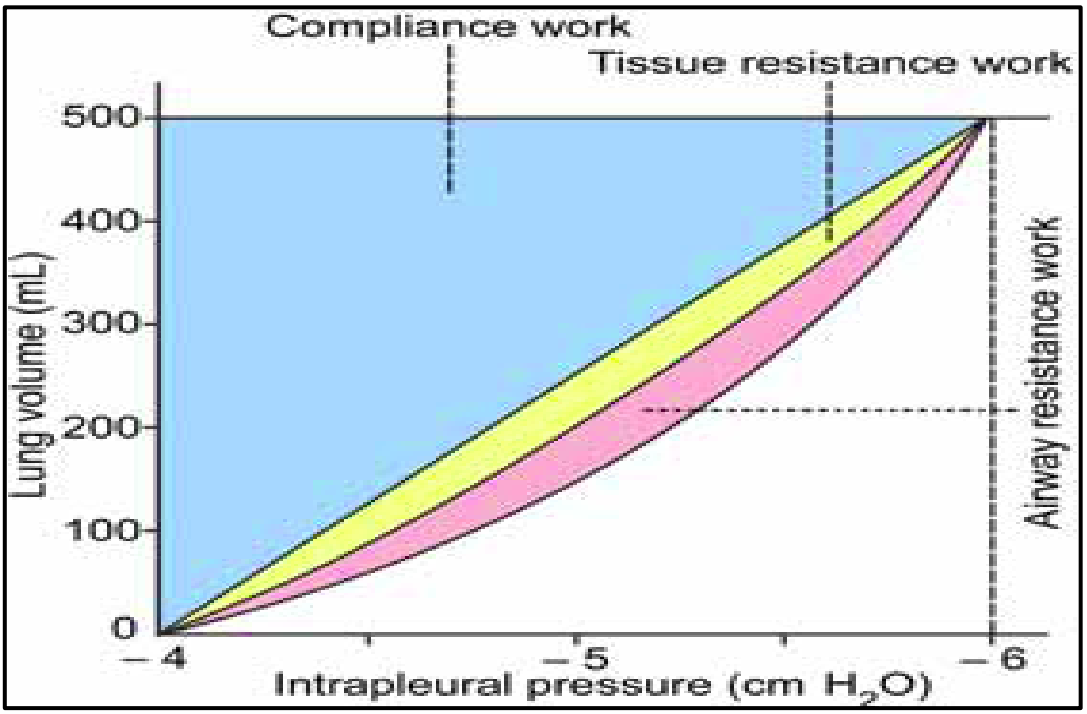
   Airway resistance is the resistance offered to the passage of air through respiratory tract. Resistance increases during bronchiolar constriction, which increases the work done by the muscles during breathing. Work done to overcome the airway resistance is called airway resistance work.

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

   Energy is required to expand lungs and thorax against the elastic force. Work done to overcome this elastic resistance is called compliance work.

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

   Energy is also required to overcome the viscosity of lung tissues and tissues of thoracic cage. Work done to overcome this viscous resistance is called tissue resistance work.



Work of breathing

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 anatomical dead space plus two additional volumes:

1. The air in the alveoli, which are nonfunctioning. In 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.*

Respiratory Protective Reflexes

Respiratory protective reflexes are the reflexes that protect the lungs and air passage from foreign particles. The respiratory protective reflexes are:

1- Cough Reflex

Cough is a modified respiratory process characterized by forced expiration. It is the protective reflex that occurs because of irritation of respiratory tract and some other areas such as external auditory canal. Cough begins with deep inspiration followed by forced expiration with closed glottis. This increases the intrapleural pressure above 100 mm Hg. Then, glottis opens suddenly with explosive outflow of air.

2- Sneezing Reflex

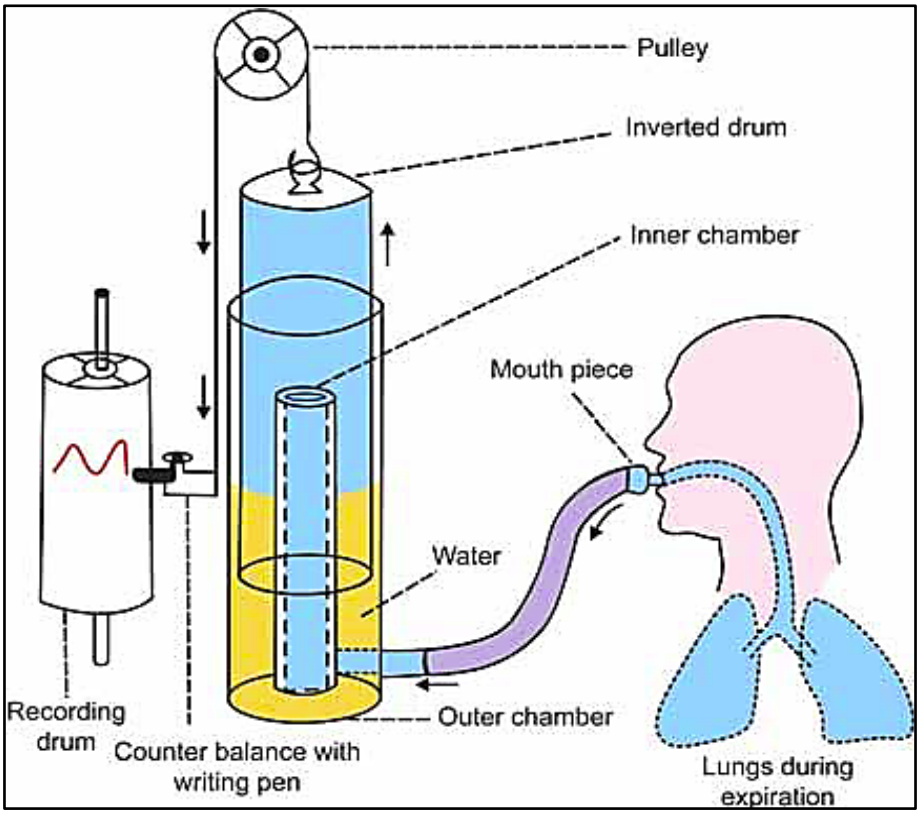
Sneezing is also a modified respiratory process characterized by forced expiration. It is the protective reflex caused by irritation of nasal mucous membrane. This irritation occurs because of dust particles, debris, mechanical obstruction of the airway, and excess fluid accumulation in the nasal passages. Sneezing starts with deep inspiration, followed by forceful expiratory effort with opened glottis resulting in exclusion of irritant agents out of respiratory tract.

3- Swallowing Reflex (Deglutition)

Swallowing is a respiratory protective reflex that prevents entrance of food particles into the air passage during swallowing. While swallowing of the food, the respiration is arrested for a while. The temporary arrest of respiration is called apnea. The arrest of breathing during swallowing is called swallowing apnea or deglutition apnea.

Pulmonary function tests

Pulmonary or lung function tests are useful in assessing the functional status of the respiratory system. These tests involve measurement of lung volumes and capacities. Pulmonary ventilation can be studied by recording the volume movement of air into and out of the lungs, a method called ***spirometry***. Pulmonary function tests are carried out mostly by using spirometer. The graphical recording of lung volumes and capacities is called ***spirogram***.



Spirometer: During expiration, the air enters the spirometer from lungs. The inverted drum moves up and the pen draws a downward curve on the recording drum.