Respiratory System

Respiration: is the process by which oxygen from the lungs is carried by the blood to the tissues; and carbon dioxide formed in the tissues by metabolic activity is carried by the blood to the lungs and is expired out. Respiration is the overall term for ventilation, gas exchange, and utilization in cells.

Stages of Respiration:

(1) ventilation (breathing);

(2) gas exchange, which occurs between the air and blood in the lungs and between the blood and other tissues of the body;

(3) oxygen utilization by the tissues in the energy-liberating reactions of cell respiration.

Types of respiration:

1- External respiration is the uptake of oxygen into the body and the disposal of carbon dioxide in the atmosphere. Ventilation and the exchange of gases (oxygen and carbon dioxide) between the air and blood are collectively called external respiration.

2- Internal respiration is the use of oxygen in energy-producing reactions and the production of carbon dioxide. Gas exchange between the blood and other tissues and oxygen utilization by the tissues are collectively known as internal respiration.

Structure of the Respiratory Tract:

1. Upper respiratory tract extends from the upper nares to the vocal cord.
2. Lower respiratory tract extends from the vocal cord to the alveoli.

TRACHEA

- The trachea (windpipe) is a cartilaginous and membranous tube, about 10 or 11 cm long.
- It is not quite cylindrical, being flattened posteriorly, its external diameter from side to side is about 2 cm in the adult male and 1.5 cm in the adult female.
- It is kept patent by incomplete C-shaped rings of cartilage on its anterolateral wall, which keeps air tubes open.
- There are plenty of seromucous glands in the submucous coat innervated by the vagi. Mucous gland along with goblet cells traps dust in the inspired air and air is moistened by contact with moist lining of serous glands. The cilia beat spontaneously and by their movement drive out mucus-trapped foreign particles and bacteria towards the mouth from the respiratory passage.

Functions of Respiration:

1. Gas transfer: Transfer of O_2 from the alveoli to the venous blood and CO_2 in the opposite direction.
2. Regulation of pCO_2 of blood: The most important function of respiration is to keep the arterial pCO_2 at 40 mm Hg which is essential for many vital functions of the body.
3. Regulation of pH of blood: By the reversible reaction H_2CO_2 equilibrium.
4. Excretion of certain volatile gases, e.g. chloroform, ether, ammonia, etc.
5. Pumping action: The rhythmic movement of the diaphragm and chest wall causes rhythmic alteration of pressure in the abdomen and chest cavity. This assists in drawing blood from the lower part of the body to the abdomen and then to chest and thus helps in maintaining venous inflow to the heart.

Apart from the respiratory functions, the non-respiratory functions are:

1. Filtration of dust particles and inhaled antigens.
2. Warming and humidification of air.
3. Olfaction: The nerve endings in roof of nasal cavity are sensitized on exposure to different odorants from the external environment. The impulse travel down to olfactory cortex and aids in identifying different odors.
4. Phonation: Larynx has two vocal cords which lines the glottis. Pitch of the sound could be varied by the altering the size of the glottis, which occurs by contraction and relaxation of the laryngeal muscles. The air movement in lung passage helps in improvement of voice.
5. Reservoir for left ventricle.
6. Filtration of blood at the pulmonary capillaries.
7. Metabolic functions of the lungs: Lungs participate in uptake or conversion of chemical substances. The chemical substances formed in lungs and releases for local use are surfactant, histamine, serotonin, leukotrienes, platelet activating factor, prostaglandins, etc. The lower airways are lined by a large number of neuro-endocrine cells. These cells are responsible for the secretion and release of bradykinin, prostaglandins, serotonin, substance P, heparin and histamine. Lung also participates in conversion of angiotensin I to angiotensin II and the catabolism of bradykinins, adrenaline and noradrenaline. Waste products and metabolites are excreted via the lungs as volatile gases (e.g. ethanol, acetone).

Intra-pleural Pressure: is pressure in the pleural cavity (between the lungs and chest wall) , it is negative and amounts to -2.5 mm Hg at the end expiratory position. This means that the lungs are not completely collapsed and that alveoli remain partially inflated even after complete expiration.

Alveolar pressure: is the pressure within the alveoli.

Transpulmonary pressure: is alveolar pressure minus intrapleural pressure. Intrapleural pressure is always less than alveolar pressure; therefore, transpulmonary pressure is always positive. It is the positive transpulmonary pressure that keeps the lungs inflated (like a balloon) against the chest wall.

Mechanics of Ventilation: Ventilation occurs in a cyclical manner with alternating inspiratory and expiratory phases.

The movement of air into and out of the lungs occurs as a result of pressure differences induced by changes in lung volumes.

Inspiration: is an active process and is principally mediated by the diaphragm during quiet breathing.

– Contraction of the diaphragm enlarges the chest cavity, reducing intrapleural pressure. This increases the transpulmonary pressure and expands the lungs. Minimal movement of the diaphragm (a few centimeters) is sufficient to move several liters of gas.

– The external intercostal and accessory muscles are not necessary for resting respiration, but they contribute substantially to deep respiration during exercise and respiratory distress.

Expiration: is a passive process during quiet breathing. When the diaphragm relaxes, air is expelled from the lungs due to the elastic recoil of the lung–chest wall system. Active expiration (using muscles of expiration) occurs during exercise or in obstructive lung disease.

Relationship of Pressures and Airflow during the Breathing Cycle

- An unforced, or quiet, inspiration results primarily from contraction of the dome-shaped diaphragm, which lowers and flattens when it contracts. This increases thoracic volume in a vertical direction. Inspiration is aided by contraction of the parasternal and external intercostals, which raise the ribs when they contract and increase thoracic volume laterally. Other thoracic muscles become involved in forced (deep) inspiration. The increase in thoracic volume produced by these muscle contractions decreases intrapulmonary (intra-alveolar) pressure, thereby causing air to flow into the lungs.
- Quiet expiration is a passive process. After becoming stretched by contractions of the diaphragm and thoracic muscles, the thorax and lungs recoil as a result of their elastic tension when the respiratory muscles relax. The decrease in lung volume raises the pressure within the alveoli above the atmospheric pressure and pushes the air out. During forced expiration, the internal intercostal muscles contract and depress the rib cage. The abdominal muscles also aid expiration because, when they contract, they force abdominal organs up against the diaphragm and further decrease the volume of the thorax. By this means, the intrapulmonary pressure can rise 20 or 30 mmHg above the atmospheric pressure.

Factors which prevent lung from collapsing:

1. Surfactant is a mixture of molecules produced by secretory cells of alveolar epithelium. Surfactant reduce the surface tension of the thin fluid lining the alveoli (without it the recoil of the alveoli can be x10 times greater).
2. Pleural pressure: balloon principle: Balloon expands when pressure inside it is greater than pressure outside. Decreasing pressure in the pleural cavity thus result in the expansion of the alveoli.