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COLLAGE OF DENTISTRY

الفرع العلمي: العلوم الاساسية

المادة: General Physiology

المحاضرة: The Respiratory System

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The Respiratory System

The two system that supplied O_2 and eliminate CO_2

Are the cardiovascular system and respiratory system?

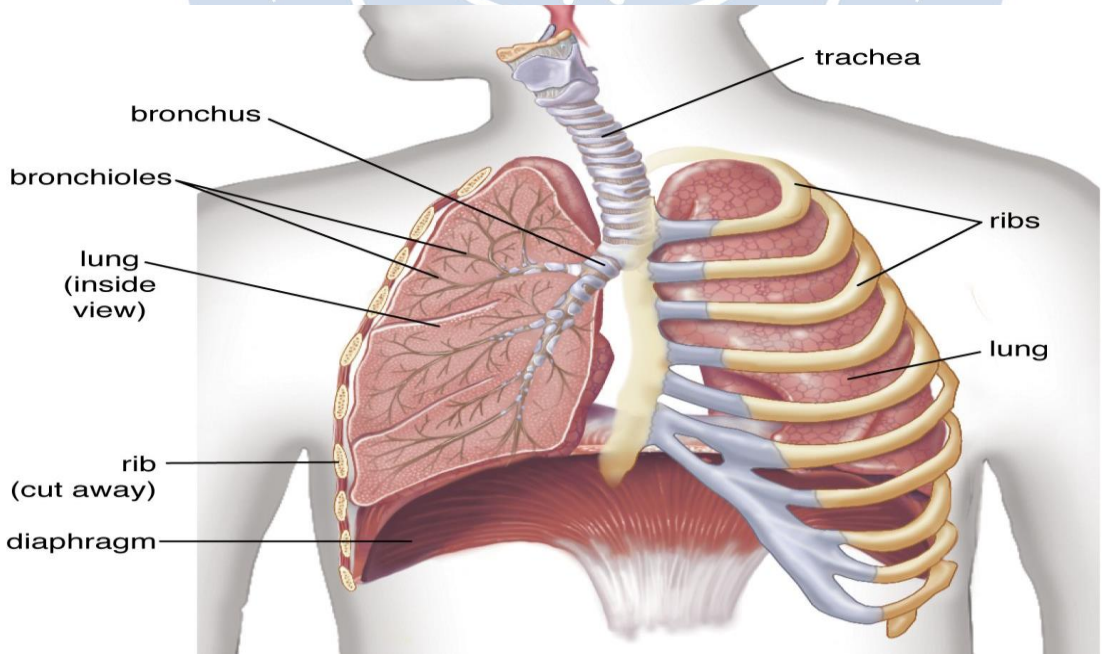
The respiratory system consists of a set of passage ways that Carry gases to and form from the respiratory membranes, which gases diffuse between the lungs and the blood.

The r.s consist of organs that exchange gases between atmosphere and blood . These organs are **1**-nose **2**-pharynx **3**-larynx **4**-trachea **5**-brochi **6**-lungs.

The upper, r.s consist of nose, pharynx and larynx.

The lower r.s = trachea, bronchi and lungs.

Respiration; is the overall exchange of gases between the Atmosphere, blood and cells.



**There are three basic processes involved in respiration:-

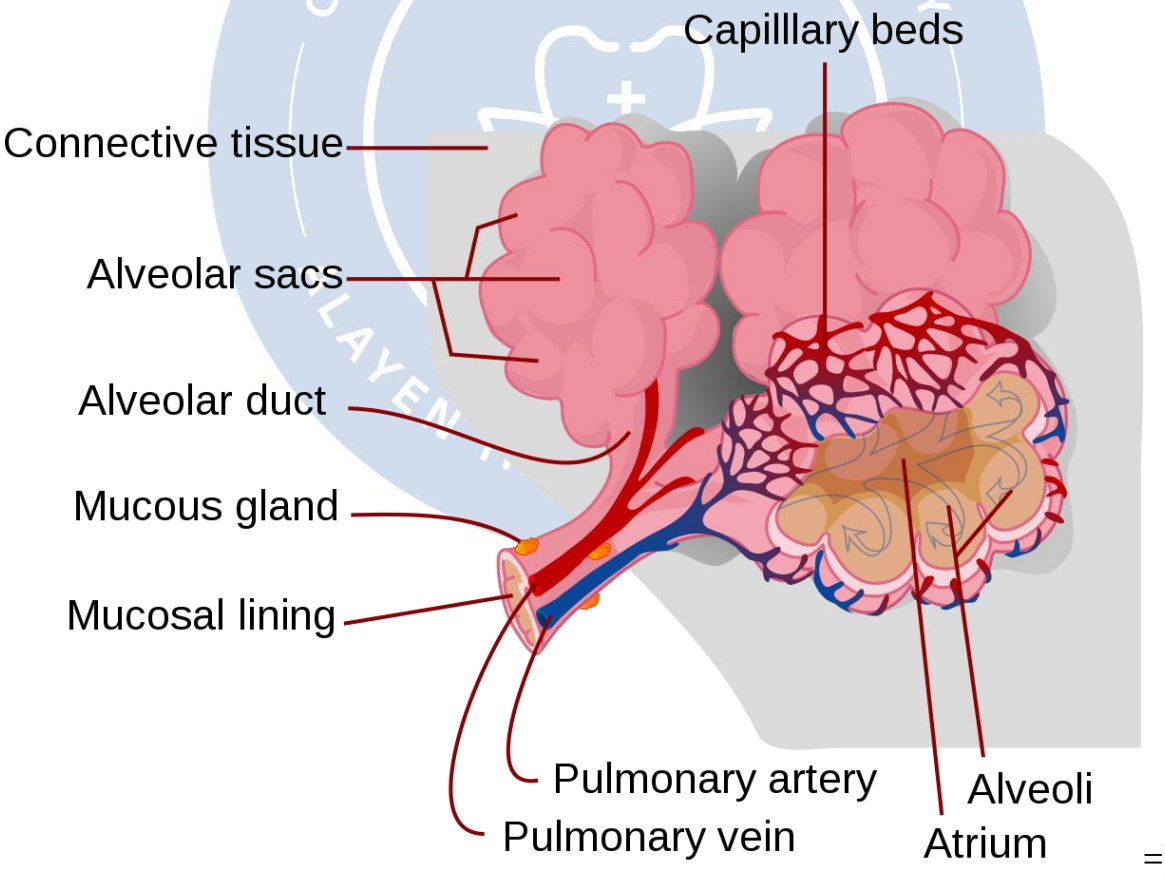
1-pulmonary ventilation(breathing);is the inspiration(in flow) and expiation(out flow) of air between the atmosphere and the lung.

2-External respiration;-is the exchange of gases between the lungs and the blood.

3-Internal respiration: the exchange of gases ,between the blood

and the cells.

*The functional structures of the lung is the alveoli plus the alveolar sac. over the alveoli the arterioles and venules disperse into a capillary network.



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Parts of respiratory system:

A)**Nose** consist of:-

1-External nares 2-Nasal cavity 3-Nasal septum

4-conchae 5-Internal nares.

*Nasal cavity in the internal position contain vestibule

B)**pharynx**(throat)

is a muscular tube lined by mucous membrane and divided into:-

1-nasopharynx:-functions in respiration

2-oro pharynx /functions in digestion and respiration.

3-laryngo pharynx/ functions in digestion and respiration.

Functions are

1-serves a passageway for air and food

2-provide a resonating chamber for speech sounds.

C)Larynx (voice box)

it is a short passageway that connects the pharynx with the trachea.

The larynx contain:-

1-cartilages (nine in number).

2-vocal folds (vocal cords)which produce sounds

*The larynx is lined with ciliated columnar cells, goblet cells, and basal cells and provide some protection a against dust.

D)Trachea

It is a tubular passageway for air extends from the larynx to the primary bronchi. It is composed of smooth muscle and C-shaped ring of hyaline cartilage and is lined with pseudo stratified epithelium .

Functions

1-protection against dust

2-the C-shaped cartilage provide a rigid support to prevent tracheal collapse inward and then prevent obstruction of air passageway.

3- the presence of the smooth muscle and elastic C.T in the trachea allow it to dilate and constrict the air passageway according to the physiological state.

E)Bronchi

The trachea terminates in the chest by dividing at the sternal angle into:-

1-right primary bronchus which goes to the right lung.

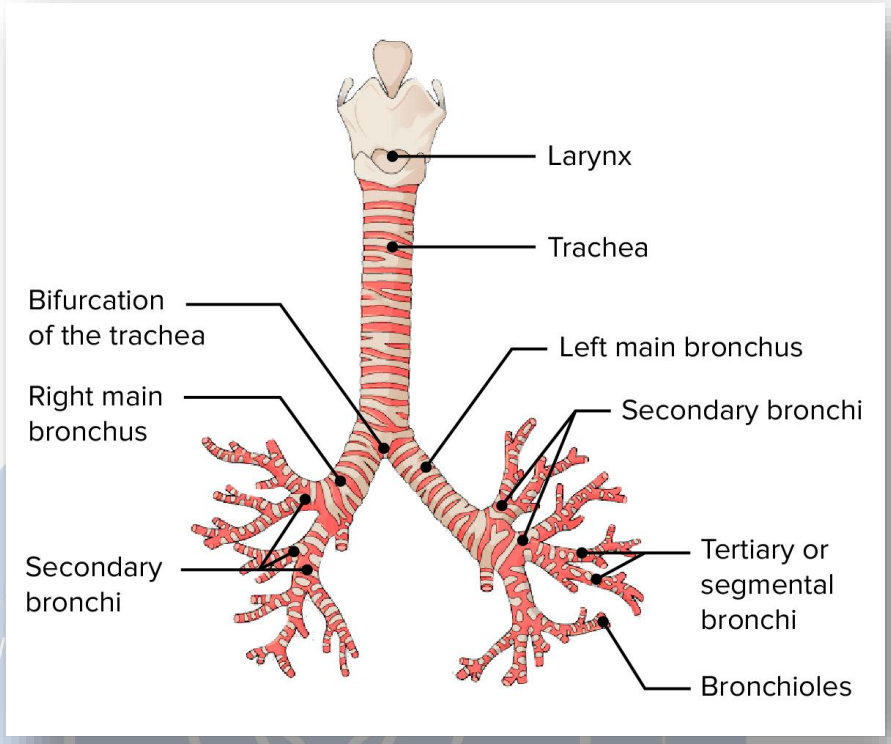
2-left primary bronchus goes to the left lung.

The bronchi (like trachea) contain incomplete ring of cartilages and are lined by pseudostratified ciliated epithelium.

On entering the lungs ,the primary bronchi divides as follows:

Primary bronchus→ secondary(lobar)bronchi(one for each lobe of the lung (the right lung has 3 lobes and the left has 2 lobes in human)→ tertiary(segmental)bronchi → that divided into bronchioles →terminal bronchioles→ resp. bronchioles→ alveolar ducts →alveolar sacs +alveoli

*This continuous branching from trachea to form a tree trunk with it is branches called



the bronchial tree.

F)Lungs

The lungs are paired cone_ shaped organs lying in the thoracic cavity They enclosed and protected by two layers of serous membrane. Called Pleural membrane. Pleural membrane is consists of :-

1-parietal pleura:-the outer layer which attached to the wall of the thoracic cavity.

2- visceral pleura :-the inner layer which cover the lungs.

Between the visceral and parietal pleura is the pleural cavity which contains a lubricating fluid secreted by the membranes. This fluid prevent frictions between the membranes and allows them to move easily on one another during breathing.

*The functional structures of the lung is the alveoli plus the alveolar sac. over the alveoli the arterioles and venules disperse into a capillary network.

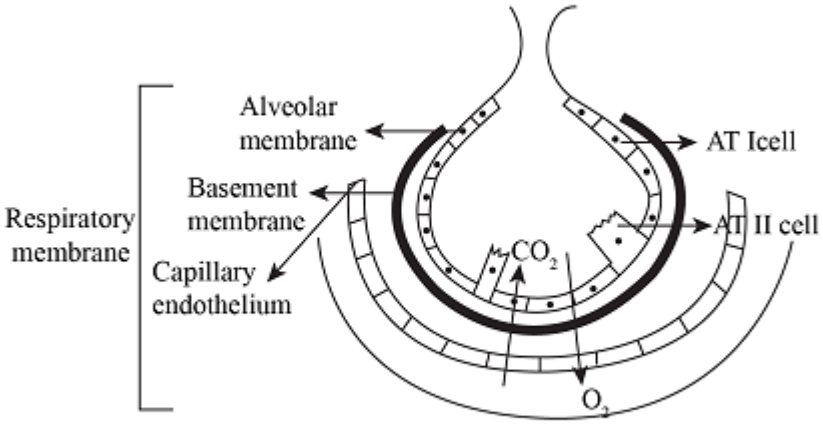
Alveolar_ capillary Membrane (Resp. membrane): It is the membrane across it the exchange of resp. Gases between the lungs and blood takes place by diffusion. This membrane is consist of:-

1-Alvoelar wall A layer of squamous pulm . epith cells with septal cells and free alveolar macrophages.

2-An epithelial basement membrane under the alveolar wall.

3- A capillary basement membrane that is often fused to the epith. Basement membrane.

4-The endothelial cells of the capillary.



*septal cells function in producing a phospholipid substance called surfactant which lowers surface tension.

*Alveolar macrophages(dust cells)are highly phagocytic cells that remove dust particles or other debris from alveolar spaces.

Physiology of respiration

1-pulmonary ventilation

It is the process by which gases are exchanged between atmosphere and lung alveoli.

→ Air flows between the atmosphere and lung a long with pressure gradient. Air moves into the lungs when the pressure inside the lungs is less than the air pressure in the atmosphere (inspiration) and air moves out of the lungs when the pressure inside the lungs is greater than the pressure in atmosphere (expiration).

A)Inspiration (inhalation)

*The pressure of a gas in closed container is inversely proportional to the volume of the container.

↑ Size of the container→ ↓ pressure inside the container .

↓Size of the container→ ↑ pressure inside the container.

in order for inspiration to occur, the lungs must be expanded. This increase lung volume and thus decreases the pressure in the lung bellow than the atmosphere pressure this differences in pressure force air into the lungs during (inhalation) .The first step toward increasing lung volume involves contraction of the inspiratory muscle (the diaphragm and external intercostals muscle).

***Eupnea** :-mean the normal quit breathing which involves:

1-costal breathing:-it is shallow breathing. It consists of an upward and outward movement of the chest as a result of contraction of the external intercostal muscles.

2-Diaphragmatic breathing :-it is deep breathing .It consists of the outward movement of the abdomen as a result of the contraction and descend of the diaphragm.

3-Deep labored inspiration(breathing):It consists of the outward movement of the abdomen as a result of the contraction of the diaphragm and accessory muscles of inspiration.

*The pressure between the two pleural layers called intraplural pressure (always sub atmosphere pressure=756MmHg).

The Ipp ↓ during inspiration (during ↑ed thoracic cavity size).

B)Expiration (exhalation)or breathing out

-Is also achieved by a pressure gradient.

-Normal expiration during quiet breathing is a passive process since no muscular contraction are involved .It depends on the elasticity of the lungs

-Expiration starts when the inspiratory muscles are relaxed. These movement (relaxation of insp. muscles)decrease the diameters of thoracic cavity (vertical and anterior- posterior dimensions)and then returns to its resting size.

Decrease the volume of thoracic cavity → ↑pressure (intrapulmonic)

=763→↑ IPP → expiration.

* At the end of expiration, the alveoli attempt to recoil inward and collapse on themselves.

Respiratory volumes and capacities

Spirometer: is the instrument used in measuring the respiratory rate and capacity (also called respirometer)

Spirogram(spirometry):-the process of recording the resp. rate and capacities.

Rv= Residual volume

IRv=inspiratory Reserve Volume

ERV =expiratory Reserve Volume

TV=Tidal volume

Tidal volume :- is the volume of air inspired or expired with each normal breath .(TV=500ml).

Inspiratory reserve Volume :-is the extra volume of air that can be inspired over the normal tidal volume (IRV= 3000ml).

Expiratory reserve volume : is the amount of air that can still be expired by forceful expiration after the end of a normal expiration (ERV= 1100ml).

Residual volume : is volume of the air still remaining in the lungs after the forceful expiration (RV = 1200ml).

The inspiratory capacity (IC) = TV + IRV = 2500 ML.

The functional residual capacity (FRC) = ERV+ RV = 2300ml.

It is the amount of air remaining in the lungs at the end of normal expiration.

The vital capacity (vc) :- = IRV + TV + ERV = 4600ml.

It is the maximum amount of air that a person can expel from the lungs after maximum inspiration & maximum expiration.

The total lungs capacity: (TLC) := IRV + TV + ERV + RV = 5800ml.

It is the maximum volume to which the lungs can be expanded with the greatest possible inspiratory effort.

2- External Respiration :

Is the exchange of O_2 & CO_2 between the alveoli of the lungs & pulmonary blood capillaries.

The PO_2 of the deoxygenated blood entering the pulmonary capillaries = 40 mm.Hg. & the PO_2 of alveolar air = 105 mm.Hg. As a result of this differences in Po_2, O_2 diffuses from the alveoli into deoxygenated blood until equilibrium is reached so that the Po_2 of the blood reach 105= mmHg.

At the same time the CO_2 diffuses in the opposite direction. The Pco_2 of deoxygenated blood entering the pulmonary capillaries = 45 mmHg. & the Pco_2 of alveolar air = 40mmhg. Because of this differences in Pco_2 , CO_2 diffuses from pulmonary deoxygenated blood into the alveoli until the Pco_2 of the blood decreases to 40 mmHg.

3- Internal Respiration :

Is the exchange of O_2 & CO_2 between tissue blood capillaries & tissue cells.

Oxygenated blood entering tissue capillaries has a Po_2 = 105 mm Hg. , whereas tissue cells have a Po_2 = 40 mm Hg. Because of this difference in Po_2 , O_2 diffuses from the

oxygenated blood through interstitial fluid & into tissue cells until the Po_2 in the blood decreases to 40 mm Hg.

At the same time the CO_2 diffusion in the opposite direction. The Pco_2 of tissue cells = 45 mm hg, whereas that of tissue capillary oxygenated blood = 40 mm hg. As a result , CO_2 diffuses from cells through interstitial fluid into the oxygenated blood until the PCO_2 in the blood increases to 45 mm hg.

* The deoxygenated blood now returns to the heart. From here it is pumped to the lungs for another cycle of external respiration.

Transport of Respiratory Gases:

The transportation of respiratory gases between the lungs & body tissue is a function of the blood. When O_2 & CO_2 enter the blood, certain physical & chemical changes occur that aid in gas transport & exchange.

Oxygen Transport:-

1- 3% of O_2 dissolved in plasma.
2- 97% of O_2 is carried in chemical combination with Hb in RBC.

*** Hemoglobin & Po_2**

→ PO_2 is the most important factor that determine how much oxygen combines with Hb.

* When Hb is completely converted to HbO_2 it is fully saturated.

* When Hb consist of a mixture of Hb & HbO_2 , it is partially saturated.

* Hb saturation %= $\frac{HbO2}{total\ Hb}$ x 100.

⟶ oxygen -Hb dissociation curve in the relationship between the percent saturation of Hb & Po_2.

* When PO_2 is high → Hb binds with large amount of O_2 or fully saturated.

* When PO_2 is low → Hb binds little amount of O_2 or partially saturated.

↑ PO_2 ⟶ ↑ HbO_2 & $Hb.CO_2$

↓PO_2 ⟶ ↓ HbO_2 & $Hb.CO_2$

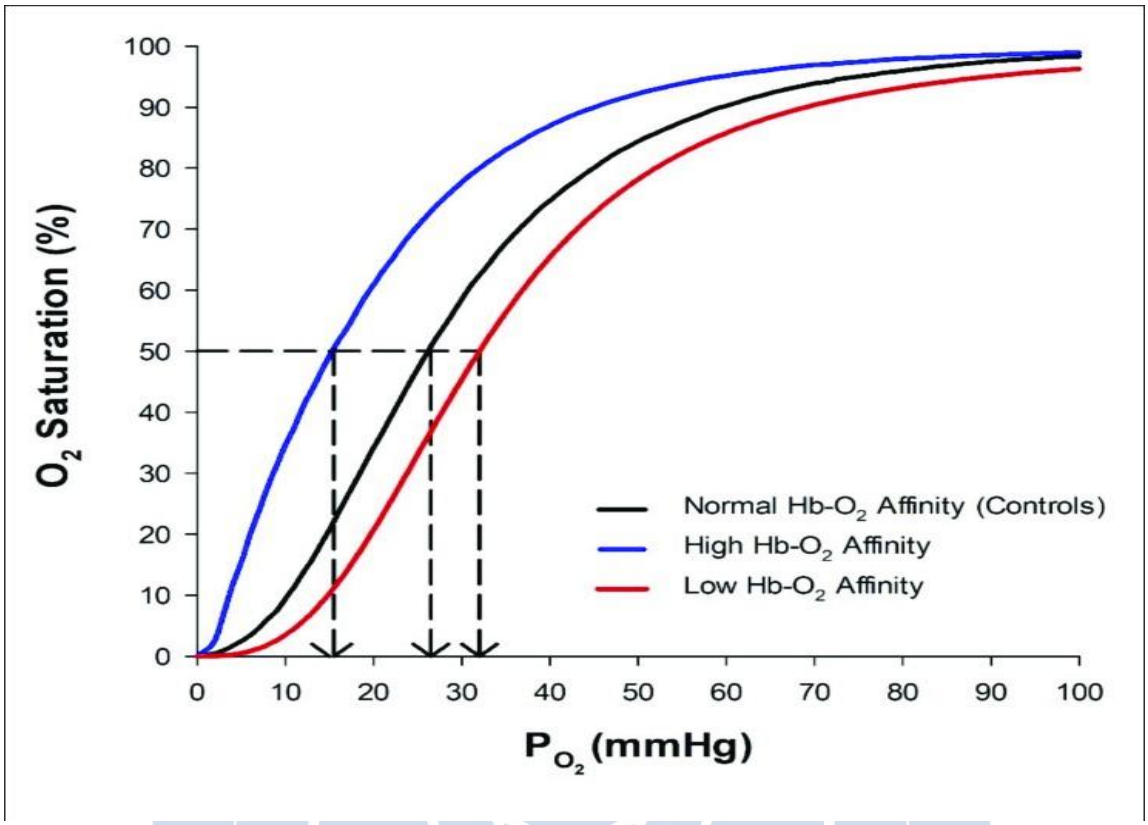
In pulmonary capillaries

High PO_2 ⟶ ↑ HbO_2 reaching saturation (oxygenated blood)

In tissue capillaries

Low PO_2 ⟶ ↓ HbO_2 (release of O_2) (deoxygenated blood)

O_2- Hb dissociation curve showing the relationship between PO_2 & Hb saturation . (Also called normal O_2 – Hb dissociation curve)



Hypoxia

It is a deficiency of O_2 at the tissue level. Based on the cause, hypoxia classified as follows :

1- Hypoxic hypoxia :- it is caused by a low PO_2 in arterial blood which may be a result of:

a. High attitude
b. Obstructions of air passageway.
c. Fluid in the lungs.

2- Anemic hypoxia :- caused by too little functioning Hb in the blood. Which may be a result of :-

a- Hemorrhage

b- Anemia

c- Failure of Hb to carry its normal completed of O_2 as in CO poisoning.

3- Stagnant hypoxia :- caused by inability of blood to carry O_2 to tissue, fast enough to sustain their need which may be a result of:

a. Heart failure.

b. Circulatory shock.

4- Histotoxic hypoxia : in this condition, the blood delivers adequate O_2 to tissue, but the tissue are unable to use it properly which result from :

a. Cyanide poisoning :

Cyanide blocks the metabolic machinery of cells related to oxygen utilization.

Control of Respiration :

1- Neural control of Respiration

Respiration is controlled involuntary by centers found in the brain (in the medulla oblongata & pons)

These centers are classified into the following areas:-

a. **Inspiratory center** it is a group of neurons localized in the dorsal part of the medulla at the left & right sides. Stimulation of this receptor lead to inspiration by stimulation of inspiratory muscles (diaphragm & external intercostal muscles).

b. **Expiratory Center**: is a group of neurons localized in the medulla superior & lateral to the inspiratory center. Stimulation of this center will lead to expiration .(labor expiration) by stimulation of expiratory muscles.

c. **Apneustic center** is group of neurons localized at the left & right sides of pons. This center controls the inspiratory center d.pneumotaxic center. is group of neurons localized at the left & right sides superior to the apneustic center in the pons. This center control the inspiratory indirectly via the apneustic center.

2- Chemical control of Respiration:

↑CO_2& ↓PH ⟶ ↑respiratory rate

↓O_2 ⟶ ↑ respiratory rate.

a. Central chemoreceptor it is a chemo sensitive area found in the ventral surfaced of the medulla oblongata.

It is sensitive to the hydrogen ion concentration.

CO_2 in the blood ⟶ ↑ CO_2 in the cerebrospinal fluid.

⟶ ↑H_2CO_3 ⟶ ↑ H^+ ⟶ st. the chemo sensitive area.

⟶St. the inspiratory center.

b. Peripheral chemoreceptor sensitive to ↑CO_2 , ↓O_2, ↓PH.

3- Other receptor influence respiration:

a. Lungs receptors.

1- Pulmonary stretch receptors.

2- Irritant receptors a) smoking b) cold c) inhaled dust.

3- Jaxta – capillary receptor , (found in bronchi & bronchioles)sensitive to chemicals also.

b. Receptors outside the lungs.

Nose & upper airways receptors: stimulated chemically & mechanically leading to sneezing ,coughing ,etc.

-Arterial baroreceptors : ↑blood pressure→st. at baroreceptors→

⟶hypoventilation

-↓bl. Pressure⟶ inhibition of baroreceptor⟶ hyperventilation

Respiratory Disorders:

Bronchial asthma it is reversible obstructive airway disease characterized by periods of coughing, difficult breathing & wheezing that reverse either spontaneously or with treatment.

Bronchial asthma is usually caused by allergic hypersensitivity of the person to foreign substances in the air.

Bronchitis :

Is inflammation of the bronchi characterized by hypertrophy & hyperplasia of seromucous glands & global cells lining the bronchial airways.

*The typical symptom is a productive cough in which a thick greenish – yellow sputum is raised.

* The most important cause of chronic bronchitis is cigarette smoking.

Emphysema

In emphysema, the alveolar walls lose their elasticity &remain filled with air during expiration. The first symptom is reduced forced expiratory volume & later, alveoli of other areas of the lungs are damaged. The patient has to work voluntary to exhale & the

O_2 diffusion does not occur as easily across the damage alveolar – capillary membrane emphysema is generally caused by a long – term irritation by air pollution or cigarette smoke.

Pneumonia

It is an acute infection or inflammation of lungs tissue (especially alveoli). In this disease, the alveolar sacs fill up with fluid & dead WBC reducing the amount of air space in the lungs.

The most common case of pneumonia is the pneumococcus bacterium (streptococcus pneumonia)

Respiratory failure

It is a condition in which the respiratory system cannot supply sufficient O_2 to maintain metabolism or cannot eliminate enough CO_2 to prevent respiratory acidosis.

Pulmonary edema

It is an abnormal accumulation of fluid in that interstitial space & alveoli of the lungs.

Causes (1) pulmonary origin:- increased pulmonary capillary permeability (2) cardiac origin: increased pulmonary capillary pressure. e.g congestive heart failure. symptom (1) dyspnea(the most common symptom)(2) wheezing (3) tachypnea (4) restlessness(5) cyanosis (6) paleness (7) diaphoresis.

Medical Terminology Associated with the Resp. System.

Asphyxia: O_2 starvation due to low atmosphere O_2 or interference with ventilation external respiration or internal respiration.

Aspiration : Inhalation of a foreign substance such as water, food, or foreign body into the bronchial tree.

Bronchiectasis: A chronic dilation of the bronchi or bronchioles.

Diphtheria: an acute bacterial infection that causes the mucous membranes of the oropharynx, nasopharynx & larynx to enlarge &became leathery.

Dyspnea: painful or labored breathing.

Epistaxis: Loss of blood from the nose due to trauma infection, allergy, neoplasms & bleeding disorders.

Hemoptysis: spitting of blood from the respiratory tract.

Cyanosis: blueness of the skin due to the excessive amount of deoxygenated blood in the skin blood vessels.

Pneumonectomy: surgical removal of a lungs.

Rales : Sounds sometimes heard in the lungs that resemble bubbling or rattling.

Rhinitis: Chronic or acute inflammation of the mucous membrane of the nose.