PHYSIOLOGY

Control of Breathing

FEBRUARY 19, 2019

اعداد
لجنة التبيض

Topic from this lecture:

- **To complete talking about the role of (RS) in acid-base balance .**
- **To talk about chemoreceptors.**

INTRODUCTION

* As we mentioned previously that O_2 is loaded on the RBCs until it's (25 , 50 , 75 and 100)% saturated .

- CO_2 is carried through the lamous equation:

$$CO_2 + H_2O \longleftrightarrow H_2CO_3 \longleftrightarrow H^+ + HCO_3^-$$

This equation:

1. It happens in the plasma (RBC) with the assist of carbonic anhydrase enzyme.
2. At the level of tissue →

$$CO_2 + H_2O \longrightarrow H_2CO_3 \longrightarrow H^+ + HCO_3^-$$

3. At the level of the lung →

$$H^+ + HCO_3 \longrightarrow H_2O + CO_2 \longrightarrow \text{Expiration}$$

NOTE !!

a. Diffusion of gas through alveolar wall is through *simple diffusion* .
b. All gases are lipid soluble but there is variation in this solubility percentage .
c. CO_2 is 40 time more lipid soluble than O_2 . (CO_2 more lipid soluble than O_2) .
d. Gases are transported with electrochemical gradient .

Control of Breathing

Spontaneous respiration depends completely on a collection of neurons in the brain stem called collectively the **respiratory center**. The neurons of the respiratory center are present in the pons and medulla.

Respiratory centers

Medullary center **Pontine center**

REGULATION OF RESPIRATION:

The activity of the respiratory center is regulated by:-

I. *Nervous factors.*
II. *Chemical factors.*

I- Nervous regulation of respiration

* Activity of respiratory centers is that they have impulse and signals that affect diaphragm and intercostal muscles.

→ inspiration ⟶ *contraction* of diaphragm and *abduction* and *eversion* of external intercostal muscles.

* The breathing process is consist of **inspiration** and **expiration** that might be passive or active .

- **Inspiration** ⟶ active process.
- **Expiration** ⟶ passive process. (because we only relax the already contract muscles).
- **Forced inspiration** ⟶ active process.
- **Forced expiration** ⟶ active process. (because it includes contraction of the internal intercostal muscles and anterior abdominal wall muscles).

* respiration is controlled by R.C. in brain which is affected by :

1. Nervous factors → the R.C. receives signals and impulse from all over the body (ex: heart muscles) to control breathing process. (further explanation in 3rd year).
2. Chemical factors → concentration of (HCO_3^- , CO_2 and H^+) controls breathing in human beings and changes in its value might lead to "increase or decrease respiration rate" (Hyper ventilation or Apnea and so on) .

The activity of the respiratory centers is modulated by afferent impulses reaching it from other centers as well as from different parts of the body.

(1) Afferent impulses from higher centers

A- From the cerebral cortex:

* Cerebral cortex: it's the sheath that covers the brain and it controls many function including thinking, speaking, moving and so on.

The cerebral cortex regulates the *voluntary ventilation*, as **voluntary hyperventilation** and **voluntary apnea**.

1) **Voluntary hyperventilation** → leads to Co2 wash from the alveolar air (lung) → leading to respiratory alkalosis (decrease of $[H^+]$).
   - At the end **apnea** will occur.

2) **Voluntary apnea** → leads to accumulation of Co2, after one minute of apnea, Co2 accumulate to a high level which can stimulate the respiratory center inspire of the effort made to inhibit it, this point is called the breaking point. The period of apnea can be prolonged by a preceding period of hyperventilation before breath holding; to increase O2 tension and decrease Co2 tension.

   (((It occur until a certain limit of CO_2 concentration in the body and then it has to be washed out from the body))).

* How to win a competition of keeping your breath for longest time (Apnea) ?

1. Hyper ventilation to wash CO_2.
2. Deep inspiration.

B- Afferent impulses from the hypothalamus:

It can control respiration and affect the respiratory centers in the following conditions :

Pain , temperature and emotions (seeing , hearing and thinking) .

(2) Afferent impulses from different systems :

A- Afferent impulses from Respiratory system:

i. Sneezing reflex:

It is caused by irritation of the mucous membrane of the nose by foreign material which gives impulses along the trigeminal nerve to the respiratory center leading to deep inspiration followed by forced expiration (against glottis opened) which removes out the foreign material.

ii. Swallowing reflex:

Breathing is inhibited during swallowing by impulses from the pharynx that pass through the gloss pharyngeal nerve.

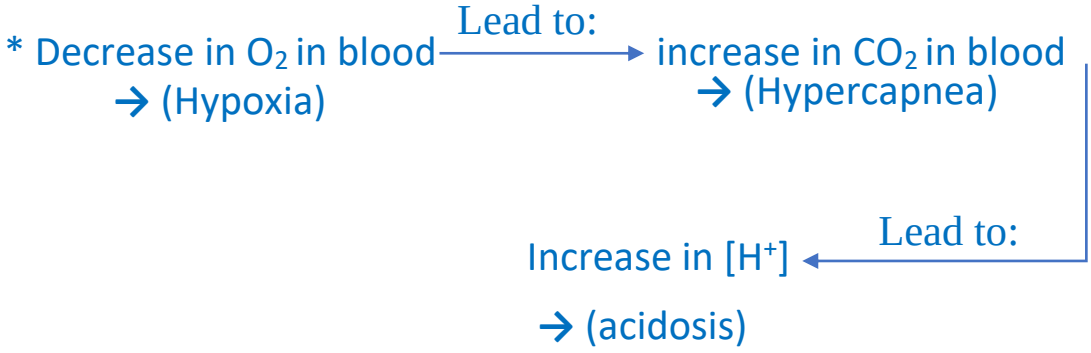
→ During eating glottis is closed and transient apnea occurs.

→ The presence of food in the end of the mouth stops respiration to prevent food from entering lungs .

iii. Cough reflex:

→ Irritant in the bronchial mucosa.

Stimulation of irritant receptors present in the airway, from trachea down to respiratory bronchioles by chemical or mechanical substance leads to reflex deep inspiration followed by deep forced expiration against closed glottis, which increases the intrapulmonary pressure that leads to sudden opening of the glottis and ejection of the foreign material.

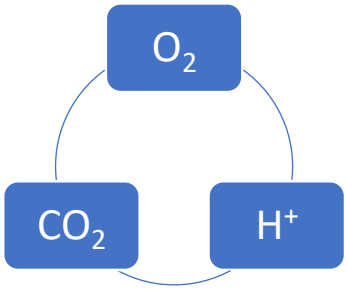


II- Chemical regulation of Respiration

Ventilation is regulated by the concentration of O2, CO2 and H+ in the arterial blood. This regulatory function is done through the chemoreceptors.

*Chemoreceptors → there are the receptor for O_2, CO_2 and H^+ concentration.

* Chemoreceptors are highly vascularized to since and defect the concentration of chemical in it .



All of them are stimulants for regulation the respiration, when hypoxia occur it's treated by increase in inspiration rate :

- Hypoxia → O_2 enters body.
- Hypercapnia → CO_2 is washed out through expiration .
- Acidosis → is treated when hypercapnia is .

There are two types of chemoreceptors: -

1) Peripheral chemoreceptors 2) Central chemoreceptor.

(both are sensitive for O_2, CO_2 and H^+ but the peripheral chemoreceptors are more sensitive for hypoxia while central chemoreceptors are more sensitive for hypercapnia "variable sensitivity") .

1) Peripheral chemoreceptors:

Site:-

a. Carotid bodies, at the bifurcation of the common carotid arteries.
b. Aortic bodies (thoracic entry) , located at the aortic arch.

Blood supply:-

The carotid and aortic bodies have a rich blood supply, and their response to changes in blood gases is very fast.

- These receptors respond to decreased arterial PO2, decreased pH, and increased CO2 concentration.
- Peripheral chemoreceptors are **more sensitive to decreased O2 tension** "hypoxia" (it is sensitive to all of them but especially the hypoxia) .

2) Central chemoreceptor :

Site:-

- They are located in the medulla oblongata close to the medullary respiratory centers. (in the brain) .
- It has a direct connection with the inspiratory centers.
- These receptors are stimulated **by increased CO2** level, and the mechanism of its activation is through H+ ions. (hypercapnia).
- NOTE : CO2 is the main stimulant for respiration , increase in CO2 level in the blood is what makes us regulate our respiration

N.B: H+ ions do not easily pass through the blood brain barrier (BBB), but it stimulates the central chemoreceptors as follow:

CO2 enter the **C.S.F** of the medulla, and then react with H20 to give carbonic acid which rapidly dissociates into HCO3 and H+ .

$$CO2 + H2O \rightarrow H2CO3 \rightarrow HCO3^- + H^+$$

- The released H ions stimulate respiration through stimulation of the central chemoreceptors.
- Central chemoreceptors are more sensitive to changes in CO2 and H+ concentration.

N.B

If respiratory (ex: pneumonia) depression is treated with pure O2, peripheral chemoreceptors will be inhibited leading to more respiratory depression. A gas mixture of 95% O2 and 5% CO2 is given instead to stimulate the central chemoreceptors by the CO2. (carbogen)

And this is an example of applied physiology

Ventilatory response to CO_2

The increase in Co2 tension of arterial blood stimulates respiration and increases pulmonary ventilation, while a decrease of CO_2 tension inhibits respiration.

NOTE: the increase of CO2 stimulates both chemoreceptors but mainly central chemoreceptors “MCQ”

Mechanism: increased CO_2 tension in arterial blood will stimulate R.C through respiratory chemoreceptors.

a- Central chemoreceptors:-

- As discussed above CO_2 diffuses through the (BBB) into the cerebrospinal fluid (C.S.F) passing the cells of the chemoreceptors.
- CO_2 is converted into H+ ions.

$CO_2 + H_2O$ H_2CO_3 H+ and HCO_3.

- The H+ ions stimulate the chemoreceptor cells (H+ ions receptors) which stimulate the neurons of the respiratory center.
- On the other hand, hyperventilation → lowers the CO_2 tension in alveolar air, CO_2 in arterial blood and CO_2 tension in the CSF. → This lowers the H+ concentration in the C.S.F. → leading to inhibition of R.C → leading to increased CO_2 tension in alveolar air and arterial blood to the normal level. (Alkalosis >> Apnea)

(b) Peripheral chemoreceptors:-

These receptors are sensitive to decreased O2 tension and to a **lesser extent to** increased H+ ion concentration and to increased CO2 tension of arterial blood.

Ventilatory response to H+ ion concentration

H+ ion concentration in the blood is proportional to the ratio of

$\frac{free\ CO2}{Bicarbonate}$ CO2 ↑ H+↑,,,, CO2 ↑ H+ ↑

Increased H+ ion concentration in arterial blood as in metabolic acidosis stimulates R.C, while decrease in H+ ion concentration will inhibit the R.C.

Mechanism:-

Increased H+ ion concentration **stimulates** peripheral chemoreceptors only, which send impulses along afferent fibers in the vagus and glossopharyngeal nerves to stimulate respiratory center.

MCQ:

Metabolic acidosis will stimulate?

Peripheral chemoreceptors only. (why?): because H+ can't cross (BBB)

Ventilatory response to O2 lack

Respiration is stimulated by a decrease in O2 tension in arterial blood

Mechanism:-

- Through stimulation of the peripheral chemoreceptors O2 lock will stimulate the respiratory center and increase pulmonary ventilation.
- **Moderate decrease** in O2 tension in arterial blood → sufficient to stimulate the peripheral chemoreceptors has no action on the central chemoreceptors.
- **Marked decrease** in O2 tension in arterial blood → will inhibit R.C **if the peripheral chemoreceptors are denervated.**

N.B

- Drop of O_2 tension in arterial blood is a **weaker** stimulus for the R.C than the rise in CO_2 tension in arterial blood.
- The R.C is stimulated when O_2 tension in arterial blood drops below 60 mmHg.

أنتهى

اعداد لجنة التبيض

لجنة الطب والجراحة

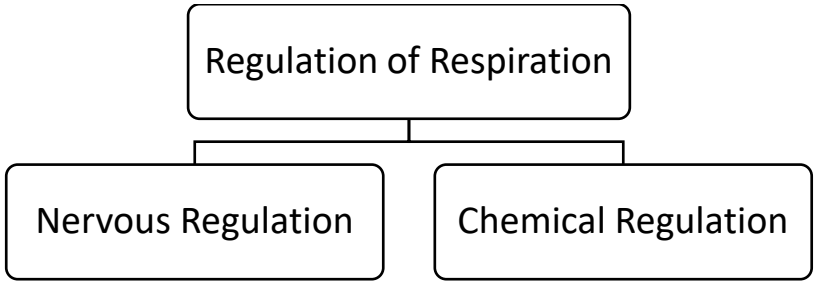
Sulaf maaitah"مبيض"

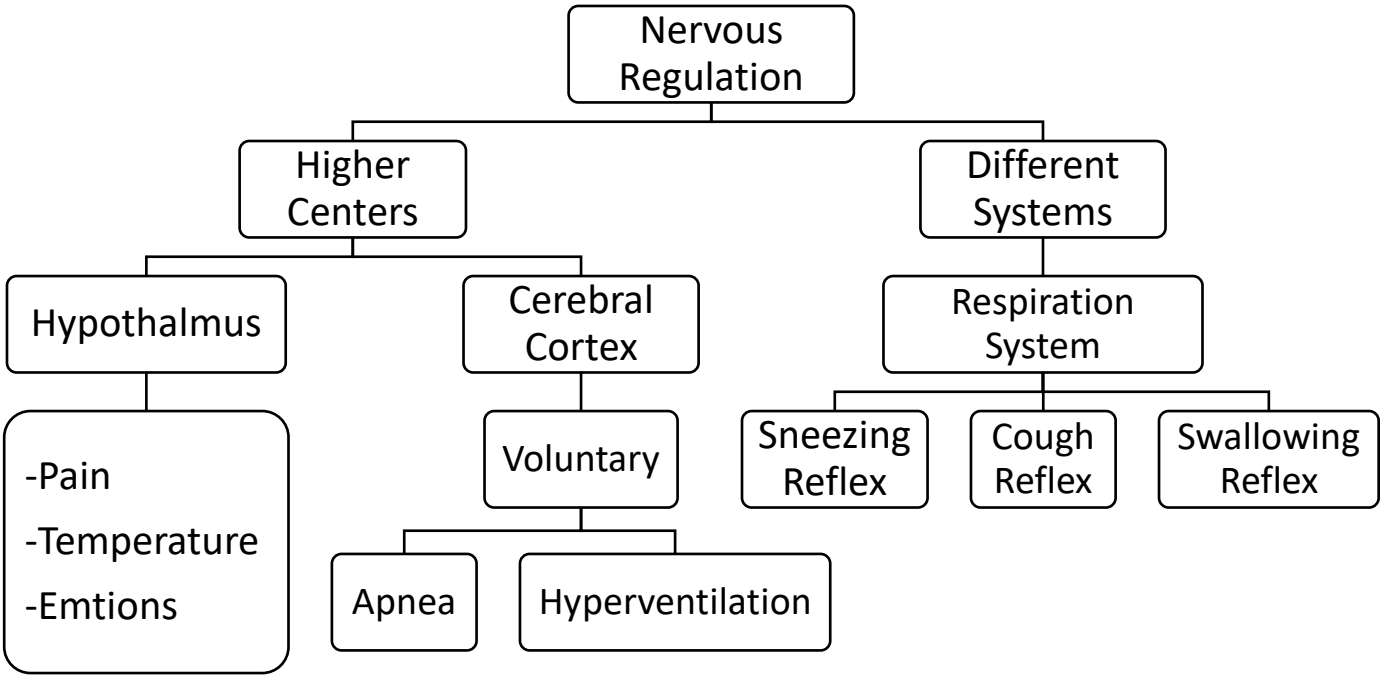
Feras Al-Heshmah"محوسب و مدقق"

Monther Qatawnah"محوسب"

Ibrahim tayseer"مدقق"

تلخيص المحاضرة





	Sneezing Reflex	***Swallowing reflex***	***Cough Reflex***
Impulses origin	Mucous membrane of the **NOSE**	The **PHARYNX**	From **TRACHEA** down to **RESPIRATORY BRONCHIOLES**
Nerve	Trigeminal nerve	Glossopharyngeal nerve	X
Action	**Deep inspiration** followed by **forced expiration**	Breath is inhibited	**Deep inspiration** followed by **deep forced expiration** against <u>closed glottis</u>
Action Result	Which removes out the foreign material.		which increases the intrapulmonary pressure that leads to sudden opening of the glottis and ejection of the foreign material.

تلخيص المحاضرة

	Peripheral chemoreceptor	Central chemoreceptor
Site	Carotid bodies Aortic bodies	Medulla oblongata
Blood Supply	Have rich blood supply, thus their response to changes in blood gases is very fast	H^+ ions do not easily pass through BBB
Sensitivity	• Sensitive to O_2 / CO_2 / H^+ • More sensitive to decreased O_2 tension	• Sensitive to O_2 / CO_2 / H^+ • More sensitive to changes in CO_2 and H^+ tension
H^+ ions	Interact with metabolic H^+ ions	Interact with H^+ ions which result from CO_2 that enter the brain

تلخيص: محمود بركات