

Regulation (Control) of Respiration

الجزء الثاني من المحاضرة اللي هو الية التحكم بالتنفس وتنظيمها من خلال الدماغ

1 - Neural Mechanism (CNS). طبعا عنا اليتين الية عصبية والية كيميائية

1. Voluntary control – by stimulating the Cerebral cortex:

- Activated only when you need voluntarily to increase the respiration rate and depth.
هون لما انت تقرر بشكل ارادي انك تتنفس

2. Automatic control - Pons and medulla(vegetative function) (BRAIN STEM):

- Activated all the time, and responsible of our unconscious breathing. وهون التنفس الطبيعي اللارارادي

2- Chemical control:

- Respond to changes in CO₂ and O₂ levels by sense it by Chemoreceptors (Central (in the brain) & Peripheral (in blood vessels))

هون التحكم الناتج عن الاستجابة للتغيرات بنسبة الغازات بالاخص يادة ثاني اكسيد الكربون

Main Goals of the Respiratory Control System:

- General.: An alveolar ventilation sufficient to maintain normal blood gases.
- Adapt to changing environments or metabolic needs (e.g. exercise).

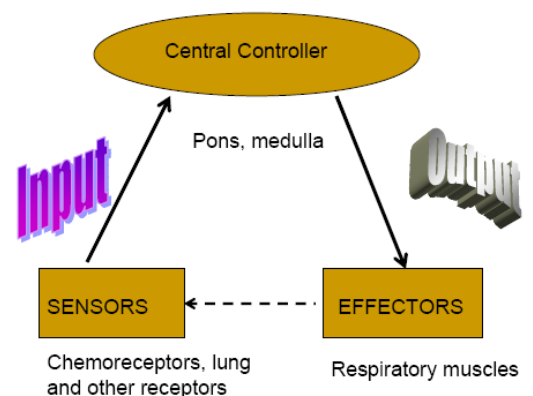
طبعا اهم وظيفة هي انه يعمل تنفس قادر على اعطاء الجسم كمية كافية من الاكسجين واذا حصل اي تغير يعدله.

Control of Respiration: عملية التحكم راح تتم بالمخ بالاخص في جذع الدماغ

- Central controller or Respiratory center in the brain.
- Sensors: we have many types
- Effectors

– Ventilation (muscles)

- diaphragm
- intercostal muscles
- abdominal muscles



- accessory muscles

Chemical Control of Respiration:

any increase or decrease in those 3 molecules will lead to stimulate the respiratory centers to make a response:

1. Carbon Dioxide
2. Oxygen
3. Hydrogen ions

Types of receptors in the respiratory system: عنا نوعين من المستقبلات اللي بحسو التغير عن الطبيعي للغازات مركزية في الدماغ وطرفية بجدار اوعية دموية مهمة، وطبعا بتم تقسيمها لمستقبلات كيميائية وميكانيكية.

1. Mechanoreceptors.
2. Chemoreceptors.

Mechanoreceptor:

- It's Slowly adapting stretch receptors (SARs) in bronchial airways, which mean it prevent overstretching of the lung and prevent rupture, terminate the inspiration, in addition to make an expiration process.
- This mechanism called HERING-BREUR REFLEX.
هون هاي مستقبلات بتمنع الرئة تتوسع زيادة عن اللزوم حتى ما تنفجر، فمنطقيا راح توقف الشهيق وتبدا عملية الزفير.

Significance of Hering-Breuer: its significant only in the situation of increase inspiration or diseases.

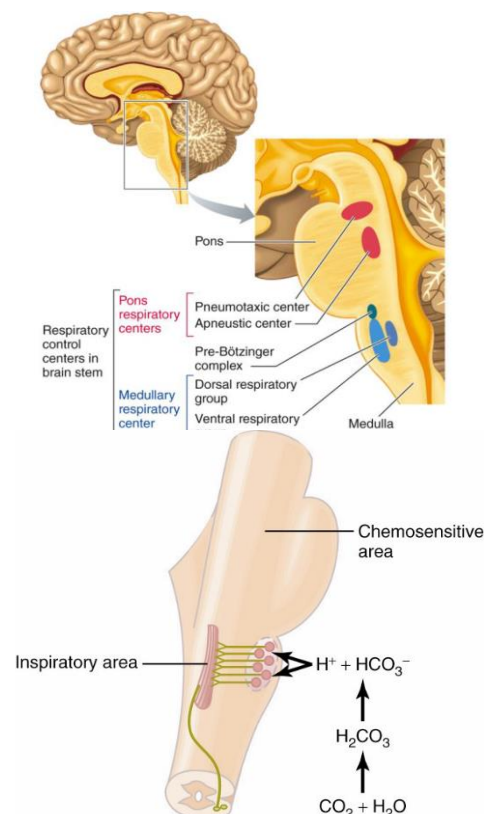
- Normal adults. Receptors aren't activated at end normal tidal volumes.
 - Become Important during exercise when tidal volume is increased.
 - Become Important Chronic obstructive lung diseases when lungs are more distended.
 - To inhibit over inflation of lungs

والمستقبلات الكيميائية وهي الالهة المسؤولة عن احساس اي تغير في الغازات وضغطها.

Chemoreceptors:

1. Peripheral Chemoreceptors: طبعاً عنا نوعين نوع طرفي ونوع مركزي

- Composed of:
 - a) **Carotid bodies** are located in the **carotid sinus**
 - b) **Aortic bodies** are located in the **aortic arch**
- Sensitive to O₂, CO₂ AND H⁺ changes.
- More sensitive to **CO₂ changes**, small increase in CO₂ activate he receptor and send message to respiratory center in the brain to increase the respiration.
- As we know CO₂ bind with water and make H₂CO₃, which dissolve into H⁺ + HCO₃⁻
- Increase CO₂ level, will increase H⁺ level which bind to the receptors and send the message to the brain.
- So CO₂ indirectly activate the receptor by **the H⁺ IONS**
- If the CO₂ increased, respiratory center activated, and the respiration increase in number and depth.
- CO₂ convert to H⁺ beside the receptors, but plasma H⁺ have minimal effect on it because H⁺ can't cross blood brain barrier.



طبعاً ثاني اكسيد الكربون بحفزها بشكل غير مباشرة عن طريق الهيدروجين اللي بنتج منه ، بس هذا الهيدروجين بتحول داخل المستقبلات من ثاني اكسيد الكربون بينما الهيدروجين اللي بالدم ما باثر لانه ما بقدر يدخل الدماغ اصلاً

2. central chemoreceptors: هذول موجودين بالمخ مباشرة

- located in the brain stem:
 - a) **pons**: contain هسا هذا الجزء فقط بنظم شغل النخاع المستطيل اللي تحته واللي هناك فيه المركز الرئيسي للتحكم
 1. **pneumotaxic center**: send impulses to dorsal respiratory group in the medulla and its function as switch of inspiratory neurons.

2. Apneustic center.

- Both control the main respiratory centers in medulla only.

b) **medulla oblongata**: main respiratory center located in it, contain:

هون مركز التحكم الرئيسي

1. **Dorsal respiratory group (DRG)**: respiratory pacemaker for normal respiration. هذا مركز التنفس العادي البسيط

- In resting state, it is responsible of generating action potential to the inspiratory muscles(**diaphragm**), to make a contraction and increase the thoracic cavity>> **normal quite inspiration**.
- Inhibition of dorsal respiratory group lead to relaxation of inspiratory muscles>> leading to elastic recoil of inspiratory muscles>> **normal quite passive expiration**.
- Generates 12-15 electrical signals each minute, and this is the normal respiratory rate.
- It controls the rate and magnitude of the breathing, by controlling the frequency of stimulation.

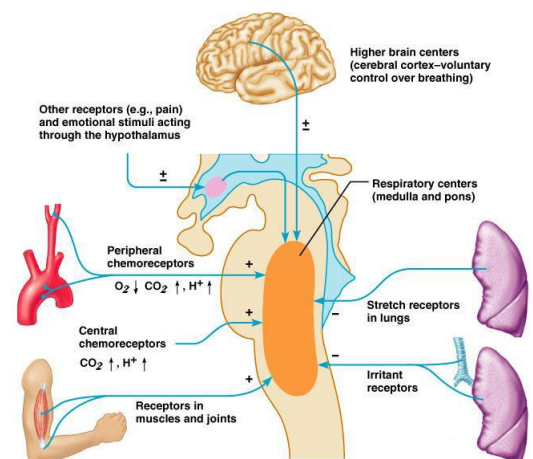
- Note: contract the diaphragm muscle, which is sufficient to make an inspiration.



2. **Ventral respiratory group (VRG)**: هذا مركز التحكم

بالتنفس القوي بحالات الرياضة والجهد

- for active forceful respiration, when doing exercise.
- Its stimulates both inspiratory and expiratory group muscles to increase both depth and rate, so this will lead to active inspiration.
- Voluntarily increase the depth of breathing>> lead to send a message to the ventral center and lead to activate muscle contraction and relaxation.
- When you prepare for doing exercise, the joints and muscles send a message to the ventral center and increase the rate and depth of respiration.



So:

- Normal inspiration and expiration: dorsal respiratory center.
- Active forceful inspiration and expiration: both dorsal and ventral groups.

Effect of CO₂ and PH AND O₂ on the respiration:

- O₂, CO₂, H⁺ affect the respiration, but CO₂ has the strongest effect then H⁺.
- 1. **Effect of H⁺:** هسا الهيدورجين باثر بشكل رئيسي على المستقبلات الطرفية لانه ما يقدر يعبر الحاجز الدماغي.
- H⁺ stimulates the peripheral chemoreceptors more than central one (in the brain), because the **blood brain barrier** prevent H⁺ from entering the brain.
- CO₂ passes to the brain through **blood brain barrier**, it bind to H₂O >> H₂CO₃ >> H⁺ AND HCO₃⁻.
- H⁺ bind strongly to the central chemoreceptor and stimulate more breathing in order to increase respiration and decrease CO₂ levels.

2. Effect of CO₂:

- When partial pressure of CO₂ increase it will affect both peripheral and center chemoreceptors:
- **Peripheral:** weak effect, so inside the carotid body, it converts into H⁺ and stimulate respiratory center in medulla oblongata.
- Medullary respiratory center: increase PP of CO₂ will lead to more H⁺ which stimulate both ventral and dorsal groups, and increase the respiration process, in order to decrease the CO₂ level.
- Increase CO₂ level chronically lead to inhibition of respiratory center instead of activation.
- When PP of CO₂ increase to 70-80 MMHG, this will lead to increase H⁺ which will decrease the PH and lead to acidosis and depression of the respiratory centers.

هون في معلومة مهمة والتي هي ببساطة انه زيادة ثاني اكسيد الكربون بتخلي التنفس يزيد حتى نتخلص من ثاني اكسيد الكربون ولكن اذا زاد الى حد كبير بادي لاثر عكسي وبدمر مراكز التحكم بالتنفس بالتنفس بتوقف وبموت الانسان.

3. Effect of O₂:

- On peripheral: stimulate it only when it is fall less than 60 mmhg (O₂ dissolved in plasma that make the partial pressure of O₂).
- Effect of central: depressed the central chemoreceptor when decrease below 60 mmhg.
- At the height of 5 km the O₂ levels will fall and the human body can't tolerate this decrease in oxygen.

Clinical correlation:

- CO poisoning: CO gas has an affinity to bind hemoglobin 100 times more than O₂, so when CO present in the room people will die, because the brain monitors the

dissolved O₂ in plasma which is not affected by CO not that bind to hemoglobin, so O₂ hemoglobin levels decrease until the patient die without any reaction from the brain. هون بدنا نعرف انه لما نترك صوبة الغاز مفتوحة عند اولاد صغار بغرفة مغلقة يرتفع عندهم غاز اول اكسيد الكربون اللي حيرتبط بدل الاكسجين مع الهيموغلوبين لانه حب ارتباطه اكبر بكثير ولكن الدماغ ما حيكشف هذا الانخفاض لانه الدماغ بفحص بس الاكسجين الذائب بالدم اللي بشكل 3% بس وهذا ما بتاثر من تسمم اول اكسيد الكربون فبعد فترة قليلة راح يموت الطفل بدون اي احساس.

▲ TABLE 13-8 Influence of Chemical Factors on Respiration

Chemical Factor	Effect on the Peripheral Chemoreceptors	Effect on the Central Chemoreceptors
↓ P_{O_2} in the Arterial Blood	Stimulates only when the arterial P_{O_2} has fallen to the point of being life threatening (< 60 mm Hg); an emergency mechanism	Directly depresses the central chemoreceptors and the respiratory center itself when < 60 mm Hg
↑ P_{CO_2} in the Arterial Blood (↑ H^+ in the Brain ECF)	Weakly stimulates	Strongly stimulates; is the dominant control of ventilation (Levels > 70–80 mm Hg directly depress the respiratory center and central chemoreceptors)
↑ H^+ in the Arterial Blood	Stimulates; important in acid–base balance	Does not affect; cannot penetrate the blood–brain barrier