RESPIRATORY BLOCK

Physiology Team~ 430

7th Lecture

Control of breathing

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- **Controls of rate and depth of respiration:**

•Arterial PO_2:

When PO_2 is VERY low, ventilation increases

- **Arterial PCO_2:**

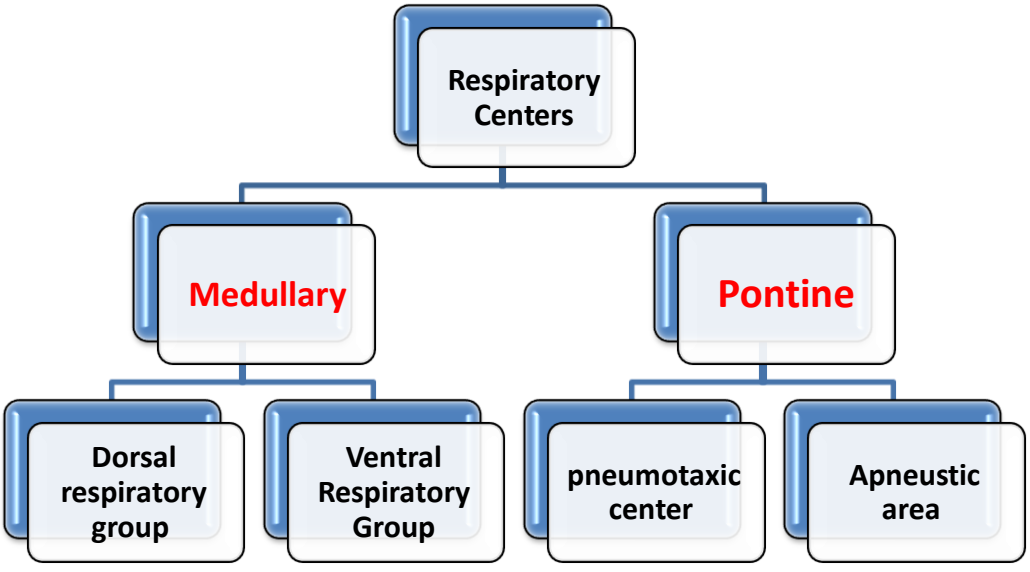
The most important regulator of ventilation, small increases in PCO_2, greatly increases ventilation

- **Arterial pH :**

As hydrogen ions increase, alveolar ventilation increases, but hydrogen ions cannot diffuse into CSF as well as CO_2

- **Respiratory Centers:**

The respiratory center is composed of several groups of neurons located bilaterally in the medulla oblongata and pons of the brain stem . It can be divided according to their location into :



1) Medullary respiratory center :

1-Dorsal respiratory group (inspiratory area):

- Determines basic rhythmof breathing
- Causes contraction of diaphragm and external intercostals which mean it cause inspiration.

2- Expiratory area (Ventral Respiratory Group) VRG:

- Inactive during normal quiet breathing
- Activated by inspiratory area during forceful breathing
- Causes contraction of internal intercostals and abdominal muscles

2) Pontine respiratory centers :

1- The pneumotaxic center :

- It's located dorsally in the superior portion of the pons
- Mainly controls the rate and the depth of breathing
- inhibits inspiratory area of medulla to stop inhalation
- Breathing more rapid when pneumotaxic area active

2- Apneustic area :

- located in pons
- stimulates inspiratory area of medulla to prolong inhalation

To understand only :

Pneumotaxic center :

It's located in the nucleus parabrachialis of the upper pons ,, it transmit the signals to the inspiratory area . its primary effect is to control the filling phase of the lung cycle . When the pneumotaxic signal is strong , inspiration might last for as little as 0.5 second , thus filing the lung slightly , but when the pneumotaxic signal is weak , inspiration might continue for 5 or more seconds , thus filling the lung with a great excess of air

As a Summery : the function of the pnemotaxic center is to limit inspiration. This has a secondary effect of increasing the rate of breathing , because limitation of inspiration also shortens expiration and the entire period of each respiration .

- **Hering-Breuer inflation reflex:**

-- It occurs when the lung become over stretched or over inflated (when the tidal volume increases to more than three times normal , about 1.5 liters per breath)

-- This reflex occur when a set of receptors called stretch receptors get activated

■ When they get activated :

They produce a similar effect to the pneumotaxic center in which they switches off inspiratory ramp and thus stop further inspiration .

■ Function of these receptors :

Transmit the signals through the vagi nerve into the dorsal respiratory group of neurons

- **Central and peripheral chemoreceptors and their role in regulation of respiration :**

1-Central chemoreceptor (Direct chemical control of respiratory center activity by carbon dioxide and hydrogen ions) :

Excess carbon dioxide or excess hydrogen ions in the blood mainly act directly on the respiratory center itself , causing greatly increased strength of both the inspiratory and the expiratory motor signals to the respiratory muscles .

- **Note that :**

Non of the (dorsal , ventral, or pneumotaxic centers) is affected by changes in the blood carbon dioxide concentration or hydrogen ions concentration. Instead, the chemosensitive area is highly sensitive to these changes

- **Chemosensitive area :**

It's located bilaterally , lying 0.2 millimeter beneath the ventral surface of the medulla .

- **Excitation and stimulation of the chemosensitive neurons :**

The sensor neurons in the chemosensitive area especially excited by hydrogen ions , but the hydrogen ions can't cross the blood brain barrier , so that they have less effect on this area than carbon dioxide does .

- **Effects of carbon dioxide in stimulating the chemosensitive area :**

1. Co2 interact with H2O from yhe tissue to form carbonic acid
2. The acid dissociates into hydrogen and bicarbonate ions
3. the hydrogen ions have direct effect on the chemosensitive area

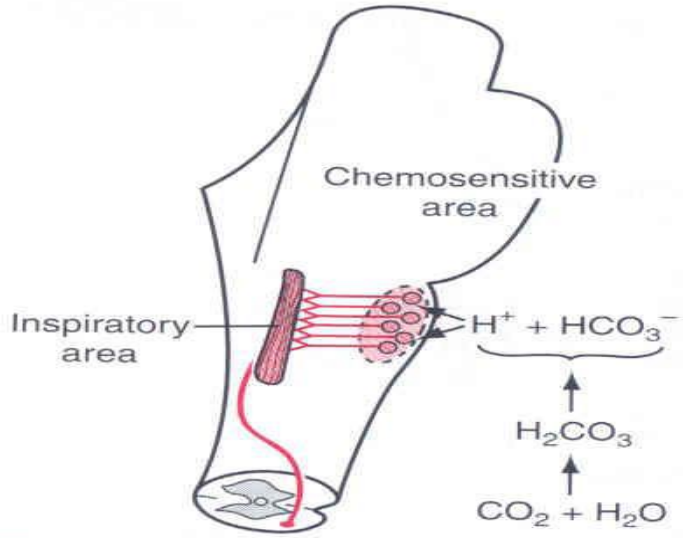


FIGURE 41–2

Stimulation of the inspiratory area by signals from the *chemosensitive area* located bilaterally in the medulla, lying only a fraction of a millimeter beneath the ventral medullary surface. Note also that hydrogen ions stimulate the chemosensitive area, whereas it is carbon dioxide in the fluid that gives rise to most of the hydrogen ions.

2- Peripheral chemoreceptor (role of oxygen in respiratory control) :

- **Peripheral chemoreceptor system : special nervous chemical receptors called chemoreceptors are located in several areas outside the brain**

  - **Their location : Many of them are in the carotid bodies , however some of them are in the aortic bodies**

To understand :

The carotid bodies are locate bilaterally in the bifurcations of the common carotid arteries. Their afferent nerve fibers pass through Hering's nerves to the glossopharyngeal nerves and then to the dorsal respiratory area of the medulla .

The aortic bodies are located along the arch of the aorta , their afferent nerve fibers pass through the vagi nerve , also to the dorsal medullary respiratory area.

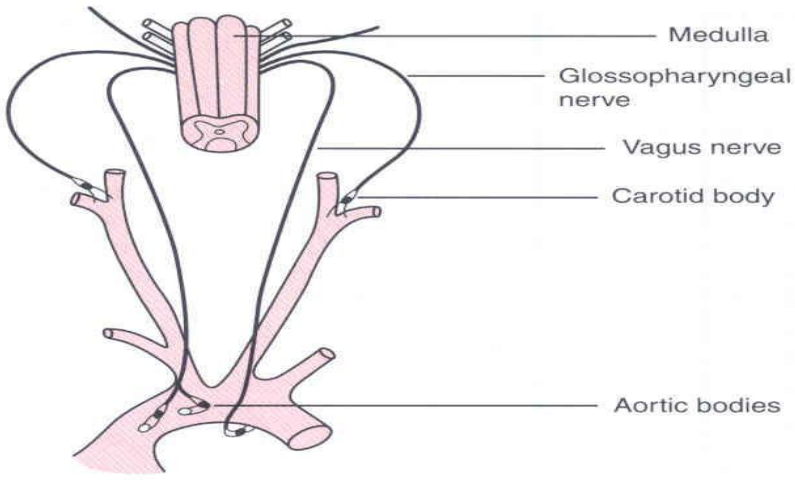


FIGURE 41 – 4
Respiratory control by peripheral chemoreceptors in the carotid and aortic bodies.

- **Its importance** : **to detect changes in the oxygen in the blood , the chemoreceptors transmit nervous signals to the respiratory center in the brain to help regulate respiratory activity .**

-- Stimulation of chemoreceptors by decreased arterial oxygen

(To understand)

- The basic mechanism still unknown , however , the carotid and the aortic bodies have glandular like cells, called glomus cells , that synaps directly or indirectly with the nerve endings So

- Either these cells act as chemoreceptor and then stimulate the nerve endings

- Or the nerve endings themselves are directly sensitive to the low Po2

- **Regulation of Respiratory centers (Factors affecting respiration) :**

Basic rhythm of ventilation coordinated by inspiratory area of respiratory centre, but modified by :

1- Cortical influences: (موجود بال CNS)

- **Voluntary control over breathing**

cortical influences

The cerebral cortex, as well as the hypothalamus and limbic system, have input into the respiratory center, so that we have some conscious control over breathing (holding our breath, for example).

(الـ cortex في الـ CNS .. تأثيرها أننا نستطيع التحكم إراديا في التنفس بحدود ,,
مثلا من الممكن أن نحبس النفس لدقائق , أو نزيد من سرعته لفترة محددة

2- Hypothalamus and limbic system

- **Emotional stimuli, pain.**
- **Temperature**

(usually they have the same effect as the cortex)

3- Proprioceptors:

- **Upper motor neurons of primary motor cortex also stimulate inspiratory area (when they get activated , they cause hyperventilation)**

4- Inflation (Hering-Breuer) reflex.

5- Chemoreceptors

Increased PCO_2, or reduced pH or PO_2 causes chemoreceptors to stimulate inspiratory area of respiratory centre

6- Effect of Irritant receptors in the airways:

the epithelium of trachea, bronchi, and bronchioles is supplied by irritant receptors that are stimulated by irritants that enter the respiratory airways causing coughing, sneezing and bronchoconstrictionin bronchial asthma and emphysema

7- Function of lung J receptors.

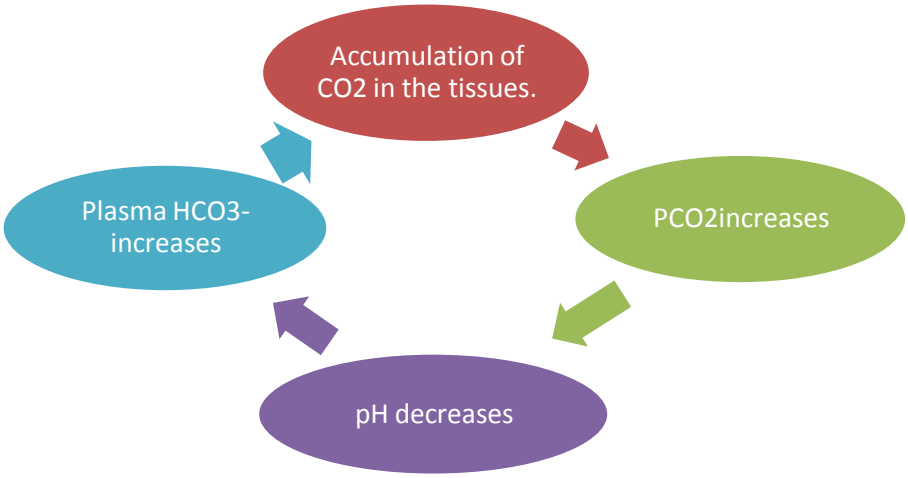
Few receptors in the wall of the alveoli in juxtaposition to the pulmonary capillaries. They are stimulated especially when pulmonary capillaries become engorged by blood or when pulmonary edema occur e.gin CHF, their excitation cause the person a feeling of dyspnea

- **Respiratory Acidosis:**

It's an increase in the alveolar and the arterial P_{CO_2} that lower the arterial PH

- What causes this condition ?

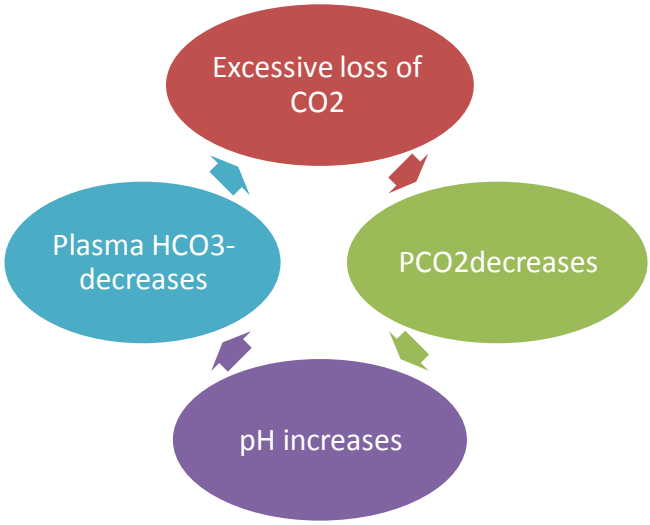
Any impairment in the alveolar ventilation, leading to hypoventilation



- **Respiratory Alkalosis:**

Alveolar ventilation in excess of that needed to keep pace with body carbon dioxide production results in alveolar and arterial P_{CO_2}s below 35 mm Hg

The cause : The causes of respiratory alkalosis include anything leading to hyperventilation



- **Metabolic acidosis :**

Metabolic acidosis can be caused by the ingestion, infusion, or production of a fixed acid ;

by decreased renal excretion of hydrogen ions;

by the movement of hydrogen ions from the intracellular to the extracellular compartment

by the loss of bicarbonate or other bases from the extracellular compartment

نشاهد هذه الحالة غالبا في مرضى السكر الذين لا يتحكمون بمستوى السكر في الدم ، حيث يحصل metabolism للدهون لتعطي keto acids وتسبب Acidosis

- **Metabolic Alkalosis :**

Metabolic or non respiratory, alkalosis occurs when there is an excessive loss of fixed acids from the body, or It may occur as a consequence of the ingestion, infusion, or excessive renal reabsorption of bases such as bicarbonate.

The respiratory system can compensate for metabolic acidosis or alkalosis by altering alveolar ventilation

GooD LucK