Physiology of the Respiratory system Lecture 4

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Control of respiration

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- **Can be studied as:**

✓ Neural control

✓ Chemical control

Neural control

- **Involuntary control**
  - By respiratory center
- **Voluntary control**
  - By the cerebral cortex

The respiratory center

- Collection of neurons in the medulla and pons
- Arranged into four groups

- Dorsal group
- Ventral group
- Apneustic center
- Pneumotaxic center

The dorsal group

- Found at the dorsal aspect of the medulla
- It contain inspiratory neurons (It is responsible for inspiration)
- It is called the rhythmicity center because it can discharge impulses rhythmically

The ventral group

- Found in the ventral aspect of the medulla
- Contains expiratory neutrons and some inspiratory neurons
- It is inactivate at rest (this is why expiration occurs passively)
- It is inactivated when the dorsal group is stimulated and vice versa (reciprocal innervation)
- It is responsible for forced expiration

The Apneustic center

- Found in the lower part of the pons
- Stimulate the dorsal group to increase depth of inspiration
- It is inhibited by the vagus nerve and Pneumotaxic center .

The Pneumotaxic center

- Found in the upper part of the pons
- Its function is unknown, may be switching between inspiration and expiration.

Factors affecting the respiratory center:-

- The respiratory center is affected by impulses coming from:-

- Higher centers
- ✓ Cerebral cortex
- ✓ Hypothalamus
- ✓ Limbic system
- ✓ Other brain stem centers
- Baroreceptors
- Chemoreceptors
- lung stretch receptors
- Proprioceptors
- Other receptors

Higher centers

- **The cerebral cortex:**

- For voluntary modification of respiration
- E.g. voluntary hyperventilation or voluntary apnea

- **The hypothalamus (temperature center):**

- Stimulate heat loss by increasing respiration
- E.g. panting in dogs.

- **The limbic system:**

- Emotion may affect respiration (e.g. fear)

Other brain centers:

- Stimulation or inhibition of the cardiac or vasomotor centers in the medulla results also in stimulation or inhibition of the respiratory center (impulses radiate between the centers). That is why hyperventilation is associated with tachycardia and hypoventilation is associated with bradycardia.

The Baroreceptors:-

- Stretch receptors found in the aortic and the carotid sinuses; connected to the cardiac and vasomotor centers in the medulla by the cranial nerves 9 &10; send inhibitory impulses to these centers when stimulated by stretch caused by high blood pressure.

- The inhibitory impulses decrease the sympathetic discharge from these centers to the heart and blood vessel. This lower the blood pressure by :-

- **Decreasing the heart rate**
- **Decreasing contractility**
- **Vasodilatation**

-The inhibitory impulses also inhibit the respiratory center. For this reason, hypertension is associated with hypoventilation and hypotension associated with hyperventilation but mainly due to activity of the chemoreceptor.

The Proprioceptors:-

- Found in the joint, ligament and tendons of the muscles
- Stimulated by movement (even passive movement)
- Send impulses directly to the respiratory center to increase respiration.

The lung stretch receptors:-

- Found in the smooth muscles of the bronchioles
- Stimulated by stretch during inflation of the lung
- Send inhibitory impulses through the vagi to stop further inspiration.
- This protective reflex is called Hering Breuer inflation reflex
- It is not active in humans(except with very high tidal volume)
- There is also Hering Breuer deflation reflex stimulated by deflation of the lung
- Here excitatory impulses are carried also through the vagi to restart inspiration

Other receptors

1. (I) receptors

- Found in the upper respiratory tract
- Simulated by irritants (dust, smoke…)
- Mediate coughing reflex, sneezing reflex,…

2. (J) receptors

- Found in juxtaposition to pulmonary capillaries
- Stimulated when the capillaries become distended with blood.
- Function unknown, may be mediation of the sense of dyspnea.

Chemical control of respiration

(Chemoreceptors)

- It is achieved by chemoreceptors that detect chemical changes in blood or CSF.
- There are 2 type of chemoreceptor :–

✓Peripheral chemoreceptors

✓Central chemoreceptors

The peripheral chemoreceptors:-

- Special receptors found in the aortic and carotid bodies. Aortic bodies are found in the aortic arch and carotid bodies are found in the carotid bifurcation and each body contain 2 type of glomus cells (I & II)
- They are stimulated by hypoxia (the main stimulus),hypercapnia and acidosis

- Hypoxia closes O_2-sensitive K^+ channels in type I glomus cells.
- The cells become depolarized, allow calcium influx through L- type calcium channels. Calcium cause exocytosis of dopamine from glomus cells type I; this excite the nerve ending of the glossopharyngeal and vagus nerves which supply the chemoreceptor. Excitatory impulses are carried through these cranial nerves to stimulate the respiratory center in the medulla. This result in hyperventilation to correct the stimulus (increase O_2,remove CO_2 and correct pH).

- The peripheral chemoreceptor can detect changes in oxygen dissolved in the blood because their blood supply (per 100 gram tissue) is very high (e.g. the carotid bodies receive 200 ml/100gm tissue compared to 420 ml/100 gram tissue in the kidney.
- Peripheral chemoreceptors are stimulated by cyanide, nicotine and high ECF potassium.
- Anemia has no direct effect on chemoreceptors because they are stimulated by low dissolved O_2 not by low Hb

The central chemoreceptors:-

- Found in the antero-lateral surface of the medulla in contact with the CSF. They are stimulated by high CO_2 in blood and therefore in the CSF and high hydrogen ions in the CSF not that in the blood.
- H^{+1} in the blood cannot cross the blood-brain barrier easily.
- H^{+1} in the CSF are formed from CO_2 that crosses the BBB and react with water in the CSF to produce carbonic acid , this dissociates into HCO_3^- and H^{+1} , then H^{+1} in the CSF stimulate the central chemoreceptors.

- **In summary:** CO_2 stimulates central chemoreceptor directly and/or indirectly (through formation of hydrogen ions).

Remember that:

- In patient with chronic hypercapnia (e.g. patient with COPD), respiration is stimulate by hypoxia not hypercapnia (because the receptors become used to the high CO_2).
- Treatment with high pressure O_2 in these patient correct hypoxia but stop respiration. That is why they should be treated with low pressure O_2 (e.g. 24% or 28%;not 80% or 100%)

FINITO

No more continue!!