HUMAN PHYSIOLOGY AND CLINICAL BIOCHEMISTRY

Topic: Respiration

REGULATION OF RESPIRATION

Lecture 5

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REFERENCE: OPEN ACCESS

REGULATION OF RESPIRATION

Two types of mechanisms regulate breathing: nervous mechanisms and chemical mechanisms.

NERVOUS REGULATION

The respiratory centers are located in the medulla and pons, Within the medulla are the inspiration center and expiration center.

- The inspiration center automatically generates impulses in rhythmic spurts. These impulses travel along nerves to the respiratory muscles to stimulate their contraction. The result is inhalation.

- As the lungs inflate, baroreceptors in lung tissue detect this stretching and generate sensory impulses to the medulla; these impulses begin to depress the inspiration center. This is called the **Hering-Breuer** inflation reflex,
- As the inspiration center is depressed, the result is a decrease in impulses to the respiratory muscles, which relax to bring about exhalation.
- Then the inspiration center becomes active again to begin another cycle of breathing.

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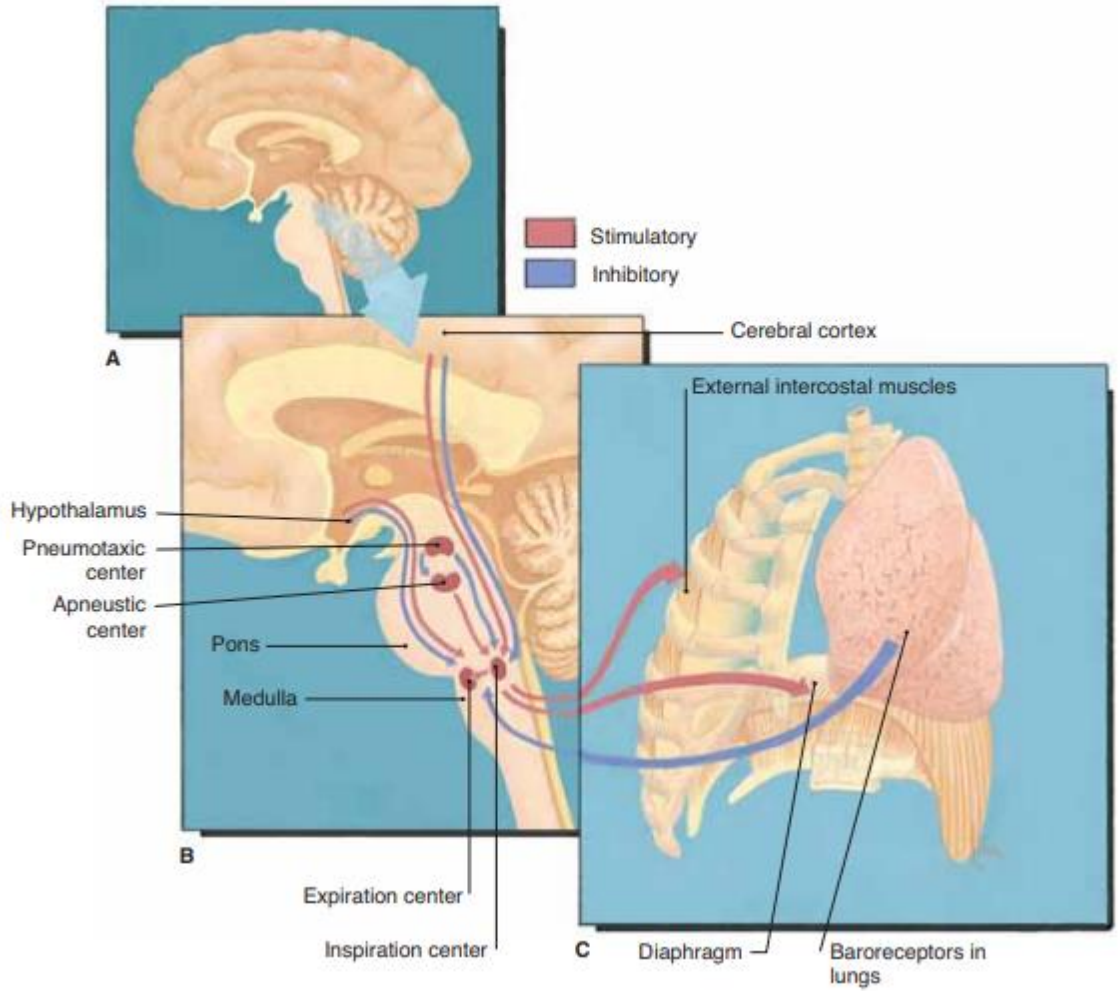

Nervous regulation of respiration. (A) Midsagittal section of brain. (B) Respiratory centers in medulla and pons. (C) Respiratory muscles.

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When there is a need for more forceful exhalations, such as during exercise, the inspiration center activates the expiration center, which generates impulses to the internal intercostal and abdominal muscles.

The two respiratory centers in the pons work with the inspiration center to produce a normal rhythm of breathing.

The apneustic center prolongs inhalation, and is then interrupted by impulses from the pneumotaxic center, which contributes to exhalation.

In normal breathing, inhalation lasts 1 to 2 seconds, followed by a slightly longer (2 to 3 seconds) exhalation, producing the normal respiratory rate range of 12 to 20 breaths per minute.

Factors affecting Respiration rate:

Emotions often affect respiration; a sudden fright may bring about a gasp or a scream, and anger usually increases the respiratory rate.

The cerebral cortex enables us to voluntarily change our breathing rate or rhythm to talk, sing, breathe faster or slower, or even to stop breathing for 1 or 2 minutes.

Such changes cannot be continued indefinitely, however, and the medulla will eventually resume control.

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- Coughing and sneezing are reflexes that remove irritants from the respiratory passages; **the medulla contains the centers for both of these reflexes.**
- Sneezing is stimulated by an irritation of the nasal mucosa, and coughing is stimulated by irritation of the mucosa of the pharynx, larynx, or trachea.
- The reflex action is essentially the same for both: An inhalation is followed by exhalation beginning with the glottis closed to build up pressure.
- Then the glottis opens suddenly, and the exhalation is explosive.
- A cough directs the exhalation out the mouth, while a sneeze directs the exhalation out the nose
- **Hiccups,** also a reflex, are spasms of the diaphragm. The result is a quick inhalation that is stopped when the glottis snaps shut, causing the “hic” sound.
- The stimulus may be irritation of the phrenic nerves or nerves of the stomach. Excessive alcohol is an irritant that can cause hiccups.
- **Yawning is another respiratory reflex**
- Most of us yawn when we are tired, but the stimulus for and purpose of yawning are not known with certainty. There are several possibilities, such as lack of oxygen or accumulation of carbon dioxide, but we really do not know.

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CHEMICAL REGULATION

Chemical regulation refers to the effect on breathing of blood pH and blood levels of oxygen and carbon dioxide.

Chemoreceptors that detect changes in blood gases and pH are located in the carotid and aortic bodies and in the medulla itself.

- A decrease in the blood level of oxygen (hypoxia) is detected by the chemoreceptors in the carotid and aortic bodies. The sensory impulses generated by these receptors travel along the glossopharyngeal and vagus nerves to the medulla, which responds by increasing respiratory rate or depth (or both).
- This response will bring more air into the lungs so that more oxygen can diffuse into the blood to correct the hypoxic state.

Carbon dioxide becomes a problem when it is present in excess in the blood, because excess CO_2 (hypercapnia) lowers the pH when it reacts with water to form carbonic acid (a source of H^+ ions).

- Excess CO_2 makes the blood or other body fluids more acidic.

The medulla contains chemoreceptors that are very sensitive to changes in pH, especially decreases.

If accumulating CO_2 lowers blood pH, the medulla responds by increasing respiration.

This is not for the purpose of inhaling, but rather to exhale more CO_2 to raise the pH back to normal.

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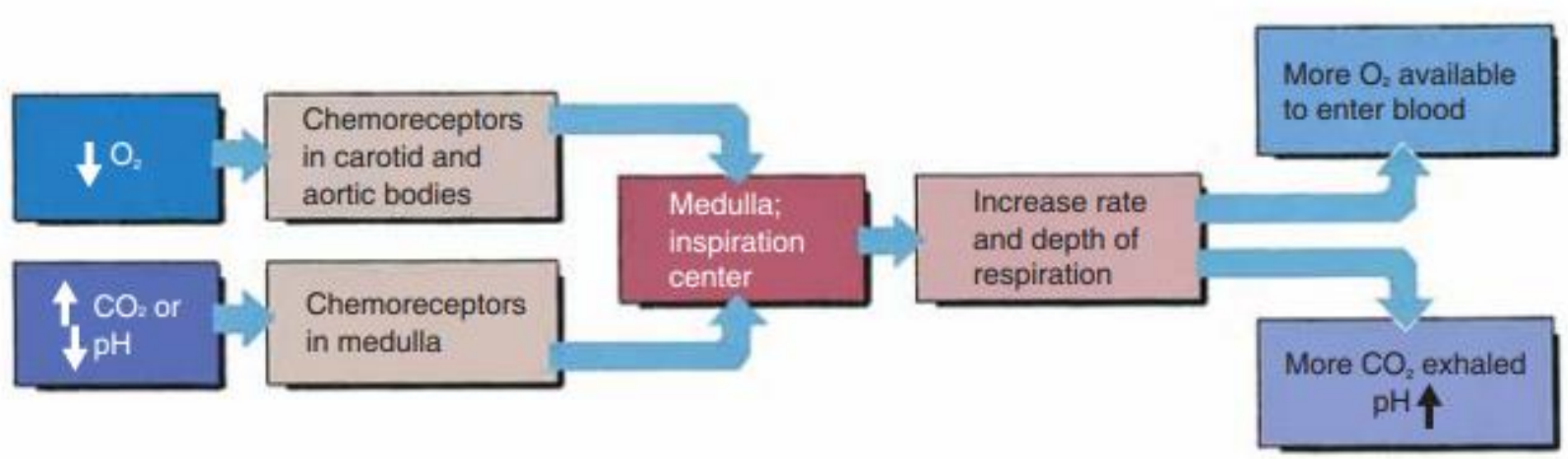

Chemical regulation of respiration

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Of the two respiratory gases, which is the more important as a regulator of respiration?

- Our guess might be oxygen, because it is essential for energy production in cell respiration but carbon dioxide is the major regulator of respiration, and the reason is that carbon dioxide affects the pH of the blood. An excess of CO_2 causes the blood pH to decrease, a process that must not be allowed to continue. Therefore, any increase in the blood CO_2 level is quickly compensated for by increased breathing to exhale more CO_2.
- Accumulating CO_2 has lowered blood pH enough to stimulate the medulla to start the breathing cycle again.
- In some situations, oxygen does become the major regulator of respiration. People with severe, chronic pulmonary diseases such as **emphysema** have decreased exchange of both oxygen and carbon dioxide in the lungs.
- The decrease in pH caused by accumulating CO_2 is corrected by the kidneys, but the blood oxygen level keeps decreasing. Eventually, the oxygen level may fall so low that it does provide a very strong stimulus to increase the rate and depth of respiration.

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RESPIRATION AND ACID–BASE BALANCE

- As you have just seen, respiration affects the pH of body fluids because it regulates the amount of carbon dioxide in these fluids.
- The more hydrogen ions present in a body fluid, the lower the pH, and the fewer hydrogen ions present, the higher the pH.
- The respiratory system may be the cause of a pH imbalance, or it may help correct a pH imbalance created by some other cause

- **Chronic alveolar hypoxia** from diseases such as emphysema or chronic bronchitis may lead to pulmonary hypertension, which in turn overworks the right ventricle of the heart.
- **Systemic hypertension** often weakens the left ventricle of the heart, leading to congestive heart failure and pulmonary edema, in which excess tissue fluid collects in the alveoli and decreases gas exchange.
- In the absence of chemical assault, respiratory function does diminish but usually remains adequate.
- The respiratory muscles, weaken with age. Lung tissue loses its elasticity and alveoli are lost as their walls deteriorate. results in decreased ventilation and lung capacity.
- The cilia of the respiratory mucosa deteriorate with age, and the alveolar macrophages are not as efficient, which make elderly people more prone to pneumonia, a serious pulmonary infection.

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