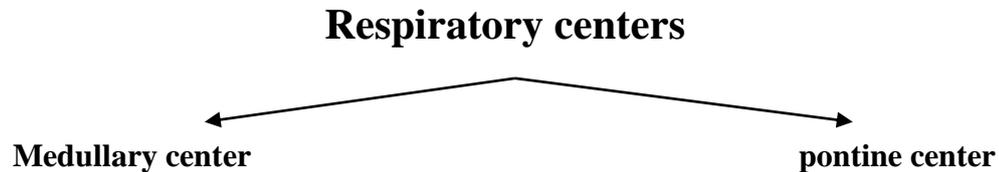


Control of Breathing

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.



Regulation of respiration

The activity of the respiratory center is regulated by:-

- I. Nervous factors.
- II. Chemical factors.

I- Nervous regulation of respiration

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.

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

- a) **Voluntary hyperventilation** leads to CO_2 wash from the alveolar air, leading to respiratory alkalosis.
- b) **Voluntary apnea** leads to accumulation of CO_2 , after one minute of apnea, CO_2 accumulate to a high level which can stimulate the respiratory center inspite 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 O_2 tension and decrease CO_2 tension.

B- Afferent impulses from the hypothalamus

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

1- Pain:

2- Temperature

3- Emotions:

(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 which removes out the foreign material.

ii. *Swallowing reflex:*

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

iii. *Cough reflex:*

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.

➤ *There are two types of chemoreceptors:-*

1) *Peripheral chemoreceptors.*

➤ *Site:-*

- a. Carotid bodies, at the bifurcation of the common carotid arteries.
- b. Aortic bodies, 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.**

2) *Central chemoreceptors*

➤ *Site:-*

- They are located in the medulla oblongata close to the medullary respiratory centers.
- 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.

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 H₂O to give carbonic acid which rapidly dissociates into HCO₃ and 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 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.

Ventilatory response to CO₂

The increase in CO₂ tension of arterial blood stimulates respiration and increases pulmonary ventilation, while a decrease of CO₂ tension inhibits respiration.

- ❖ **Mechanism:** increased CO₂ tension in arterial blood will stimulate R.C through respiratory chemoreceptors.

a- Central chemoreceptors:-

- As discussed above CO₂ diffuses through the (BBB) into the cerebrospinal fluid (C.S.F) passing the cells of the chemoreceptors.
- CO₂ is converted into H⁺ ions.
$$\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3 \rightarrow \text{H}^+ \text{ and } \text{HCO}_3.$$
- 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 CO₂ tension in alveolar air, CO₂ in arterial blood and CO₂ tension in the CSF. This lowers the H⁺ concentration in the C.S.F. leading to inhibition of R.C leading to increased CO₂ tension in alveolar air and arterial blood to the normal level.

(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

$$\frac{\text{free CO}_2}{\text{Bicarbonate}}$$

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, which send impulses along afferent fibers in the vagus and glossopharyngeal nerves to stimulate respiratory center.

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 lack 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 O₂ tension in arterial blood is a weaker stimulus for the R.C than the rise in CO₂ tension in arterial blood. The R.C is stimulated when O₂ tension in arterial blood drops below 60 mmHg