Review Article

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Basics of Neural Regulation of Respiration

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Abstract

The nervous system normally adjusts the rate of alveolar ventilation as per the demands of the body so that partial pressure of oxygen (PO2) and partial pressure of carbon dioxide (PCO2) in the arterial blood are hardly altered, even during heavy exercise and other respiratory stress situations.

Respiratory centres are classified into two types i.e. medullary and pontine. These centres contain various neurons like Dorsal respiratory group of neurons (DRG) controls inspiration and Ventral group of neurons (VRG) controls expiration along with other centres controlling the rate and depth of respiration. Reflexes like cough reflex, sneeze reflex and J reflex are mediated through these centres. Central and peripheral control of respiration is mainly regulated by PCO2 and PO2.

Keywords: Alveolar Ventilation; Respiratory Centres; Cough Reflex; Sneeze Reflex; J Reflex.

Introduction

The nervous system normally adjusts the rate of alveolar ventilation as per the demands of the body so that partial pressure of oxygen (PO2) and partial pressure of carbon dioxide (PCO2) in the arterial blood are hardly altered, even during heavy exercise and other respiratory stress situations.[1]

Role of Respiratory centres

The respiratory centres are classified into medullary and pontine centres. Medullary includes dorsal respiratory group of neurons (DRG) which controls inspiration and ventral group of neurons (VRG) controls expiration. Pontine includes pneumotaxic centre which controls rate and depth of respiration and apneustic centre controls inspiration2. Dorsal respiratory group of neurons (DRG) arises from Nucleus tractus solitarius (NTS) Rhythmical discharges from DRG leads to generation of inspiratory ramp: Make – 2sec and Break – 3sec. Ventral respiratory group of neurons (VRG) functions both in inspiration and expiration. Pneumotaxic centre is located dorsally in the upper pons. It controls the "switch off" point of the inspiratory ramp thus controlling the duration of inspiratory signals. Strong-inspiration might be lost in as little as 0.5 second i.e. shallow breathing. Weak, the ramp continue to rise for as long 5 to 10 seconds i.e. slow breathing3. Apneustic centre is situated in the lower part of pons. It discharges tonically upon the DRGN- promoting more sustained respiratory activity. Two factors normally control and lessen this tonic influence are Pneumotaxic centre and vagal afferent impulses (Hering Bruer inflation reflex). An animal with midpontine transection and vagotomy develops apneustic breathing i.e prolonged inspiration- brief expiratory period- another sustained inspiration4. Lung inflation signals limit inspiration by Hering-Breuer inflation reflex. When the tidal volume becomes more than 1.5 lit/ breath, stretch receptors situated in the walls of bronchi and bronchioles becomes stimulated thus transmitting signals through vagi and inhibits DRGN which switches off inspiratory ramp. This reflex acts as a protection from excessive lung inflation.[5]

Role of Cough Reflex

Cough reflex begins with the irritation of the bronchi and larynx. The impulses pass through vagus nerve to medulla (Inspiratory Center) for initiating inspiration and thus 2.5 litres air is inspired. Epiglottis and vocal cords close completely to obstruct the air below vocal cords. The expiratory muscles contract forcefully and create a pressure of 100 mm Hg in the lungs and respiratory passage below

the vocal cords and the vocal cords suddenly open widely. Air in the lungs explodes out widely with a velocity of 500 miles/hour thus removing the irritating foreign particles, present in the respiratory passage.[6]

Role of Sneezing Reflex

In sneezing reflex, all the steps are almost the same as that of cough reflex except that the irritation occurs in nasal mucosa instead of bronchi and lungs. Sensation travels through Trigeminal nerve instead of vagus nerve and soft palate and uvula are closed instead of vocal cords.[7]

Role of J- reflex

"J receptors"- are sensory nerve endings in the alveolar walls in juxtaposition to the pulmonary capillaries. They are stimulated when the pulmonary capillaries pressure is increased or the pulmonary capillaries become engorged with blood or when pulmonary oedema occurs in such conditions as congestive heart failure, high altitude and exercise. Excitation may give the person a feeling of dyspnoea.[8]

Role of CO_2, H^+ and O_2

Direct or central control of respiratory centre activity is by CO_2 and Hydrogen ions. Chemo sensitive area of respiratory centre is situated on the ventral surface of medulla. Primary stimulus is H+ for stimulation of chemo sensitive area and CO_2 has a weak direct effect. Potent indirect effect occurs through H^+ Decrease stimulatory effect of CO_2 occurs due to renal readjustment by increasing bicarbonate which binds with H+ ions in blood and cerebrospinal fluid. Changes in PO_2 have little direct effect on control of respiratory centre.[9] Peripheral chemoreceptor system for control of respiratory activity is mainly by PO_2. Role of O^2 in respiratory control is carried by Carotid bodies and aortic bodies. Impulses are transmitted along glossopharyngeal nerve and vagal nerve. Decrease arterial O_2 stimulate chemoreceptors when PO_2 is 60-30 mm Hg.[10]

Mechanism of stimulation of chemoreceptor by O_2 deficiency

Glomus cells located in peripheral chemoreceptors have O_2 sensitive K^+ channels which are inactivated when blood PO_2 decreases. As a result of depolarisation there is increased opening of voltage gated calcium channels leading to increase in intracellular calcium concentration and release of neurotransmitter (ATP) resulting in activation of afferent neurons to CNS leading to stimulation of respiration.[11]

Conclusion:

Spontaneous respiration is produced by rhythmic discharge of motor neurons orchestrated by brain that innervate the respiratory muscles. The rate and depth of respiration change appropriately in response to alterations in metabolic demands without any voluntary effort on our part. This involuntary process is mainly controlled by various respiratory centres located in pons and medulla.

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