Regulation of respiration:

Breathing is regulated by two mechanisms:

- Neural regulation
- Chemical regulation

Neural regulation of breathing:

I. Voluntary control.
II. Automatic control
III. Reflex control

Voluntary control:

- Respiration is a spontaneous process but it can be regulated by the motor cortex in the brain which send impulses to the respiratory motor neurons through corticospinal tract to the muscles of respiration → an individual can voluntarily change the pattern of breathing in talking, singing and can also stop breathing for a period of time.
- Voluntary control pathway bypasses the medullary respiratory center (automatic)
- Sometimes automatic control is damaged without loss of voluntary control (Ondine’s curse) which can be caused by a pathological conditions that affect the medullary center.

Automatic control:

Is done by groups of neurons located bilaterally in the medulla oblongata and pons called Respiratory center which can be classified into medullary and pontine center

A. Medullary center:
   ➢ it is the basic respiratory control. It contains the pre BÖtzinger complex which is a group of pacemaker cells situated in either side of the medulla. They discharge spontaneously and rhythmically. They have two types of receptors:
   - NK1 receptors which is stimulated by P substance (associated with pain)
• μ–opioid receptors: opioids inhibit respiration through these receptors → opioid drugs side effect → cause respiratory depression

➢ medullary center contains two other groups of neuron (dorsal respiratory group and ventral respiratory group). Impulses from these cells activate respiratory motor neurons in the spinal cord.

1) **Dorsal respiratory group:**
  • they contain I neurons (Inspiration)
  • they are active during quite inspiration and is controlled by pre Botzinger complex
  • they receive sensory signals which are transmitted through Vagus (CN 10) and glossopharyngeal nerve (CN 9) from Peripheral chemoreceptors, Baroreceptors and pulmonary receptors in the lung (ex: stretch receptors)
  • send impulses to **inspiratory** motor neuron.
  • **Inspiratory ramp signal**: is the pattern of the action potential produced by DRG to the inspiratory muscles. It begins weakly and increases gradually in a ramp like manner for 2 second then stops for 3 seconds → gradual increase in lung volume during inspiration rather than inspiratory gasps and allow the elastic recoil of the chest and the lung to cause expiration in between

2) **Ventral respiratory group:**
  • Has neurons for inspiration (type I neurons) and for expiration (type E neurons). → these neurons contribute to both inspiration and expiration
  • They are **inactive** during normal quiet respiration.
  • When the respiratory drive ↑→ respiratory signals pass to the ventral respiratory neurons → extra respiratory drive.
  • Send impulses to **inspiratory and expiratory** motor neuron
  • They are important in providing an overdrive mechanism
    When high levels of pulmonary ventilation are required (exercise).
B. Pontine center: modifies the activity of the medullary center:
1. Apneustic center 2. Pneumotaxic center

**Apneustic center**: (enhance inspiration)
- Locates in the lower pons.
- Send *excitatory impulses* to the dorsal neurons to increase depth of breathing

**Pneumotaxic center**: (limit inspiration)
- Locates dorsally in the upper portion of the pons
- *Transmits inhibitory* impulses to the dorsal respiratory group by inhibiting Apneustic center to → decrease depth of inspiration and secondary effect causes increase in the rate.
  - The apneustic and pnuemotaxic centers work against each other together to control the respiratory rate and depth of inspiration.

**Effect of different brain stem and vagus nerve lesions on respiratory center activity**:

A. Above the pons:
- Vagus intact → normal breathing (respiratory center is intact)
- After Vagatomy → loss of inhibitory impulse of lung stretching → ↑depth, ↓rate

B. Below pneumotaxic center (mid pons):
- Vagus intact: ↑ depth and ↓ rate
- After vagatomy: apneusis (prolong inspiratory spasm that resemble breath holding).

C. Pontomedullary junction: irregular breathing

D. Below medulla: stop breathing (Fatal)