Module J
Control of Ventilation

Chapter 11 – Beachey
Control of Ventilation
Chapter 13 – Egan’s Fundamentals
Regulation of Breathing

Objectives
At the end of the module you will:
• Describe the function of the respiratory centers in the medulla oblongata.
• Describe the function of the apneustic center and pneumotaxic center in the pons.
• List 3 conditions that would depress the respiratory centers of the medulla oblongata.
• Describe the function of the central chemoreceptors.

Objectives
At the end of the module you will:
• Describe the function of the peripheral chemoreceptors.
• Describe the function of the Hering-Breuer reflex.
• Describe the function of the deflation reflex.
• Describe the function of the irritant reflex.
• Describe the function of the juxtapulmonary capillary receptors.
• Describe the function of the Paradoxical reflex of Head.

Control of ventilation

CENTRAL CONTROLLER
Pons, Medulla, & Others

SENSORS
Chemoreceptors, lung & Other receptors

EFFECTORS
Respiratory Muscles

Input Output

Medulla Oblongata

• The lower portion of the brainstem.
• Inferior to the pons
• Anterior to the cerebellum
• Associated with vital involuntary reflexes (sneezing, coughing) and regulation of cardiovascular and respiratory activity.
• Two dense bilateral groups of neurons
  • Dorsal Respiratory Groups
    • Mainly inspiratory cells that innervate inspiratory muscles
    • Also receives input from IX & X cranial nerves, peripheral receptors and impulses from the cerebral cortex.
  • Ventral Respiratory Groups
    • Both inspiratory & expiratory cells

Pituitary and Pineal Glands

Pineal gland
Cerebellum
Pituitary gland
Pons
Medulla oblongata
Spinal cord
Pons
- Located superiorly to the medulla oblongata.
- Two respiratory centers
  - Apneustic Center (APC)
    - Directly above medulla
    - Inspiratory cut-off switch
    - Usually is inactivated by other impulses
  - Pneumotaxic Center (PNC)
    - Superior to APC
    - Controls Apneustic center and "fine-tunes" breathing by sending inhibitory impulses to medulla.

Depression of Medulla Oblongata
- Reduced blood flow through the medulla as a result of increased pressure caused by cerebral edema or other intracerebral abnormality.
- Acute poliomyelitis.
- Drugs that depress CNS function.

Central Chemoreceptors
- Located in the medulla of the brain.
- Responsive to ↑H⁺ ions in the cerebral spinal fluid (CSF).
- During hypoventilation, CO₂ molecules readily diffuse across the blood brain barrier and enter the CSF. The blood brain barrier is impermeable to H⁺ ions but very permeable to CO₂.
- In the CSF: CO₂ + H₂O ⇌ H₂CO₃ ⇌ H⁺ + HCO₃⁻
- The H⁺ ions cause the pH to ↓ in the CSF;
  This increases ventilation (f increases)
Peripheral Chemoreceptors

- Carotid Bodies
  - Bilirubin of the internal & external carotid arteries
  - Afferent impulses travel by way of glossopharyngeal nerve (IX)
- Aortic Bodies
  - Aortic Arch
  - Afferent impulses travel by way of the vagus nerve (X)
  - Proximal to the Baroreceptors learned earlier.
- Both response to $\downarrow$O$_2$, $\uparrow$PaCO$_2$, $\downarrow$ pH ($\uparrow$ H$^+$ ions)
  - PaO$_2$ of 60 mm Hg or less stimulates a response
  - Response is blunted when PaO$_2$ falls below 30
  - Response is to increase ventilation ($f$ & $V_t$)
  - Response is to PaO$_2$; NOT CaO$_2$

Pulmonary Reflexes

- Hering Breuer Reflex
- Deflation Reflex
- Irritant Reflex
- Juxtapulmonary Capillary Receptor Reflex – J receptors
- Head’s Paradoxical Reflex

Hering Breuer Reflex

- Receptors located in the walls of the bronchi and bronchioles
- When stretched (deep inspiration) a reflex response is triggered to reduce the tidal volume.
- Only activated at large tidal volumes (greater than 800 – 1000 mL)
  - Not important control mechanism in quiet breathing

Deflation Reflex

- When the lungs are compressed or deflated (atelectasis, pneumothorax), tachypnea results.
- Unknown reason for this reflex.
Irritant Reflex

- Irritant receptors are located in the nasal mucosa, trachea, bronchi and bronchioles.
  - Vagal Response
  - Subepithelial mechanoreceptors
  - Responds to mechanical stimuli (ET tubes, suctioning and bronchoscopy).
  - Responds to chemical stimuli (noxious gases).
  - Responds to physiologic stimuli (histamine induced bronchospasm).
- Results in increased respiratory rate, cough, sneeze, laryngospasm, bronchoconstriction, gag reflex.

Juxtapulmonary Capillary Receptors – J Receptors

- J receptors are located in the interstitial space between the pulmonary capillaries and the alveoli.
- Responds to increased pulmonary capillary pressure
  - Pulmonary capillary congestion
  - Capillary hypertension
  - Edema of the alveolar walls
  - Emboli in the circulation
- When stimulated, a reflex response triggers a rapid, shallow breathing

Head’s Paradoxical Reflex

- Paradoxically stimulates a deeper breath rather than inhibiting further inspiration.
- Responsible for
  - Deep Breath (Sighs)
  - First breaths of Infants