

RESPIRATORY SYSTEM

Functions (GRVOI)

1. Gas Exchange
2. Regulation of blood pH
3. Voice production
4. Olfaction
5. Innate immunity

Anatomy

UPPER RESPIRATORY TRACT

- External nose, nasal cavity, pharynx

LOWER RESPIRATORY TRACT

- Larynx, trachea, bronchi, lungs

NOSE

- Consists of the external nose and nasal cavity

EXTERNAL NOSE – visible structure that forms a prominent feature of the face

NARES (nostrils) – external openings of the nose

CHOANAE – openings into the pharynx

NASAL CAVITY – extends from the nares to the choanae

NASAL SEPTUM – a partition dividing the nasal cavity into right and left parts

- **DEVIATED NASAL SEPTUM** – occurs when the septum bulges to one side

HARD PALATE – floor of the nasal cavity; separates the nasal and oral cavity

CONCHAE – three prominent bony ridges on the lateral walls on each side of the nasal cavity; increase the surface area of the nasal cavity and cause air to churn

PARANASAL SINUSES – air-filled spaces within bone

NASOLACRIMAL DUCTS – carry tears from the eyes

SNEEZE REFLEX – dislodges foreign substances from the nasal cavity

PHARYNX

- Common passageway for both the respiratory and digestive systems.

THREE REGIONS:

1. **NASOPHARYNX** – superior part
 - a. **SOFT PALATE** – an incomplete muscles and connective tissue partition separating the nasopharynx from the oropharynx
 - b. **UVULA** – posterior extension of the soft palate
 - c. **PHARYNGEAL TONSIL** – helps defend the body against infection

2. **OROPHARYNX** – extends from the uvula to the epiglottis

- a. **PALATINE TONSILS** – located in the lateral walls near the border of the oral cavity and the oropharynx
- b. **LINGUAL TONSIL** – located on the surface of the posterior part of the tongue

3. **LARYNGOPHARYNX** – passes posterior to the larynx and extends from the tip of the epiglottis to the esophagus; lined with stratified squamous epith. and ciliated columnar epith.

LARYNX

- Voice box

- Passageway for air between the pharynx and trachea

- Has **3 unpaired cartilages** and **6 paired cartilages**

UNPAIRED (3):

1. **THYROID CARTILAGE** – *Adam's apple*; largest cartilage
2. **CRICOID CARTILAGE** – most inferior, forms the base of the larynx
3. **EPIGLOTTIS** – 3rd unpaired cartilage; consist of elastic cartilage

PAIRED (6): *they form an attachment site for the vocal folds*

1. **CUNEIFORM CARTILAGE** – Top
2. **CORNICULATE CARTILAGE** – Middle
3. **ARYTENOID CARTILAGE** – Bottom
4. **VESTIBULAR FOLDS** – false vocal cords; superior
5. **VOCAL CORDS** – true vocal cords; inferior
6. **LARYNGITIS** – inflammation of the mucous epith. of the vocal folds

TRACHEA

- Windpipe

- Membranous tube attached to the larynx

- Consists of CT and smooth muscle; Reinforced with 16-20 C-shaped pieces of hyaline cartilage

C-SHAPED CARTILAGES – form the anterior and lateral sides of the trachea; protect the trachea and maintain an open passageway for air

COUGH REFLEX – dislodges foreign substances from the trachea

- **SMOKER'S COUGH** – results from constant irritation and inflammation of the respiratory passages by cigarette smoke

BRONCHI

- The trachea divides into the left and right **main bronchi** or **primary bronchi**, each of which connects to a lung

LEFT MAIN BRONCHUS – more horizontal because it is displaced by the heart

RIGHT MAIN BRONCHUS – where foreign objects that enter the trachea usually lodge; more vertical

LUNGS

- Principal organs of respiration

RIGHT LUNG – has 3 lobes (superior, middle, inferior)

LEFT LUNG – has 2 lobes (superior, inferior)

- The lobes of the lungs are separated by deep, prominent fissures on the lung surface.
- Each lobe is divided into **Bronchopulmonary segments** separated from one another by CT septa.
- The main bronchi branch many times to form the **TRACHEOBRONCHIAL TREE**.

• MAIN BRONCHI

- **LOBAR BRONCHI** – Secondary bronchi
 - **SEGMENTAL BRONCHI** – Tertiary bronchi
 - **BRONCHIOLES**
 - **TERMINAL BRONCHIOLES**
 - **RESPIRATORY BRONCHIOLES**
 - **ALVEOLAR DUCTS** – long, branching hallways with many open doorways
 - **ALVEOLI** – Small air sacs

RESPIRATORY MEMBRANE OF THE LUNGS – where gas exchange between the air and blood takes place

- It is very thin to facilitate the diffusion of gases
- Consists of **6 LAYERS**:

1. **Thin layer of fluid** lining the alveolus
2. **Alveolar epithelium** – composed of simple squamous epithelium
3. **Basement membrane** of the alveolar epith.
4. **Thin interstitial space**
5. **Basement membrane** of the capillary endothelium
6. **Capillary endothelium** – simple squamous epith.

PLEURAL CAVITIES

- surround the lungs and provide protection against friction

PLEURA – serous membrane lining the pleural cavity

- **PARIETAL PLEURA** – lines the walls of the thorax, diaphragm and mediastinum
- **VISCERAL PLEURA** – covers the surface of the lung

PLEURAL FLUID – acts as a lubricant and helps hold the pleural membranes together

LYMPHATIC SUPPLY

SUPERFICIAL LYMPHATIC VESSELS – are deep to the visceral pleura; they drain lymph from the superficial lung tissue and the visceral pleura

DEEP LYMPHATIC VESSELS – follow the bronchi; they drain lymph from the bronchi and associated CTs

VENTILATION AND RESP. VOLUMES

VENTILATION (breathing) – the process of moving air into and out of the lungs.

2 PHASES:

1. **INSPIRATION** – inhalation; movement of air into the lungs
2. **EXPIRATION** – exhalation; movement of air out of the lungs

CHANGING THORACIC VOLUME

MUSCLES OF INSPIRATION – include the diaphragm and the muscles that elevate the ribs and sternum, such as the *external intercostals*

- **DIAPHRAGM** – a large dome of skeletal muscle that separates the thoracic cavity from abdominal cavity

MUSCLES OF EXPIRATION – *internal intercostals*; depress the ribs and sternum.

PRESSURE CHANGES AND AIRFLOW

Two physical principles that govern the airflow:

1. *Changes in volume result in changes in pressure.*
2. *Air flows from an area of higher pressure to an area of lower pressure*

- During **INSPIRATION**, air flows into the alveoli because atmospheric pressure is greater than the alveolar pressure.

- During **EXPIRATION**, air flows out of the alveoli because alveolar pressure is greater than atmospheric pressure.

LUNG RECOIL

- The tendency for an expanded lung to decrease in size.
- When thoracic volume and lung volume decrease during quiet expiration.
- Two factors keep the lungs from collapsing: **SURFACTANT** and **PLEURAL PRESSURE**.

SURFACTANT – reduces the surface tension of the fluid lining the alveoli (surface acting agent).

PLEURAL PRESSURE – lower than alveolar pressure, which causes the alveoli to expand.

CHANGING ALVEOLAR VOLUME

- **Increasing thoracic volume** results in decreased pleural pressure, increased alveolar volume, decreased alveolar pressure, and air movement into the lungs (**inspiration**).

- **Decreasing thoracic volume** results in increased pleural pressure, decreased alveolar volume, increased alveolar pressure, and air movement out of the lungs (**expiration**).

RESPIRATORY VOLUMES & CAPACITIES

SPIROMETRY – is the process of measuring volumes of air that move into and out of the respiratory system.

SPIROMETER – device that measures the resp. volumes

RESPIRATORY VOLUMES – are measures of the amount of air movement during different portions of ventilation

RESPIRATORY CAPACITIES – are sums of two or more respiratory volumes

RESPIRATORY VOLUMES:

1. **TIDAL VOLUME** – air inspired or expired with each breath (at rest, quiet breathing = 500mL)
2. **INSPIRATORY RESERVE VOLUME** – air that can be inspired forcefully beyond the resting TV (3000mL)
3. **EXPIRATORY RESERVE VOLUME** – air that can be expired forcefully (1100mL)
4. **RESIDUAL VOLUME** – air still remaining in the respiratory passages and lungs after maximum expiration (1200mL)

RESPIRATORY CAPACITIES:

1. **FUNCTIONAL RESIDUAL CAPACITY** – $ERV + RV$
 - Amount of air remaining in the lungs at the end of a normal expiration (2300mL)
2. **INSPIRATORY CAPACITY** – $TV + IRV$
 - Amount of air a person can inspire maximally after a normal expiration (3500mL)
3. **VITAL CAPACITY** – $IRV + TV + ERV$
 - It is the maximum volume of air that a person can expel from the resp. tract after maximum inspiration (4600mL)
4. **TOTAL LUNG CAPACITY** – $IRV + ERV + TV + RV$
 - Also equal to the VC + RV (5800mL)

GAS EXCHANGE

- Gas exchange bet. air and blood occurs in the **respiratory membrane**

DEAD SPACE – the parts of the resp. passageways where gas exchange bet. air and blood does not occur.

RESPIRATORY MEMBRANE THICKNESS

- Increases in the thickness of the respiratory membrane result in decreased gas exchange.

SURFACE AREA

- Small decreases in surface area adversely affect gas exchange during strenuous exercise. When the surface area is decreased to 1/3 or 1/4 of normal, gas exchange is restricted under resting conditions.

PARTIAL PRESSURE

- is the pressure exerted by a specific gas in a mixture of gases, such as air.

DIFFUSION OF GASES IN THE LUNGS

- O₂ diffuses from a higher partial pressure in the **alveoli** to a lower pp in the **pulmonary capillaries**.
- CO₂ diffuses from a higher partial pressure in the **pulmonary capillaries** to a lower pp in the **alveoli**.

DIFFUSION OF GASES IN THE TISSUES

- O₂ diffuses from a higher pp in the **tissue capillaries** to a lower pp in the **tissue spaces**.
- CO₂ diffuses from a higher pp in the **tissues** to a lower pp in the **tissue capillaries**.

GAS TRANSPORT IN THE BLOOD

OXYGEN TRANSPORT

OXYHEMOGLOBIN – hemoglobin with oxygen bound to its heme groups

MORE OXYGEN IS RELEASED FROM HEMOGLOBIN IF (FOUR FACTORS):

1. Partial pressure for O₂ is **low**
2. Partial pressure for CO₂ is **high**
3. **pH** is **low**
4. **Temperature** is **high**

CO₂ TRANSPORT AND BLOOD pH

CARBONIC ANHYDRASE – enzyme that promotes the uptake of CO₂ by RBCs

- As CO₂ levels increase, blood pH decreases (becomes more **acidic**)
- As CO₂ levels decrease, blood pH increases (becomes more **basic**)

RHYTHMIC BREATHING

RESPIRATORY AREAS IN THE BRAINSTEM

MEDULLARY RESPIRATORY CENTER – establishes rhythmic breathing

- **DORSAL RESPIRATORY GROUPS (2)** – primarily responsible for stimulating contraction of the diaphragm.
- **VENTRAL RESPIRATORY GROUPS (2)** – primarily responsible for stimulating the external and internal intercostal, and abdominal muscles.
 - **PRE-BOTZINGER COMPLEX** – establish the basic rhythm of breathing

PONTINE RESPIRATORY GROUP – is a collection of neurons in the pons.

- It plays a role in switching between inspiration and expiration.

GENERATION OF RHYTHMIC BREATHING

- involves the integration of stimuli that start and stop inspiration

1. **Starting inspiration**
2. **Increasing inspiration**
3. **Stopping inspiration**

NERVOUS CONTROL OF BREATHING

HIGHER BRAIN CENTERS – allow voluntary control of breathing.

HERING-BREUER REFLEX – supports rhythmic respiratory movements by limiting the extent of inspiration

TOUCH, THERMAL, PAIN RECEPTORS – can stimulate breathing

CHEMICAL CONTROL OF BREATHING

HYPERCAPNIA – a greater than normal amount of CO₂ in the blood

CARBON DIOXIDE – major chemical regulator of breathing

CHEMORECEPTORS (in medulla oblongata) – respond to changes in blood pH

CHEMORECEPTORS (in carotid and aortic bodies) – respond to changes in blood O₂.

HYPOXIA – a condition when blood O₂ declines to a low level

EFFECT OF EXERCISE ON BREATHING

1. *Breathing increases abruptly*
2. *Breathing increases gradually*

ANAEROBIC THRESHOLD – the highest level of exercise that can be performed without causing a significant change in blood pH

RESPIRATORY ADAPTATIONS TO EXERCISE

- Training results in increased minute volume at maximal exercise because of increased TV and respiratory rate.

EFFECTS OF AGING ON THE RESP. SYSTEM

1. VC and Maximum min. ventilation decrease
2. RV and dead space increase
3. Increase in resting TV compensates for increased dead space, loss of alveolar walls, and thickening of alveolar walls
4. The ability to remove mucus from respiratory passageways decreases with age