Respiratory System

A. Functions

1. Respiration

2. Smell

3. Filtration/defense

4. Sound & speech production

5. Eliminate waste

B. Anatomy of the Respiratory System

1. Nose/Nasal Cavity

A) Functions

1) Provide airway for respiration

2) Filter incoming air

3) Warm and moisten incoming air

4) Aids in speech

5) Location of olfactory receptors

B) Has external and internal components

C) External components

1) Root

2) Bridge

3) Apex

4) External nares or nostrils

D) Internal components

1) Nasal cavity – divided into 2 sections by the nasal septum

a) Roof is composed of ethmoid and sphenoid bones

b) Floor is composed of the hard and soft palates

c) Each side is further divided into sections by the superior, middle, and inferior

concha

i) These cause air to swirl causing particles to become trapped in mucus

2) Internal nares – openings between the nasal cavity and pharynx

2. Pharynx – throat

A) Composed of 3 regions

1) Nasopharynx

a) Is continuous with nasal cavity

b) Normally serves as a passageway for air only

c) Blocked by soft palate and uvula during swallowing

2) Oropharynx

a) Lies posterior to oral cavity – from soft palate to tip of the upright epiglottis

b) Passageway for both food and air

3) Laryngopharynx

a) Lies posterior to the upright epiglottis and extends to esophagus/trachea

b) Passageway for both food and air

3. Larynx – voice box

A) Extends from hyoid bone to the trachea

B) Main functions

1) Provide open airway

2) Acts as a switching mechanism to route food and air down correct paths

3) Location of the vocal folds (cords) – speech

4) Initiation of the cough reflex – caused when something other than air enters the

trachea

C) Composed of nine pieces of cartilage

1) Largest piece is the thyroid cartilage – causes protrusion = laryngeal prominence

(Adam’s apple)

2) Epiglottis – blocks trachea during swallowing

3) 3 paired cartilages – arytenoid, cuneiform & corniculate

4) Cricoid cartilage is the inferior-most piece

D) Glottis – opening between the vocal folds within the larynx

4. Trachea – windpipe

A) Extends from larynx until it branches

B) Is ciliated and produces mucus to help trap particles in inspired air

C) Tracheal rings – rings of hyaline cartilage that provide strength and support

5. The Respiratory Tree – structures serve as a conduit for air

A) Right and left primary bronchi

1) Initial branches of the trachea

B) Secondary bronchi

C) Tertiary bronchi

D) Continues branching (up to 23 times)

E) Bronchioles – 1mm diameter

1) Continue to branch and get smaller

F) Terminal bronchioles – < 0.5mm

6. The Respiratory Zone – structures where gas exchange occurs

A) Respiratory bronchioles (contain alveoli)

B) Alveolar sacs – cluster of alveoli

C) Alveoli

1) Actual site of gas exchange

2) About 300 million per lung

3) Coated in surfactant

a) Detergent-like lipoprotein chemical

b) Reduces surface tension of the water in the alveoli and prevents the alveoli

from collapsing upon themselves

C. Respiration – Breathing, Exchange, Transport

1. Inspiration (Inhalation)

A) Result of a pressure difference between:

1) Atmospheric pressure

2) Intrapulmonary pressure

B) Boyle’s Law – the pressure exerted by a gas varies inversely to its volume

C) Mechanism

1) Diaphragm & external intercostals

2. Expiration (Exhalation)

A) Normal/restful (tidal) expiration

B) Exercise or forced expiration

1) Abdominals & internal intercostals

3. Gas exchange (O2 & CO2)

A) Dictated by Dalton’s Law – the total pressure exerted by a mixture of gases is the

sum of the pressures exerted independently by each gas in the mixture

1) Partial pressure

B) A partial pressure difference is necessary at all locations where gases are

exchanged

1) Alveoli & blood

2) Blood & cells

C) pO2 is **lowest** in the cells and increase as you move **up** the respiration pathway

D) pCO2 is **highest** in the cells and decreases as you move **up** the respiration pathway

E) Rate of gas exchange is affected by:

1) Partial pressure difference

2) Gas solubility

3) Surface area

4) Diffusion distance

4. Transport of Gases

A) O2 transport

1) 2 main forms

a) Dissolved in plasma – 1.5%

b) Bound to hemoglobin (Hb) – 98.5%

i) Hb + O2 = HbO2 (oxyhemoglobin)

2) The RBC’s affinity for O2 is affected by:

a) pH – decreased pH causes decreased affinity

b) pCO2 – increased pCO2 causes decreased affinity

c) Temperature – increased temp causes decreased affinity

B) CO2 transport – 3 basic forms

1) Dissolved in plasma – 7%

2) Bound to hemoglobin – 23%

a) Hb + CO2 = HbCO2 (carbaminohemoglobin)

3) Bicarbonate (HCO3-) ions – 70%

a) Forms in RBC

CO2 + H2O 🡪 H2CO3 🡪 H+ + HCO3-

i) HCO3- leaves the RBC

ii) Chloride shift – Cl- moves into the RBC

iii) H+ binds with hemoglobin

b) Process reverses in the lungs

CO2 + H2O 🡨 H2CO3 🡨 H+ + HCO3-

i) HCO3- enters the RBC

ii) H+ breaks from hemoglobin and binds with HCO3-

iii) Reverse chloride shift – Cl- moves out of the RBC

5. Control of Respiration

A) Respiratory Center – located within the medulla oblongata and the pons

1) Dorsal respiratory group (DRG) – dominant group

a) Stimulates the diaphragm and external intercostals

i) Sets the tidal (restful) breathing rhythm (eupnea)

(a) 2 sec. inhalation/3 sec. exhalation

(b) 12-15 breaths/min

b) Integrates input from peripheral stretch and chemoreceptors

i) Stimulates the VRG when ventilation demands increase

2) Ventral respiratory group (VRG)

a) Stimulates the accessory inspiratory and expiratory muscles (abdominals &

internal intercostals) when necessary

3) Apneustic center

a) Helps coordinate transition from expiration to inspiration

b) It stimulates the DRG to initiate inspiration during both restful and forceful

breathing

4) Pneumotaxic center

a) Helps coordinate transition from inspiration to expiration

b) It inhibits the apneustic center to promote restful or forceful expiration as

needed

c) Along with the apneustic center, it helps modify and fine-tune breathing

during activities such as speaking, singing, sleeping, and exercising

B) The respiratory center is influenced by:

1) Higher brain centers (conscious control)

2) Stretch receptors in lungs

3) Irritant receptors in trachea & lungs

4) Chemoreceptors in brain

a) Detect CO2 &H+ in the blood

5) Chemoreceptors in aortic arch and common carotid arteries

a) Detect O2, CO2 &H+ in the blood

6. Respiratory Air Volumes

A) Respiratory Volumes

1) Tidal volume (TV) – the amount of air inhaled or exhaled with each breath

under resting conditions

2) Inspiratory reserve volume (IRV) – the amount of air that can be forcefully

inhaled after a normal tidal volume inhalation

3) Expiratory reserve volume (ERV) – the amount of air that can be forcefully

exhaled after a normal tidal volume exhalation

4) Residual volume (RV) – amount of air remaining in the lungs after a forced

exhalation

5) Dead Space Volume (DSV) – amount of air in the respiratory pathway not

involved in gas exchange

B) Respiratory capacities

1) Total lung capacity (TLC) – the sum of all respiratory volumes.

2) Vital capacity (VC) – the total amount of exchangeable air

7. Breathing Patterns

A) Eupnea – normal breathing

B) Apnea – transient cessation of breathing

C) Dyspnea – difficult, labored, or painful breathing

1) Often indicates lung infection/injury

D) Hyperventilation

1) Can result in respiratory alkalosis

E) Hypoventilation

1) Can result in respiratory acidosis

8. Respiratory Disorders

A) Sinusitis – inflamed sinuses from a nasal cavity infection

B) Laryngitis – inflammation of the vocal cords

C) Pharyngitis (strep throat) – inflammation of the pharynx; caused by *Streptococcus*

bacteria

D) Pleurisy – inflammation of the pleural membranes

E) Pneumothorax – air in the intrapleural spaces

F) Atelectasis – lung collapse

G) Carbon Monoxide Poisoning – CO binds with Hb in place of O2

H) Pneumonia – infectious inflammation of the lungs (usually bacterial but can also be

viral or fungal)

I) Emphysema – permanent enlargement of the alveoli due to destruction of the

alveolar walls

J) Chronic bronchitis – inhaled irritants lead to chronic excessive mucus production as

well as inflammation and fibrosis of the mucosa

K) Asthma – bronchoconstriction prevents airflow into the alveoli

L) Tuberculosis – an infectious disease caused by the bacterium *Mycobacterium*

*tuberculosis* resulting in fibroid masses in the lungs

M) Cystic Fibrosis – genetic disorder that causes an increase in mucus production

resulting in clogged respiratory passages

N) Infant Respiratory Distress Syndrome (IRDS) – alveoli collapse between breaths

causing labored breathing and sometimes inadequate respiration

1) Usually seen in premature infants