BMSN1601 – Anatomy – Part II – Part B (L16~L17)

Introduction to the Respiration Process

- Respiration involves **4 distinct** processes

Pulmonary ventilation	External respiration	Transport	Internal respiration
movement of air into & out of lungs	Gas exchange between lungs & blood	transport of O_2 & CO_2 between lungs & tissues	gas exchange between systemic arterial blood & body tissues across capillary membrane

- Recap: Basic Information About Different Pressure during the discussion
  - Atmospheric pressure: 760mmHg
  - Intrapulmonary Pressure [P_{alv}]: Pressure in the alveolar
  - – Intrapleural Pressure [P_{ip}] = Collapsing Pressure of Lung
    → The Intrapleural Pressure is always smaller than Intrapulmonary Pressure
- Recap: Basic Information About Inspiration
  - Lungs are stretched & intrapulmonary volume increases
    → Intrapulmonary pressure drops (-1 mmHg / Minimum Value)
    → Air flows into lungs down pressure gradient
    → Intrapulmonary Pressure gradually increase → Intrapulmonary Pressure = Atmospheric Pressure (760mmHg)

Lungs can slide but not separated from pleura
- Lungs adhere to thoracic wall
- Expand/recoil as thoracic cavity changes in volume during breathing

- Recap: Basic Information About Expiration
  - Quiet expiration depends on natural elasticity of lungs
    → No Muscle Contraction
  - **Inspiratory muscles relax** & **resume resting length**
    → Rib cage descends due to gravity
    → Volume of thoracic cavity decreases
    → Lungs **recoil**
  - Intrapulmonary volumes decreases
    → Intrapulmonary pressure rises (to +1 mm Hg / Maximum Value)

- Pressure & Volume Changes during Pulmonary ventilation

	Intrapulmonary pressure (Relative)	Intrapleural pressure (Relative)
Inspiration	-1mmHg	-6mmHg
Expiration	+1mmHg	-3mmHg Still **(< intrapulmonary pressure)** to **keep alveoli inflated**

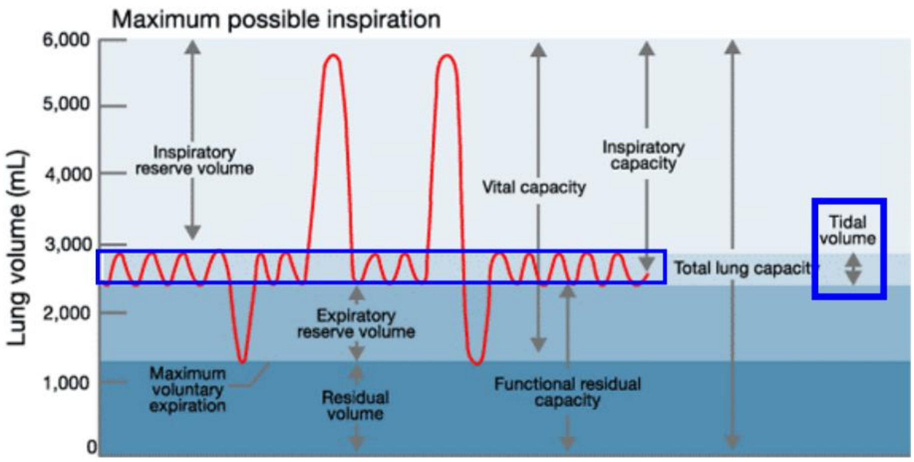
Introduction to the Clinical Physiology Regarding the Pulmonary Ventilation

- Dead Space: Volume of inhaled air which **does not take part in gas exchange**

Dead Space	
Anatomical Dead Space	Volume of conducting respiratory passageways (~150mL)
Alveolar dead spaces	Volume occupied by alveoli that stop to act in gas exchange (**due to collapse, obstruction or lack of adjacent pulmonary capillaries**) ● Emphysema ● Pneumonia ● Chronic obstructive pulmonary disease

- Non-respiratory Air Movements
  - Coughing, Sneezing, Crying, Laughing, Yawning

Introduction to the Lung Volume & Lung Capacities



Tidal volume (TV)	• volume of air that moves into or out of lungs with **each normal, quiet breath** (~ 500 mL)
Inspiratory reserve volume (IRV)	• extra volume of air that can be inspired forcibly **after a tidal inspiration** (2,100 – 3,200 mL)
Expiratory reserve volume (ERV)	• extra volume of air that can be evacuated from lungs **after a tidal expiration** (1,000 – 1,200 mL)
Residual volume (RV)	• volume of air left in lungs **after strenuous expiration** (1,200 mL)

Inspiratory capacity (IC) [**total amount of air that can be inspired after a tidal expiration**]	Tidal volume (TV)
	Inspiratory reserve volume (IRV)

Functional residual capacity (FRC) [~~total~~ **amount of air remaining in lungs after a tidal expiration**]	Expiratory reserve volume (ERV)
	Residual volume (RV)

Vital capacity (VC) [**total amount of exchangeable air (TV + IRV + ERV)**]	Tidal volume (TV)
	Inspiratory reserve volume (IRV)
	Expiratory reserve volume (ERV)

Total lung capacity (TLC)	Tidal volume (TV)
	Inspiratory reserve volume (IRV)
	Expiratory reserve volume (ERV)
	Residual volume (RV)

External Respiration – Gas Exchange between Lungs & Blood

- The Characteristic of Alveoli:

Account for most of Volume of Lung	Large Surface Area to facilitate the gas exchange	Surrounded by **fine elastic fibers**	**Densely** covered with of **pulmonary capillaries**

- Structure of Alveoli:

Type I Alveoli Cells	• Single Layer of Squamous epithelial cells that form Alveolar Wall → For Gas Exchange
Type II Alveoli Cells	• Secrete Surfactant → Coat the outer, Alveolar surfaces
Marcophages:	• Keep The Alveolar Surfaces **sterile**
Alveolar Pores:	• Connect adjacent alveoli • Equalize the air pressure throughout the lung

- Respiratory Membrane:

Barrier across which gases are exchanged between alveolar air & blood (~1μm-thick)		
Alveolar Epithelium	Capillary Endothelium	Basement Membrane between Alveolar Epithelium and Capillary Endothelium

- Pulmonary Gas Exchange:

At alveoli with **maximal ventilation**	• pulmonary arterioles dilate → increasing blood flow into associated capillary
At alveoli with **inadequate ventilation**	• pulmonary arterioles constrict → redirecting blood to other respiratory areas

- Pressure Gradient @ External Respiration

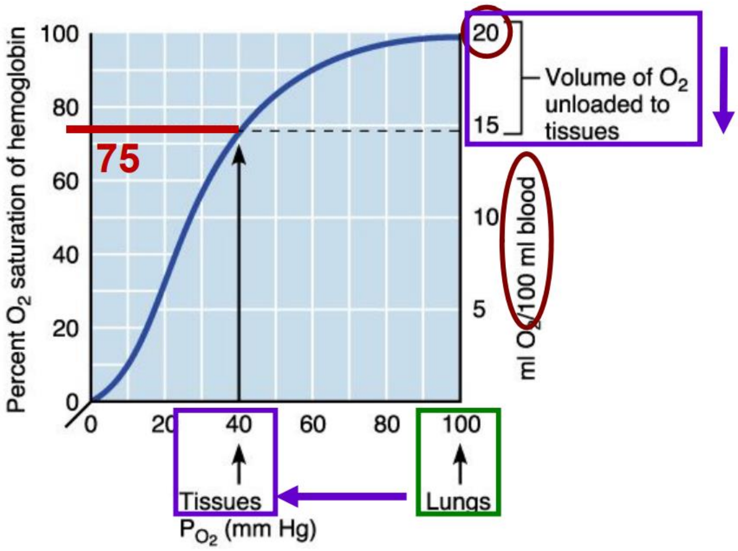
	PO_2	PCO_2
Alveoli	100 mmHg	40 mmHg
Pulmonary Artery	40 mmHg	46 mmHg

Transportation – Transport of O_2 & CO_2 between Lungs & Tissue

- Transportation of O_2

Direct Dissolve in Plasma	• By Direct Diffusion
Bound to Hemoglobin with RBCs	• Each hemoglobin molecule binds 4 oxygen molecules ○ Oxyhemoglobin (HbO2) ○ Deoxyhemoglobin (After Releasing O_2)

- Equilibrium of Oxyhemoglobin
  - The Factors: PO_2, PCO_2, $[H^+]$, [BPG]/[2,3-bisphosphoglycerate]



Note: Haemoglobin-Oxygen dissociation graph shift to the right, affinity is reduce; Haemoglobin-Oxygen dissociation graph shift to the left, affinity is increase.
(RR: Right → Reduce Affinity).

The Chemical Equations:

$Hb + 4O_2 \rightleftharpoons Hb.4O_2$

$Hb.4O_2 + H^+ \rightleftharpoons HHb^+ + 4O_2$

Thus, we have:

$$Hb + 4O_2 + H^+ \rightleftharpoons HHb^+ + 4O_2 \quad (\Delta H > 0)$$

Increase PCO_2 → Acidity of Blood is Higher → Equilibrium Shift to the Right → Affinity Decrease
Increase PO_2 → Equilibrium of Equation I shift to the Left → Affinity Increase
Increase in Temperature→ Forward Reaction is Endothermic → Equilibrium shift to the Right → Affinity Decrease
Increase $[H^+]$ → Equilibrium shift to Right → Affinity Decrease
Increase [BPG]→ BPG selectively binding to deoxyhemoglobin → $[HHb^+]$ Decrease → Equilibrium shift to the Right →Affinity Decrease

- Transportation of CO_2
  - Dissolved in plasma
  - Bound to hemoglobin (carbaminohemoglobin)
  - Bicarbonate ions in plasma (70%)