EDO UNIVERSITY IYAMHO

Department of Physiology

PHS 214Respiratory System

Instructor: ***MJ ADENIYI***, email: Adeniyi.mayowa@edouniversity.edu.ng
Lectures: Monday, 11am ï 1pm, LT6, phone: (+234) 8066796517
Office hours: Wednesday, 2.30 to 3.30 PM (just after class), Office: Floor2 Rm 4

Teaching Assistants: *Nil*

Description: The aim of this course is to give students thorough knowledge of physiology of respiratory system and related pathophysiological conditions. This course covers topics such as pulmonary blood supply, overview of the functions of respiratory system, physiologic anatomy of respiratory system, mechanics and mechanism of breathing, control of respiration, lung volumes. & capacities, pulmonary surfactant, compliance,work of breathing, fluctuations in respiration, gas transport& exchange, respiration during exercise, altitude & deep sea

Prerequisites: Students should be familiar with the basic concepts of respiratory system (*e.g.,*inspiration and expiration, the lungs and gas exchange)

Assignments: We wish to have 3 individual homework assignments throughout the course and a preparatory test in addition to a Mid-Term Test and a Final Exam. Preparatory test and home works are organized and structured as preparation for the midterm and final exam.

Grading: We will assign 10% of this class grade to home works, 10% for the term papers, 10% for the mid-term test and 70% for the final exam. The Final exam is comprehensive.

Textbooks: The recommended textbooks for this class are:
Title: *Textbook of Medical Physiology*
Authors: Arthur C. Guyton, MD
John E. Hall, PhD
Publisher: Elsevier Inc. 12th edition
ISBN: 0-7216-0240-1
Year: 2006
Title: *Review of Medical Physiology*

Authors: Kim Barret, Heddwen Brooks, Scott Boitano, Susan Barman
Publisher: Mcgraw Hills
ISBN: 978-0-07-160568-7
Year: 2010

Lectures: Below is a description of the contents. We may change the order to accommodate the materials you need for the projects.

INTRODUCTION

In this unit, we want to examine the system that is responsible for obtaining oxygen from the external environment and expelling carbon dioxide, a metabolic waste into the external environment. Let us begin by differentiating ***external respiration***, ***internal respiration*** and ***cellular respiration***. External respiration entails movement of air in and out of lungs and exchange of gases between the alveoli and blood capillaries. Internal respiration deals with exchange of gases between red blood cells and body cells and cellular respiration deals with the utilization of oxygen by body cells for the production of energy in form of **ATP**. Since cellular respiration has been discussed in the previous unit, we will be considering movement of air in and out of the lungs, exchange of air between alveoli and pulmonary capillaries and exchange of air between body tissues and blood capillaries.

BLOOD SUPPLY TO LUNGS

The lungs received dual blood supplies from pulmonary and bronchial circulations. The latter is part of systemic circulation. Due to the dual circulation, the likelihood of infarction is low.

Pulmonary artery supplies oxygen-deficient blood to the alveoli which are used for gas exchange and pulmonary vein carries oxygen rich blood into the left atrium.

OVERVIEW OF THE FUNCTIONS OF RESPIRATORY SYSTEM

-Humidification, warming & filtration of air take place in airway.

-Exchange of oxygen and carbon dioxide between the tissues and the external environment occurs in the alveoli.

-The larynx helps in production of vocal sound

-Olfactory receptors present in the upper aspect of nasal cavity help in perception of smell. Sensory information is conducted via cranial nerve I (olfactory nerve).

PHYSIOLOGIC ANATOMY OF HUMAN RESPIRATORY SYSTEM

The human respiratory system consists of:

- Lungs encaged by thorax
- System of tubes that act as conduit to the lungs
- Muscles that affect the size of thoracic cage
- Respiratory centres (medulla & pons)

Nerve tract linking the respiratory centres with the muscles

MECHANICS AND MECHANISM OF BREATHING

As stated earlier, the environment is the source of oxygen. About 21% of air at 760mmHg is oxygen and 0.04% is carbon dioxide. When we breathe in air, about 250ml of oxygen enters through respiratory tract to the lungs per minute and 200ml of carbon dioxide is expelled.

The lungs are not capable of distending themselves against the rib cage and diaphragm. Hence, for breathing to take place, neurally controlled mechanical changes must take place in ribs and respiratory muscles. We have just established that activation of inspiratory center will lead to contraction of inspiratory muscles and contraction of inspiratory muscles will also produce inspiration.

Inspiration is the influx of air into the lungs. It is an active process at rest. During inspiration,

-Contraction of external intercostal muscle leads to outward and upward movement of ribs and sternum resulting in increased anterior posterior diameter of thoracic cavity (please study table 1).

-When diaphragm contracts, it flattens and this leads to increased vertical diameter of the thoracic cavity

-During forced breathing as occur in exercise and emotion, contraction of sternocleidomastoid muscle of the neck further raises the sternum upward bring about much more increase in size of thoracic cavity (check table 1 for other accessory inspiratory muscles and their effects on thoracic cavity).

-When the diameters of thoracic cage increases, intrathoracic volume increases. According to Boyleôs law, increase in intrathoracic volume leads to decrease in intrathoracic pressure.

-Decrease in pressure within the thorax implies decreases in intrapleural pressure (from -4mmHg to -6mmHg) and intralveolar pressure (from +4 to -4mmHg). Transpulmonary pressure, the difference between intrapleural pressure and intralveolar pressure also decreases. -6mmHg means that intrapleural pressure is lesser than atmospheric pressure (760mmHg) by 6mmHg. -4mmHg means intralveolar pressure is lesser than atmospheric pressure by 4mmHg.

-The difference between atmospheric pressure and the intrathoracic pressures creates great diffusion gradient for air to flow into the lung.

- During deep inspiration as occurs during exercise and emotion, contraction of accessory inspiratory muscles occurs such that the intrathoracic pressure may ***decrease up to -30mmHg***. This great pressure helps in drawing a large quantity of air into the lung

Expiration is the efflux of air from the lungs. It is a passive process at rest (i.e. does not require muscle contraction). However, forceful expiration is active.

-Filling and distension of lungs stimulates stretch receptors of the lungs resulting in inhibition of inspiratory center and stimulation of expiratory centre.

-Inhibition of inspiratory centre results in relaxation of inspiratory muscles.

-At rest, inhibition of inspiratory centre brings about relaxation of diaphragm and external intercostal muscles. Relaxation of external intercostal muscle draws the ribs inward and downward leading to decreased size of thoracic cavity. Also, the elastic recoil of the ribs begins due to relaxation of external intercostal muscles. The vertical diameter greatly diminishes due to relaxation of the diaphragm. The cumulative results of these changes include increase in intrapleural pressure (from -4mmHg to -2.5mmHg), compression of the lungs and expulsion of air. Expulsion of air leads to lung elastic recoil.

-Strong expiratory effort such as during coughing may result in a great increase in intrapleural pressure up to +100mmHg.

CONTROL OF RESPIRATION

Nervous Mechanism

Inspiratory Center; is located in the solitary tract nucleus forming dorsal group of nuclei. Stimulation cause inspiratory ramp and increases depth of inspiration.

Expiratory Center: is situated in nucleus ambiguus forming ventral group of nuclei. Stimulation causes inspiration and expiration. Nucleus ambiguous and dorsal motor nucleus are also cardiac center, Therefore, stimulation of these nuclei will result in both expiration and decrease in heart rate. Alteration in heart rate due to respiration is called ***sinus arrhythmia***.

Chemical Mechanism

There are chemoreceptors in the brain and arteries. Chemoreceptors are stimulated by changes in chemical composition of composition of hydrogen ion, carbon dioxide and oxygen in the blood. There are two types of chemoreceptors.

COMPLIANCE

Inspiration and expiration are associated with changes in size of the lungs (lung recoil). The measure of elasticity of the lungs is called compliance. The elasticity of the lung is higher than that of the lung and chest wall. The elasticity of lung is 220mL/cmH_20 and that of lung and chest wall is 110mL/cmH_20.

SURFACTANT

In inspiration, the lung increases in size and in expiration, the size of the lung decreases. Despite the decrease in lung volume in expiration, the lungs do not collapse. What prevents the lungs from collapsing is surfactant. Surfactant is a surface acting substance produced by type II alveoli epithelial cells (cuboidal epithelial cells). It is made up of lipids and proteins.

LUNG VOLUME AND CAPACITIES

Lung volumes and capacities are useful in the assessment of the function of the lungs and respiratory tract. All lung volumes and capacities are measured using **spirometer** except residual volume and functional residual capacity.

FLUCTUATION IN RESPIRATION

-Normal respiratory rate is 12-20cycles/minute in adult at rest. This is termed ***eupnea.***

-Increase in respiratory rate is called ***tachypnea***. Tachypnea is a respiratory mechanism designed to draw oxygen rich air into the lungs. When the frequency of respirationis too high, the major challenge is decrease in volume of air inhaled and exhaled.

-***Hyperpnea*** means increase in rate of and depth of respiration.

-***Polypnea*** refers to rapid shallow breathing or increase in respiratory rate and decrease in depth of respiration.Rapid shallow breathing occurs during intense exercise in untrained individuals. ***Kussmaul breathing*** seen in diabetic is a form of rapid shallow breathing.

-Decrease in respiratory rate is termed ***bradypnea***.

TRANSPORT OF RESPIRATORY GASES

Transport of Oxygen

Oxygen is carried majorly by hemoglobin in form of oxyhemoglobin.

Transport of carbon dioxide

As solution: Carbon dioxide can be transported in plasma as solution. 7% of carbon dioxide is carried in this form.

RESPIRATION DURING EXERCISE

As stated earlier, the basic function of respiratory system is to supply oxygen needed to produce ATPs and to get rid of carbon dioxide. During exercise, there is a great increase in demand for oxygen intake and carbon dioxide excretion. When oxygen demand exceeds oxygen supply, cells depend on anaerobic processes to make ATP. During anaerobic glycolysis, you will recall that lactic acid and other metabolic products are formed. Therefore, the extra volume of oxygen consumed after exercise to remove lactic acid and restore energy and oxygen stores is called ***oxygen debt***.

RESPIRATION IN HIGH ALTITUDE

Climbing mountains or travelling to countries with high topography is fascinating. However, the very major constraints as we move up the sea level are:

-Low partial pressure of gases

-Decrease in temperature

-Exposure to ultraviolent radiation

RESPIRATION IN DEEP SEA

Deep sea expedition is a hobby of divers. As we move down sea level, the partial pressure of gases increases.

You will recall that at sea level, nitrogen gas occupies 78% of the air. Therefore, one would expect greater concentration as one move down the sea level. At 100 ft below sea level, the concentration of nitrogen in blood and body tissue increase that unconsciousness sets in. This condition is termed ***nitrogen narcosis***