2016 Medical Physiology 100 Course Learning Objectives

General Course Objectives

The primary objective of the Medical Physiology Course is to ensure that students understand how the body works. After completing this course students should be able to:

1. Define *homeostasis* and explain how homeostatic mechanisms normally maintain a constant *interior milieu*.
2. State the functions of each organ system of the body, explain the mechanisms by which each functions, and relate the functions and the anatomy and histology of each organ system.
3. Understand and demonstrate the interrelations of the organ systems to each other.
4. Predict and explain the integrated responses of the organ systems of the body to physiological and pathological stresses.
5. Explain the pathophysiology of common diseases related to the organ systems of the body.

AUTONOMIC NERVOUS SYSTEM

1. Know ANS divisions and organization
   a. Functional units
   b. Principal neurotransmitters
   c. Receptor types
2. Identify sensory input to ANS
a. Explain how it integrates function (BP)
3. List main physiological responses under ANS control
a. Distinguish SNS from PSNS mediated responses
4. Understand the consequences of ANS dysregulation

SKELETAL, CARDIAC AND SMOOTH MUSCLE LECTURES

1. These lectures introduce basic concepts of muscle structure, mechanics and function.
2. Identify contractile and regulatory proteins
3. Describe excitation-contraction coupling
4. Recognize the role and source of Ca in muscle contraction
5. Identify energy sources for muscle contraction
6. Describe mechanisms that regulate muscle contraction and relaxation
7. Contrast structural, energetic & regulatory aspects of 3 muscle types

ELECTROPHYSIOLOGY OF THE HEART

1. Discuss the various factors that contribute to the resting membrane potential of cardiac, myocytes.
2. Describe the characteristics of "fast" and "slow" response action potentials.
3. Define diastolic depolarization and explains the basis for rhythmic electrical activity of cardiac cells.
4. Trace the movement of a cardiac impulse throughout the heart during a normal cardiac cycle.

ELECTROCARDIOGRAPHY I

1. Describe the standards that are used for recording a 12-lead electrocardiogram.
2. Compare the various waveforms that are generated when recording electrocardiograms with the standard limb leads, augmented limb leads, and precordial leads.
3. State the relationship between electrical events of cardiac excitation and the generation of the various waveforms, intervals, and segments that occur during the recording of an electrocardiogram.
4. Discuss the basic principles used by clinicians to interpret electrocardiograms.
5. Explain several methods that can be used to calculate effective atrial and ventricular rates.
6. Describe common supraventricular and ventricular rhythms that are associated with cardiac disease.
7. Identify various types of atrio-ventricular heart blocks and discuss their clinical significance.

HEMODYNAMICS

1. Explain the relationship between flow, pressure and resistance.
2. Explain the relationship between pressure, height, gravity and density.
3. Explain the concepts of volume, flow and velocity.
4. Explain Poiseuille's Law and describe how length, radius and viscosity influence resistance.
5. Explain parallel and series resistances and how they contribute to total resistance.
6. Explain the difference between laminar and turbulent flow.
7. Explain Reynolds number and its relationship to turbulent flow.
8. Explain how hemodynamics in blood vessels, especially in the microcirculation, deviates from theory due to anomalous viscosity, distensibility and axial streaming.
9. Describe the systemic and pulmonary circuits.
10. Explain how systemic vascular resistance and pulmonary vascular resistance differ

CARDIAC CYCLE

1. Explain what occurs during systole and diastole.
2. Explain the relationship between ventricular pressure, aortic pressure and atrial pressure during the cardiac cycle.
3. Explain these relationships for the right side of the heart.
4. Explain the relationship between ventricular volumes and pressure and aortic volumes and pressures during the cardiac cycle.
5. Explain how systole and diastole are affected by changes in heart rate.

CARDIAC OUTPUT

1. Define cardiac output.
2. Explain the relationship between cardiac output and whole body oxygen consumption and/or work.
3. Explain the role of heart rate and stroke volume in increasing cardiac output 4 to 6 fold over resting levels.
4. Describe how cardiac output can be measured by the Fick principle; dye dilution and thermodilution.

VENTRICULAR FUNCTION I AND II

1. Define isometric and isotonic contraction.
2. Describe the length tension relationship of cardiac muscle; explain preload.
3. Describe the force-velocity relationship of cardiac muscle; explain afterload.
4. Explain the ventricular function curve and discuss the in vivo correlates of length and tension.
5. Explain the effects of the sympathetic nervous system on cardiac muscle contraction (contractility or
6. inotropy) and therefore on ventricular function.
7. Explain the pressure volume relationship.
   a. Explain the phases of the cardiac cycle.
   b. Explain when and where the valves open and close.
   c. Explain what the changes in volume are called and how they are calculated.
8. Demonstrate the effects of changes in preload, afterload and contractility on the pressure volume relationship.

VENOUS RETURN

1. Differentiate between the true and the effective pressure gradient for venous return.
2. Explain the concept of compliance and its relevance to the venous circulation.
3. Explain the role of the sympathetic nervous system in altering compliance.
4. Explain the effects of gravity on the venous circulation.
5. Explain the compensation that occurs by way of the baroreceptor reflex when blood pressure falls or increases.

CONTROL OF PERIPHERAL CIRCULATION

1. Describe the intrinsic mechanisms by which vascular smooth muscle contracts or relaxes - myogenic properties vs. response to vasodilator agents.
2. Describe the effects of autonomic nervous system stimulation of vascular smooth muscle contraction or relaxation.
3. Explain how the cardiac output is distributed during severe exercise and how vascular smooth muscle is regulated in different organs such as the heart, brain, skeletal muscle, kidney, skin and gastrointestinal tract.
4. Explain how the cardiac output is distributed during severe blood loss and how vascular smooth muscle is regulated in different organs such as the heart, brain, skeletal muscle, kidney, skin and gastrointestinal tract.

CONTROL OF BLOOD PRESSURE

1. Define mean arterial blood pressure.
2. Explain the relationship between cardiac output and systemic vascular resistance and blood pressure.
3. Explain the function and components of a control system.
4. Explain how the arterial baroreceptors work.
5. Explain the response in the medulla to baroreceptor input.
6. Explain the output of the sympathetic and parasympathetic nervous systems in response to afferent information from the baroreceptors.
7. Describe how the baroreceptors reflex functions when body position is changed from supine to upright.

HEART SOUNDS AND MURMURS

1. Describe when the normal heart sounds are heard and what causes the sound.
2. Explain the phonocardiogram.
3. Describe the pathophysiology that occurs with stenosis of any of the heart valves.
4. Describe the pathophysiology that occurs with insufficiency of any of the heart valves.
5. Differentiate between eccentric and concentric hypertrophy and what factors induce them.
6. Discuss the third and fourth heart sounds.

CAPILLARY DYNAMICS AND LYMPH

1. Explain the structure of the various types of capillaries in the organs of the body.
2. Explain the process of diffusion.
3. Explain the process of bulk flow and the Starling forces that determine the balance of filtration vs. reabsorption in the capillaries.
4. Describe the consequences of altering interstitial and/or capillary oncotic and/or hydrostatic forces on capillary dynamics.
5. Explain the function of the lymphatic circulation with reference to reabsorption of protein, interstitial volume regulation, the immune system and distribution of materials in the body.

CALCIUM AND HEART FUNCTION

1. Describe the role of the sarcolemma in effecting the changes in cytosolic calcium concentrations that occur from diastole to systole and back to diastole.
2. Describe the role of the sarcoplasmic reticulum in effecting the changes in cytosolic calcium that occur from diastole to systole and back to diastole.
3. Describe the effects of the sympathetic nervous system on calcium movements.
4. Describe how contractility can be altered.

CORONARY CIRCULATION

1. Use the Fick principle to explain the relationship between myocardial O2 consumption and coronary blood flow.
2. List the factors that affect myocardial O2 consumption over and above the O2 utilized to support

basal metabolic requirements.
3. Explain the determinants of coronary blood flow.
4. Describe the effects of extravascular compression on blood flow during systole and diastole.
5. Describe the relationship between myocardial metabolism and coronary blood flow.
6. Explain the effects of autonomic nervous system stimulation on coronary blood flow.

CEREBRAL CIRCULATION

1. Describe the relationship between cerebral blood flow and cardiac output
2. List the factors that affect cerebral blood flow.
3. Describe the relationship between regional cerebral metabolism and regional cerebral blood flow.
4. Explain the effects of autonomic nervous system stimulation on cerebral blood flow.
5. Describe the effects of extravascular compression on blood flow during changes in cerebral spinal fluid pressure.
6. Describe the blood brain barrier and its functions (barrier, carrier, receptors).
7. Describe the formation, circulation and absorption of the cerebral spinal fluid (CSF). Explain the functions of the CSF

ENDOTHELIUM AND DISEASE

1. Explain the normal functions of the endothelium:
   a. As a barrier.
   b. Anti-constrictive
   c. Metabolic
2. Describe the pathway for endothelial dependent vasodilation

MECHANICS OF BREATHING I, II and III

1. The student understands the mechanical properties of the lung and the chest wall during breathing.
2. Describes the generation of a pressure gradient between the atmosphere and the alveoli.
3. Describes the passive expansion and recoil of the alveoli.
4. Defines the mechanical interaction of the lung and the chest wall, and relates this concept to the negative intrapleural pressure.
5. Describes the pressure-volume characteristics of the lung and the chest wall, and predicts changes in the compliance of the lung and the chest wall in different physiologic and pathologic conditions.
6. States the roles of pulmonary surfactant and alveolar interdependence in the recoil and expansion of the lung.
7. Defines the functional residual capacity (FRC), and uses his or her understanding of lung-chest wall interactions to predict changes in FRC in different physiologic and pathologic conditions.
8. Defines airways resistance and lists the factors that contribute to or alter the resistance to airflow, including the parasympathetic and sympathetic influences on airway smooth muscle.
9. Describes the dynamic compression of airways during a forced expiration.
10. Relates changes in the dynamic compliance of the lung to alterations in airways resistance.
11. Lists the factors that contribute to the work of breathing.
12. Predicts alterations in the work of breathing in different physiologic and pathologic states.

ALVEOLAR VENTILATION

1. The student understands the ventilation of the alveoli.
2. Defines alveolar ventilation.
3. Defines the standard lung volumes, and understands their measurement.
4. Predicts the effects of alterations in lung and chest wall mechanics, due to normal or pathologic processes, on the lung volumes.
5. Defines anatomic dead space, and relates the anatomic dead space and the tidal volume

to alveolar ventilation.
6. Understands the measurement of the anatomic dead space and the determination of alveolar ventilation.
7. Defines physiologic and alveolar dead space, and understands their determination.
8. Predicts the effects of alterations of alveolar ventilation on alveolar carbon dioxide and oxygen levels.
9. Describes the regional differences in alveolar ventilation found in the normal lung, and explains these differences.
10. Predicts the effects of changes in lung volume, aging, and disease processes on the regional distribution of alveolar ventilation.
11. Defines the closing volume, and explains how it can be demonstrated.
12. Predicts the effects of changes in pulmonary mechanics on the closing volume.

PULMONARY CIRCULATION

1. The student knows the structure, function, distribution, and control of the blood supply of the lung.
2. Compares and contrasts the bronchial circulation and the pulmonary circulation.
3. Describes the anatomy of the pulmonary circulation, and explains its physiologic consequences.
4. Compares and contrasts the pulmonary circulation and the systemic circulation.
5. Describes and explains the effects of lung volume on pulmonary vascular resistance.
6. Describes and explains the effects of elevated intravascular pressures on pulmonary vascular resistance.
7. Lists the neural and humoral factors that influence pulmonary vascular resistance.
8. Describes the effect of gravity on pulmonary blood flow.
9. Describes the interrelationships of alveolar pressure, pulmonary arterial pressure, and pulmonary blood flow.
10. Predicts the effects of alterations in alveolar pressure, pulmonary arterial and venous pressure, and body position on the regional distribution of pulmonary blood flow.
11. Describes hypoxic pulmonary vasoconstriction and discusses its role in localized and widespread alveolar hypoxia.
12. Describes the causes and consequences of pulmonary edema.

VENTILATION-REPERFUSION RELATIONSHIPS

1. The student understands the importance of the matching of ventilation and perfusion in the lung.
2. Predicts the consequences of mismatched ventilation and perfusion.
3. Describes the methods used to assess the matching of ventilation and perfusion.
4. Describes the methods used to determine the uniformity of the distribution of the inspired gas and pulmonary blood flow.
5. Explains the regional differences in the matching of ventilation and perfusion of the normal upright lung.
6. Predicts the consequences of the regional differences in the ventilation and perfusion of the normal upright lung.

DIFFUSION OF GASES

1. The student understands the diffusion of gases in the lung.
2. Defines diffusion, and distinguishes it from bulk flow.
3. States Fick's law for diffusion.
4. Distinguishes between perfusion limitation and diffusion limitation of gas transfer in the lung.
5. Describes the diffusion of oxygen from the alveoli into the blood.
6. Describes the diffusion of carbon dioxide from the blood to the alveoli.
7. Defines the diffusion capacity and discusses its measurement.

THE TRANSPORT OF OXYGEN AND CARBON DIOXIDE IN THE BLOOD

1. The student understands how oxygen and carbon dioxide are transported to and from the tissues in the blood.

2. States the relationship between the partial pressure of oxygen in the blood and the amount of oxygen physically dissolved in the blood.
3. Describes the chemical combination of oxygen with hemoglobin and the A oxygen dissociation curve.
4. Defines hemoglobin saturation, the oxygen-carrying capacity, and the oxygen content of blood.
5. States the physiologic consequences of the shape of the oxygen dissociation curve.
6. Lists the physiologic factors that can influence the oxygen dissociation curve, and predicts their effects on oxygen transport by the blood.
7. States the relationship between the partial pressure of carbon dioxide in the blood and the amount of carbon dioxide physically dissolved in the blood.
8. Describes the transport of carbon dioxide as carbamino compounds with blood proteins.
9. Explains how most of the carbon dioxide in the blood is transported as bicarbonate.
10. Describes the carbon dioxide dissociation curve for whole blood.
11. Explains the Bohr and Haldane effects.

THE REGULATION OF ACID-BASE STATUS

1. The student understands the basic concepts of the regulation of the acid-base status of the body.
2. Defines acids, bases, and buffers.
3. Lists the buffer systems available in the human body.
4. Describes the interrelationships of the pH, the PCO2 of the blood, and the plasma bicarbonate concentration, and states the Henderson-Hasselbalch equation.
5. States the normal ranges of arterial pH, PCO2 and bicarbonate concentration, and defines alkalosis and acidosis.
6. Lists the potential causes of respiratory acidosis and alkalosis and metabolic acidosis and alkalosis.
7. Discusses the respiratory and renal mechanisms that help to compensate for acidosis and alkalosis.
8. Evaluates blood gas data to determine a subject's acid-base status.
9. Classifies and explains the causes of tissue hypoxia.

THE CONTROL OF BREATHING

1. The student understands the organization and function of the respiratory control system.
2. Describes the general organization of the respiratory control system.
3. Localizes the centers that generate the spontaneous rhythmicity of breathing.
4. Describes the groups of neurons that effect inspiration and expiration.
5. Describes the other centers in the brainstem that may influence the spontaneous rhythmicity of breathing.
6. Lists the cardiopulmonary and other reflexes that influence the breathing pattern.
7. States the ability of the brain cortex to temporarily override the normal pattern of inspiration and expiration.
8. Describes the effects of alterations in body oxygen, carbon dioxide, and hydrogen ion levels on the control of breathing.
9. Describes the sensors of the respiratory system for oxygen, carbon dioxide, and hydrogen ion concentration.

FETAL CIRCULATION

1. Describe the intracardiac and extracardiac shunts that are present in the fetal circulation.
2. Explain the compensatory mechanisms present in the fetal circulation to handle the low oxygen environment.
3. Explain what changes occur in the fetal circulation at birth.
4. Explain what factors cause the closure of the shunts after birth.

ALTITUDE AND DIVING

1. The student uses the knowledge he or she gained from the preceding lectures to predict the response of the respiratory system to the physiologic stresses of ascent to altitude and diving.
2. Identifies the physiologic stresses involved in the ascent to altitude.

3. Predicts the initial responses of the respiratory system to the ascent to altitude.
4. Describes the acclimatization of the cardiovascular and respiratory systems to residence at high altitudes.
5. Identifies the physiologic stresses involved in diving.
6. Predicts the responses of the respiratory system to various types of diving.

NONRESPIRATORY FUNCTIONS OF THE LUNG

1. The student understands the nonrespiratory functions of the components of the respiratory system.
2. Lists and describes the mechanisms by which the lung is protected from the contaminants in inspired air.
3. Describes the air-conditioning function of the upper airways.
4. Describes the filtration and removal of particles from the inspired air.
5. Describes the removal of biologically active material from the inspired air.
6. Describes the reservoir and filtration functions of the pulmonary circulation.
7. Lists the metabolic functions of the lung, including the handling of vasoactive materials in the blood.