Chapter 02: Physiology of the Cardiovascular and Pulmonary Systems
Hillegass: Essentials of Cardiopulmonary Physical Therapy, 4th Edition

MULTIPLE CHOICE

1. The primary function of the pulmonary system is which of the following?
   a. Regulating acid–base balance and maintaining normal blood pH
   b. Filtering and metabolizing toxic substances
   c. Achieving temperature homeostasis through evaporative heat loss
   d. Exchange of oxygen and carbon dioxide between environment, blood, and tissue

   ANS: D
   According to the author, the most important function of the pulmonary system is to exchange oxygen and carbon dioxide between the environment, blood, and tissue.

   PTS: 1

2. The total volume of air that is inhaled or exhaled in 1 minute is termed:
   a. tidal volume.
   b. minute ventilation.
   c. inspiratory reserve volume.
   d. inspiratory capacity.

   ANS: B
   The minute ventilation represents the total volume of air that is inhaled or exhaled in 1 minute.

   PTS: 1

3. The maximum amount of air that can be inhaled after a normal tidal exhalation is termed:
   a. inspiratory reserve volume.
   b. expiratory reserve volume.
   c. inspiratory capacity.
   d. vital capacity.

   ANS: C
   The inspiratory capacity (IC) is the sum of the tidal and inspiratory reserve volumes; it is the maximum amount of air that can be inhaled after a normal tidal exhalation.

   PTS: 1

4. Which of the following brain areas provides control for automatic breathing?
   a. Medulla oblongata
   b. Pons
   c. Frontal lobe of the cerebrum
   d. Hypothalamus

   ANS: A
   The medulla oblongata contains inspiratory neurons that produce inspiration and expiratory neurons that are triggered with force expiration. These neurons control automatic breathing.

PTS: 1

5. Which of the following statements BEST explains why increasing administered oxygen should be done cautiously in a patient with severe chronic obstructive pulmonary disease (COPD) AT REST?
   a. The body may rely on hypoxic drive to breathe (oxygen receptors) and increasing administered oxygen at rest leads to hyperoxemia suppressing the hypoxic drive.
   b. The body needs additional time to allow the peripheral chemoreceptors to cause an increase of ventilatory rate to improve oxygenation.
   c. The body is relying on carbon dioxide to regulate the respiratory cycle, and increasing administered oxygen at rest leads to inhibition of the carbon dioxide receptors.
   d. Increasing administered oxygen to the body oversaturates the system leading to toxicity.

   ANS: A
   A patient with severe COPD who develops high CO_2 blood levels subsequently leads to the body relying more on oxygen receptors instead of carbon dioxide receptors. This is termed hypoxic drive to breathe. If administered oxygen is too high and causes hyperoxemia (increased oxygen in the blood), the oxygen receptors may be suppressed, which reduces the drive to breathe.

   PTS: 1

6. Which of the following lung tissue receptors are located along the smooth muscles lining the airways are sensitive to increasing size and volume within the lung, termed the Hering–Breuer reflex?
   a. Irritant receptors
   b. Stretch receptors
   c. Chemoreceptors
   d. Juxtapulmonary receptors

   ANS: B
   Stretch receptors are located along smooth muscles lining the airways and are sensitive to increasing size and volume within the lung. The Hering–Breuer reflex is active with large increases in the tidal volume, especially seen during exercise, and protects the lung from excessive inflation.

   PTS: 1

7. Which of the following lung receptors are stimulated in a patient with left-sided congestive heart failure who develops pulmonary edema causing the patient to breathe in a SHALLOW, tachypneic pattern.
   a. Irritant receptors
   b. Stretch receptors
   c. Chemoreceptors
   d. Juxtapulmonary receptors

   ANS: D

The juxtapulmonary receptors (J receptor) are located near the pulmonary capillaries and are sensitive to increased pulmonary capillary pressures. On stimulation, these receptors initiate a rapid, shallow breathing pattern. In a patient with congestive heart failure, pulmonary edema would stimulate the interstitial J receptors.

PTS: 1

8. Which of the following events occur as a result of the diaphragm and external intercostals contracting to facilitate inspiration?
   a. An increase in the volume of the thoracic cavity and lung reducing the intrapulmonary pressure
   b. An increase in the pressure within the lung occurring due to Boyle's law
   c. A decrease in the volume of the thoracic cavity and lung increasing the intrapulmonary pressure
   d. A change in the thoracic cavity and lung volume leading to an intrapulmonary pressure that exceeds the atmospheric pressure

   ANS: A
   When the diaphragm and external intercostals contract to facilitate inspiration, it causes an increase in the volume of the thoracic cavity and lung, which reduces the intrapulmonary pressure. The intrapulmonary pressure is decreased below the atmospheric levels facilitating the flow of air into the lungs to normalize pressure differences.

   PTS: 1

9. Which of the following BEST describes the intrapleural pressure compared to the intrapulmonary pressure?
   a. Intrapleural pressure is less than intrapulmonary pressure.
   b. Intrapleural pressure is the same as intrapulmonary pressure.
   c. Intrapleural pressure is greater than intrapulmonary pressure.
   d. Intrapleural pressure is not related to the intrapulmonary pressure.

   ANS: A
   The intrapleural pressure is normally lower than the intrapulmonary pressure developed during both inspiration and expiration. This difference in pressures helps to maintain the lung near the chest wall.

   PTS: 1

10. Compliance is BEST explained by which of the following statements.
    a. The tendency of a structure to return to its initial size after being distended
    b. The pressure that acts to collapse the alveolus and increase the pressure of air within the structure
    c. The tendency of a force that exists to collapse or recoil the structure while inflated
    d. The pressure that allows changes in lung volume to parallel changes in thoracic excursion during breathing

    ANS: C
    Compliance of lung tissue is likened to a balloon during inspiration, where there exists a tendency to collapse or recoil while inflated. A = elasticity; B = surface tension; D = transmural pressure.

PTS: 1

11. Which of the following statements is MOST correct about surfactant?
    a. Diminishes the overall surface tension of the alveoli to keep air in smaller alveoli.
    b. Pulmonary surfactant is composed of a single class of molecules.
    c. Compression of the surfactant molecules decreases their density.
    d. Surfactant develops early in fetal life.

    ANS: A
    Surfactant is a surface-active agent that is needed to decrease the overall surface tension of alveoli in order to lower wall tension in proportion to the radius of the alveolus. Pressure within the alveolus is directly proportional to the surface tension and inversely proportional to the radius of the alveolus. The availability of surfactant assists in keeping air in alveoli of varying sizes.

    PTS: 1

12. Which of the following factors act to decrease airway resistance?
    a. The presence of mucus and edema
    b. Smaller airway diameter
    c. Parasympathetic nervous system
    d. Sympathetic nervous system

    ANS: D
    Sympathetic nervous system influence decreases airway resistance, which would be congruent with the need to improve airflow in order to keep up with the body's demand for oxygen during exercise. Poiseuille's law states that the flow through a vessel or airway is directly proportional to the pressure difference and radius and inversely proportional to the length of the airway and viscosity of the gas. Small changes in radius account for large changes in airflow.

    PTS: 1

13. Which of the following physical properties of lungs facilitates passive expiration?
    a. Compliance
    b. Elasticity
    c. Surface tension
    d. Resistance to airflow

    ANS: B
    Elasticity refers to the tendency of a structure to return to its initial size after being distended. This elastic recoil of the lung allows passive expiration to occur.

    PTS: 1

14. To facilitate the diffusion of oxygen from alveoli to pulmonary capillary, which of the following must occur?
    a. The alveolar walls become thicker.
    b. Concentration of oxygen is high in the pulmonary artery.
    c. Concentration of oxygen is high in the alveoli.
    d. Partial pressure of oxygen must equal 20.93%.

ANS: C
For gas exchange to occur, a pressure gradient must be created across the alveolar capillary interface. This gradient will enable gases to diffuse from an area of high concentration to areas of low concentration across the semipermeable respiratory membrane.

PTS: 1

15. Which of the following improves gas exchange in the base of the lungs?
    a. Gas ventilation is greater than blood perfusion.
    b. Patient is positioned in prone.
    c. Patient is positioned in upright sitting.
    d. Blood perfusion amount is greater than gas ventilation.

    ANS: C
    A change in the position of the patient changes areas of ventilation and perfusion. Generally, greater ventilation and perfusion occur in gravity-dependent areas, thereby allowing better respiration to occur in the dependent lung. The upright sitting position would facilitate better ventilation/perfusion matching in the base of the lungs due to gravity dependency.

    PTS: 1

16. Which of the following forms of hemoglobin molecules refers to the binding of heme to carbon monoxide instead of oxygen?
    a. Oxyhemoglobin
    b. Deoxyhemoglobin
    c. Methemoglobin
    d. Carboxyhemoglobin

    ANS: D
    Carboxyhemoglobin is another form of hemoglobin that involves the binding of heme to carbon monoxide instead of oxygen. The bond with carbon monoxide is 210 times stronger than oxygen, and therefore displaces oxygen and inhibits its binding capacity.

    PTS: 1

17. In the systemic arteries, at a partial pressure of 100 mm Hg, the percent of hemoglobin should be:
    a. 85%.
    b. 97%.
    c. 74%.
    d. 21%.

    ANS: B
    In the systemic arteries, at a partial pressure of 100 mm Hg, the percent of hemoglobin is 97% indicating that 97% of hemoglobin molecules in blood are bound to oxygen. The remaining 3% reflects deoxyhemoglobin, methemoglobin, and carboxyhemoglobin concentrations.

    PTS: 1

18. Which of the following is the BEST way to measure oxyhemoglobin saturation?
    a. Pulse oximeter

b. Hemoglobin blood test
c. Arterial blood gas
d. Pulmonary function test

ANS: C
The gold standard or best test for measuring oxyhemoglobin saturation is through an analysis of arterial blood gases. Pulse oximeter can also be utilized to obtain this number, but is less accurate due to it being an estimation and not a direct measure.

PTS: 1

19. Which of the following changes in the system would cause a shift in the oxyhemoglobin dissociation curve to the left?
a. An increase in the pH
b. A decrease in the pH
c. Increase in tissue temperature
d. Prolonged hypoxemia

ANS: A
An increase in pH or alkalemia would shift the curve to the left. Answer choices B, C, and D all shift the curve to the right.

PTS: 1

20. Which of the following factors will potentially diminish cardiac output?
a. Medications that have a positive ionotropic effect
b. Beta-blocker effect on beta-receptors
c. Release of epinephrine and norepinephrine
d. An increase in blood volume

ANS: B
Beta-blocker medications blunt heart rate response during exercise by making the beta-receptors on the myocardial wall unresponsive to sympathetic stimulation and appropriately increase heart rate. A lack of heart rate response would potentially diminish cardiac output.

PTS: 1

21. In patients with congestive heart failure, which of the following positions should be avoided to minimize the preload on a failing heart?
a. Sitting up in a bedside chair
b. Standing at a support surface
c. Semireclined on an exercise mat
d. Supine with lower extremities elevated

ANS: D
In patients with congestive heart failure, the Frank–Starling mechanism does not apply. An increase in preload puts additional stress on the failing heart. These patients will not tolerate supine (flat) or supine with legs elevated due to the effects of gravity and a resultant increase of blood volume return to the heart.

PTS: 1

22. The positive ionotropic effect on myocardial contractility produced by the release of norepinephrine from sympathetic nerve endings is an example of:
    a. intrinsic control factor.
    b. extrinsic control factor.
    c. Frank–Starling mechanism.
    d. parasympathetic stimulus.

    ANS: B
    The extrinsic control of contractility depends on the activity of the sympathoadrenal system. Epinephrine from the adrenal medulla and norepinephrine from the sympathetic nerve endings produce a positive ionotropic effect, or increase myocardial contractility by promoting an influx of calcium available to the sarcomeres of the myocardial cells.

    PTS: 1

23. Afterload is BEST defined by which of the following statements?
    a. A reflection of the pressure against which the heart has to contract
    b. The amount of load (stretch) on the myocardial wall prior to contraction
    c. The maximum amount of blood that can be filled in the ventricles
    d. The pressure within the arterial system during the diastolic phase of the cardiac cycle

    ANS: A
    The afterload is a reflection of the pressure against which the heart has to contract to pump blood into the aorta. The pressure within the arterial system during the diastolic phase of the cardiac cycle is a function of total peripheral resistance.

    PTS: 1

24. The BEST indicator of cardiac function is:
    a. stroke volume.
    b. end-diastolic volume.
    c. ejection fraction.
    d. end-systolic volume.

    ANS: C
    The ejection fraction represents a ratio or percentage of the volume of blood ejected out of the ventricles relative to the volume of blood received by the ventricles before contraction and is the best indicator of cardiac function.

    PTS: 1

25. In a patient with systolic heart failure, the compromised ejection fraction is commonly reflected as:
    a. 70%.
    b. 60%.
    c. 50%.
    d. 35%.

    ANS: D

In patients with systolic heart failure, the ejection fraction is compromised as evidenced by a ratio less than 40%. For every 100 mL of blood brought into the ventricles, less than 40 mL of blood is ejected per contraction due to a failing heart.

PTS: 1

26. Peripheral muscle contraction and deep diaphragmatic inspiratory maneuvers directly enhance which of the following influences on cardiac function?
    a. Venous return
    b. Myocardial contractility
    c. Afterload
    d. End-systolic volume

    ANS: A
    Venous return represents the return of blood to the right side of the heart via the veins. Factors that directly influence venous return include the pressure gradient in the venous system, peripheral muscle activity, deep diaphragmatic inspiratory maneuvers, and sympathetic nerve fiber stimulation on smooth muscle cell contraction in veins.

    PTS: 1

27. Myocardial tissue requires constant aerobic metabolism both at rest and during heavy exercise. Which of the following attributes of myocardial tissue BEST facilitates the supply of oxygen during systole (myocardium contraction)?
    a. High capillary density
    b. Myoglobin
    c. Coronary perfusion
    d. Hemoglobin

    ANS: B
    The myocardium contains large amounts of myoglobin. These structures have the ability to store oxygen during diastole and release the stored oxygen during systole to myocardial cells. Systole involves myocardial contraction, which squeezes coronary arteries reducing the perfusion of blood. Capillary density is helpful, but its influence does not change as related to diastole and systole phases.

    PTS: 1

28. The rate pressure product is a clinically useful tool to estimate the myocardial oxygen demand and is calculated using which of the following variables?
    a. Respiratory rate × systolic blood pressure
    b. Respiratory rate × diastolic blood pressure
    c. Heart rate × systolic blood pressure
    d. Heart rate × diastolic blood pressure

    ANS: C
    The rate pressure product is a clinically useful tool to estimate the myocardial oxygen demand and is calculated by using heart rate × systolic blood pressure. During exercise, alterations in autonomic nervous system stimulation also influence coronary blood flow by directly affecting heart rate and force of contraction—the two primary determinants of the myocardium's metabolic rate.

PTS: 1

29. Which of the following age-related cardiovascular physiological changes MOST likely leads to increased ventricular wall thickness?
    a. Increased body weight
    b. Decreased maximal heart rate
    c. Reduced arteriovenous oxygen uptake
    d. Increased collagen presence

    ANS: D
    With increasing age, left-ventricular wall thickness increases due to increased collagen and the enhanced size of myocardial cells. Increased body weight, decreased maximal heart rate, and reduced arteriovenous oxygen uptake contribute to a decline in maximal oxygen uptake.

    PTS: 1

30. Which of the following age-related cardiovascular physiological changes is considered a peripheral factor?
    a. Compromised arteriovenous oxygen uptake
    b. Reduced stroke volume
    c. Decreased maximal heart rate
    d. Low stroke volume values

    ANS: A
    Arteriovenous oxygen uptake is considered a peripheral factor (not specific to heart) whereas reduced stroke volume, decreased maximal heart rate, and low stroke volume values all reflect specific heart (central) factors.

    PTS: 1